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THIRD REPORT

OF THE

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ROYAL COMMISSION.

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ON

SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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Presented to both Houses of Parliament by Command of Her Majesty.

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COMMISSIONS

REPORT -

APPENDIX

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE

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VICTORIA R.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

## THIRD REPORT.

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TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty the following Report on the Universities of Oxford and Cambridge.

We have received a large amount of valuable information from persons well acquainted with, and deeply interested in, the progress of Scientific Education and Research within these two Universities; and the evidence thus placed at our disposal contains not only a full account of the present state of scientific study in them, but also much that is suggestive of hope for the future.

In reporting on this evidence, we desire at the very outset to guard against a possible misconception. Our use of the term Science in this Report is limited, by the scope of the duties assigned to us, to the Sciences of Organic and Inorganic Nature, including under that general designation the Sciences of Number and Magnitude, together with those which depend on Observation and Experiment; but excluding the Mental and Moral Sciences, as well as all those parts of human knowledge and culture which are not usually regarded as having any scientific character. In dealing with the relations of the Universities to Science, we shall use the word in this restricted sense; and we can refer only in a very secondary manner to the equally important duties which such academical bodies owe to literature and learning, and to education in other than purely scientific directions. Nor must it be supposed that in referring only incidentally, as we shall have to do, to subjects which justly form a large part of the business of an University, we intend in any manner to undervalue them, or even to suggest any comparison between the place which they occupy in University Education and that which has hitherto been assigned, or which ought hereafter to be assigned, to training in the methods of Science. Least of all should we wish to imply that there is any antagonism between the literary and scientific branches of education and research; it is rather our conviction that neither branch can be neglected without grave detriment to the other; and that an University in which the Mathematician, the Experimental Philosopher, and the Biologist are actively engaged in the endeavour to advance human knowledge in their own provinces, is not on that account less likely to be productive of original labours in the fields of Literature and Learning.

For the sake of convenience we have classified the subjects referred to in the evidence under the following heads:—

- I. The Courses of Study, and the Examinations.
- II. The Professoriate.
- III. The Scientific Institutions within the Universities.
- IV. The Colleges.
- V. The Relation of the Universities to Technical Education, and to Education for Scientific Professions.
- VI. The Duty of the Universities and the Colleges with regard to the Advancement of Science.

We shall consider these subjects in order, observing, however, that, as we shall recognise throughout the twofold character which ought to attach to the Universities as centres of Scientific Education and as centres of Original Research, much that would properly fall under the last two heads will of necessity be anticipated in earlier parts of the Report.

## I.—THE COURSES OF STUDY AND THE EXAMINATIONS.

## I.—Matriculation and Entrance Examinations.

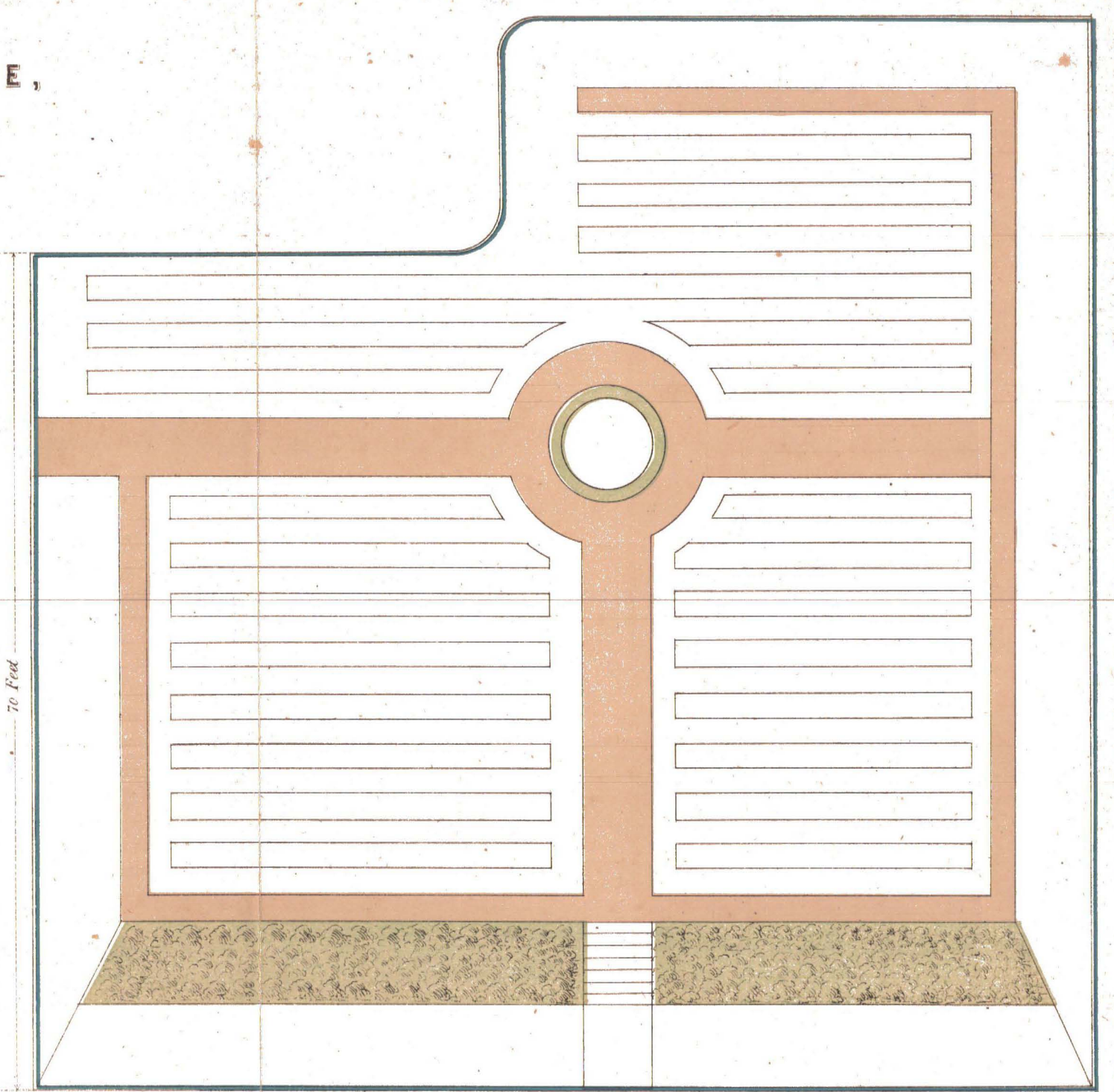
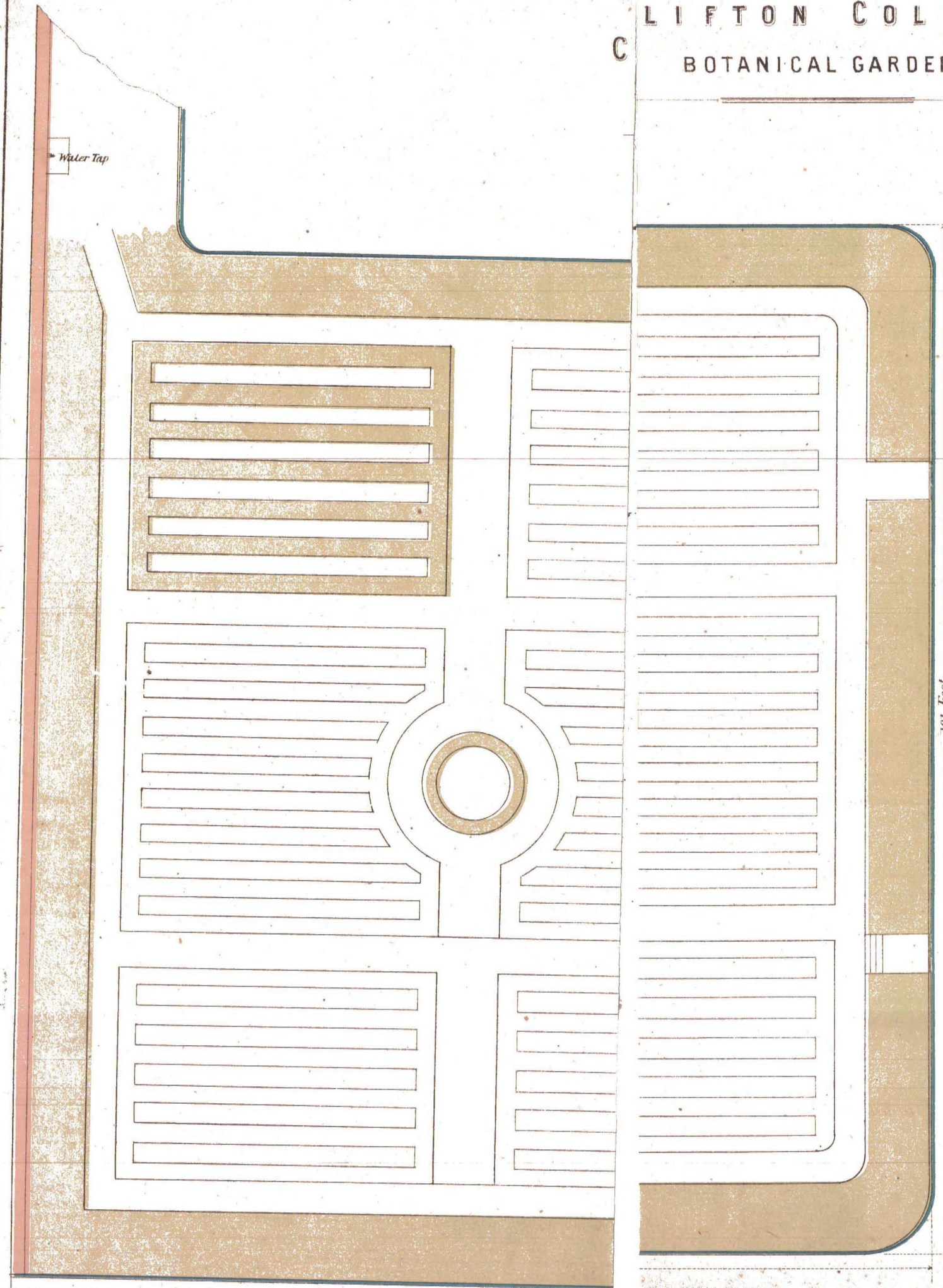
1. Neither at Oxford nor at Cambridge is there at present any University Matriculation Examination. At Oxford, its place is usually supplied by a College Entrance Examination, of which the subjects to a certain extent, and the standard to a very great extent, vary in the different Colleges. With regard to the Unattached Students who are allowed to reside without belonging to any College or Hall, the Censors are authorised to impose, and do impose, an Entrance Examination in lieu of that required by the college authorities; it is understood, however, that the standard of the Censors' examination is not intended to be a very high one. At Cambridge, Trinity College stood, till lately, alone in having an Entrance Examination; one has recently been established at Trinity Hall. When there is no entrance examination, the tutors require a certificate of fitness from a Master of Arts of Cambridge or Oxford. The regulations respecting Unattached Students are entrusted by the University to a Board constituted for the purpose.

2. At both Universities the question has been frequently raised, and it has been brought before us in the evidence, whether it would be desirable to institute an University Matriculation Examination, and if so, what should be the subjects of examination, and what standard of attainment should be required? The question is one of a double aspect, affecting the Public and First Grade Schools on the one hand, as much as the Universities on the other. It is not improbable that the Masters of the Public and other Schools would prefer to see an uniform matriculation standard sanctioned by the Universities, instead of having to prepare their pupils, as at present, for examinations requiring such various degrees of proficiency as the College Entrance Examinations. At the same time, it must be borne in mind that the advantage which the schools would thus obtain would, so far, at least, as Oxford is concerned, be more apparent than real, inasmuch as those colleges which now maintain a high entrance standard would most probably refuse to accept the University Matriculation Examination in the place of their own severer test; and thus the inconveniences arising from the alleged uncertainties and fluctuations of the present entrance examinations would not really be got rid of; while a new inconvenience would be superadded in the co-existence of two examinations, one by the College and one by the University, both being intended to test the same thing—the fitness of the candidate to enter upon a course of University study.

3. But independently of the well-founded claim for a more uniform and satisfactory test than any now existing of the proficiency of a schoolboy when his school studies are just ending, there appears to be a growing disposition on the part of many Masters of Schools to admit the Universities to a larger share in the direct guidance of school studies than is at present conceded to them. One way of supplying such guidance would be to institute a Matriculation Examination, at which, in all probability, if the Universities should offer no objection, a certain number of pupils would offer themselves who had no intention of continuing their studies as resident students. So long as the older Universities abstain from instituting a Matriculation Examination (or some equivalent examination, such as that which we shall presently propose), they do, *pro tanto*, neglect the function which is most usefully and efficiently discharged by the University of London, that, namely, of systematising and stimulating education in a large number of schools.

4. It is, however, contended by those, whether masters of schools or others, who are opposed to an organised matriculation system, that the enormous indirect influence which the University curriculum and the later University examinations exercise over the course of school instruction is sufficient for all useful purposes; and that more is gained by leaving to the schools their present freedom, than by attempting to enforce the same course of study upon all. A common objection to a Matriculation Examination is based upon the fear that if the standard were low it would exercise a depressing rather than an elevating influence on the schools; and that if it were high it would be exclusive, and would keep away from the Universities a certain number of students who at present find their way to them. If it were only the careless and the idle who would thus be rejected, the Universities would be by so much the gainers; but there are cases of a very different kind and deserving of much more consideration. A young man may have a fair share of rough untrained ability, but if his circumstances have not enabled him to enjoy the advantage of a good secondary education, he may easily find himself worsted in an examination which ought to be adapted to test boys from the upper forms of the best schools in the country. This objection (which, indeed, would be much weakened, if secondary education in England were more satisfactorily organised than it

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is) might, to a certain extent, be obviated by so arranging the examination as to admit of a certain number of options between different subjects, so that no one would be rejected who could give satisfactory proof of his fitness to profit by academical instruction in any one of its more important branches. It may be mentioned that at Oxford students are usually required by their Colleges to pass their Responsions at the end of the first term of their residence, and may pass it before coming into residence at all, though they may also postpone it for a year. The elasticity of this arrangement is thought to have some advantages as compared with the "hard-and-fast" line of a Matriculation Examination.

## II.—Proposed Examination on leaving School.

5. While we fully appreciate the importance of the Matriculation Examination as conducted at the University of London, which is essentially an examining body, we are of opinion that as regards Oxford and Cambridge, which are teaching as well as examining bodies, an examination on leaving school, analogous, in some respects, to the *Abiturienten Examen* in Germany, would be open to fewer objections than a Matriculation Examination on entering the University, and would possess great advantages of its own. Such a "Leaving Examination" could only be established by the co-ordination of the Universities on the one hand, and the First Grade Schools on the other; unless, indeed, the duty should be undertaken by Government, in which case the control of the examination would, in all probability, be entirely withdrawn from the Universities. At the present moment the two Universities have expressed their willingness to undertake the examination of First Grade Schools; and with the view of taking immediate action in the matter, a Delegation has been appointed at Oxford, and a Syndicate at Cambridge, with power to form a Joint Committee representing the two Universities. In the present state of the negotiation, however, it might be premature to assume that the plan will be accepted by all the First Grade Schools.

6. We prefer a "Leaving Examination" to an Examination at Matriculation for the following reasons:—

7. The education of a great number of the pupils of a First Grade School ceases when they leave the school. What is wanted in the interest of this large class of boys is an examination supplying not only a standard in accordance with which their school teaching may be directed, but a test whether that teaching has been efficient. A satisfactory standard is supplied by such a matriculation examination as that of the University of London. But, as it must be presumed that only a certain proportion of the senior boys in any school present themselves for matriculation, that examination fails to afford an adequate test of the general merits of a school, because it is applied only to selected candidates from the school, and not to all the senior boys without exception. It might be desirable, in a "Leaving Examination," to allow of more than one standard of proficiency, and it is altogether improbable that the lowest of the standards allowed could be kept as high as the present standard of the Matriculation Examination at the University of London. But, however this might be, the result of a "Leaving Examination" would supply the best conceivable criterion of the goodness or badness of the teaching given in a school, because it would (as a general rule) be undergone by all the senior boys alike, and would place on record the proportion of successes to failures.

8. These considerations have satisfied us that a "Leaving Examination" might exercise a most beneficial influence upon the First Grade Schools, by reaching a class of pupils who never proceed to any University examination at all. But we also conceive that the "Leaving Examination" might be so arranged as to harmonize with the system of University instruction, and might thus be made equally suitable to those students who intend to pursue an University course. It would, we think, be very undesirable to make admission to the Universities depend on the passing of the "Leaving Examination;" on the contrary, we should wish the opportunities of entering the Universities to continue as unrestricted as they are at present. But the "Leaving Examination" might serve to mark the limit between school studies and University studies, so that the student whose performance in the examination had come up to a certain standard, might be supposed to have acquired such an amount of general culture and scientific knowledge as to entitle him, thenceforward, to be left as free as possible to choose for himself among the great lines of literary or scientific study. At the same time we should recommend that a student who should, for any reason, be unable to offer himself for a "Leaving Examination," or who should fail to attain the required standard, should not suffer any disadvantage at the University, beyond that of incurring the obligation to pass an equivalent examination at some later period in his course.

9. We are of opinion that it is of the utmost importance for the future of scientific education in England, that, in case such an examination should be instituted, those parts of science which are suitable to form part of the education of boys should be fully recognised in it. We feel it necessary to insist strongly upon this point, because any disparagement of science, in comparison with other subjects, in an examination intended for schoolboys upon leaving school, would put insurmountable obstacles in the way of the efforts that are now being made to procure the more general recognition of certain scientific subjects as parts of the ordinary work of a school. Whether, in such an examination, any specified subjects should be made compulsory, or whether, in every case, an option should be allowed between different subjects, are questions which may be safely left to the Universities and the Schools. But we could not approve the institution of a Leaving Examination in which classical or mathematical subjects alone were rendered obligatory, while no similar requirement was made with regard to any part of the sciences of observation and experiment. Such a "præjudicium" against science would not only exercise an influence adverse to some of the best tendencies at present observable in the schools, but would greatly detract from that impartiality which the Universities should endeavour to maintain with regard to all the great branches of human knowledge.

### III.—Proposed arrangements with regard to the Scientific Curriculum.

10. As to the curriculum of study to be prescribed to the student when he has once been admitted to the University, there is less divergence of opinion than there is as to the conditions under which he should be admitted. There is a general concurrence among the witnesses, that the student, at an early period of his academical course, should be left free to choose for himself among the principal lines of study, and should not be hampered and distracted by being compelled to pass examinations in subjects having no direct bearing on his own immediate pursuits. Mr. Pattison, indeed, would go further, and would insist on the course of the scientific student being free from the very beginning, without the University requiring him to devote any time to literary studies, or expecting him to pass any examination whatever in non-scientific subjects. He says, "I would propose that when a young man comes up to the University, it should be open to him to matriculate at once as a scientific student; that he should not be checked in that career at any point by a classical requirement; that if he chooses to enter as a scientific student, the University should know nothing of him but as a scientific student, and that it should not throw what I may call a bar in his way by seeing whether he knows anything of Greek or Latin. A young man does not usually come to the University until 18, more usually it is 19, but 18 is the earliest age, and by that time I think that a good school might have laid a sufficient groundwork in literature, either classical or modern, and that there would be quite enough to do in the three years during which he is in the University, to conduct him through a course of mathematics and natural science." Again, to the question if he "would allow a young man who had had no literary training whatever to enter himself on the scientific side in the University of Oxford?" Mr. Pattison answers, "As far as the University is concerned, I would have the University take no cognizance of that matter if he chooses to enter as a scientific student. I would have the University take no cognizance of any literary attainments. Whether you should require the schools to certify themselves in any way of a man's literary attainments, is a different question; but I would not have the University put a barrier in his way at the beginning." Mr. Pattison would also dispense with the Matriculation Examination, "in order to avoid the waste of time which now occurs in preparing for subjects which are not afterwards to be studied."
11. On the other hand, Professor J. C. Adams in answer to the question, "You would not wish mathematics and physics to be studied to the exclusion of literary culture?" replies, "Certainly not. I think that literary culture is extremely important, that without it the mind is apt to become narrowed, especially if it be exclusively devoted to material objects, and that in consequence even physical studies themselves are likely to be pursued with less success. I should not, therefore, be at all in favour of establishing separate schools of science where the scientific studies should take the place of literary or of mathematical studies." He does not, however, consider it imperative that classical and physical studies should both be carried on to the end of an undergraduate's course; for in reply to the question, "At a certain period, do you think that classics might be laid aside, and the student's attention might be devoted to mathematics and physical science?" he says, "After a certain time, and after a certain amount of culture had been insured, I should be disposed to allow that." From his

answer to the preceding question it would appear that he contemplated the requirement of the "previous examination" as sufficient. When this evidence was given the regular time at which a student was obliged to present himself for the Previous Examination was in his third term.

12 We have already stated that, in our opinion, it is essential that some evidence of literary culture should be required by the University from every student; and in the interests of science itself we should not be disposed to see the standard of literary attainment which is expected from the scientific student placed at too low a level. Rather, we regret that a principle so sound in itself should receive only an one-sided application; and admitting, as we do, that literary cultivation, up to a certain point, is indispensable for the scientific student, we are of opinion that, in like manner, evidence of corresponding scientific culture should be required from the student of Classical Literature or of Theology. The Regius Professor of Greek at Oxford appears to admit that the present system is indefensible, when he says, "It may very fairly be retorted on this plan which I have just suggested, 'then you require Literature as a condition of taking a degree, 'but you do not require Science.' I should be inclined to require from everyone a certain amount of Science before he took his degree. I should put the different individuals on the same footing in that respect." \* \* \* "I think I would wish to leave it in this way, that I am prepared to demand Latin and Greek and a fair amount of Science of everyone; but I am not prepared to say, considering the small amount of Physical Science that is at present taught in the country, that I would make the amounts equivalent."

Qu. 3897.

Qu. 3974.

13. Since the greater part of the evidence relating to the Universities was received, the University of Oxford has been engaged in remodelling its Examination System, the general effect of the changes being to carry out, to a certain extent at least, the views laid before us by the witnesses, and to allow a greater freedom of choice between different branches of study than had previously been conceded. According to the Statute now coming into force, every scientific student who wishes to obtain the degree of Bachelor of Arts has to pass three examinations in non-scientific subjects; the first, Responsions, at the end of his first term; the second, Moderations, at the end of his fourth term; the third, an examination in Divinity (or in substituted matter) for which he cannot offer himself before his twelfth term. If it be admitted that a certain proficiency in both Greek and Latin is to be expected from an University Student of Science,—a question on which we do not propose to express any opinion in this Report,—the amount required at Responsions and Moderations will probably not be regarded as excessive; while the early period at which these examinations may be passed leaves him free to attend to his scientific work during that portion of his University residence which is by far the most valuable, as being not only the longest, but also the latest in point of time. In fact, if a student pass Moderations in his fourth term, he has two full years before he can offer himself for an examination in Honours; and, if he pleases, he may prolong this period to two and a half or to three years. Nor is this all; for if he has obtained an Honour in any one of the Honour Schools at the Final Examination, he acquires the right to offer himself for examination in any other honour school as late as his twentieth term. Thus, a Student in Natural Science who should obtain a fourth class in the School of Mathematics would have nearly four years, after passing Moderations, which he might devote almost without interruption to his scientific work.

14. As, however, an University course of five or even of four years is of inconvenient length, it would be very desirable for the scientific student to obtain the privilege of passing Moderations as soon as he finds himself prepared for that examination, instead of passing it, as at present, at the end of the first year. The effect of this alteration would be, not to lower the standard of literary acquirement at present expected from him, but simply to give him the opportunity of showing, at the earliest period possible, that he can satisfy the requirements of that standard. The anticipation of a classical examination at the end of the first year not unfrequently altogether prevents a student from settling down with proper regularity to his scientific work; not to mention the obvious tendency of the arrangement to unduly lengthen the course of those students who, at first coming up, could pass both examinations without difficulty. It must be admitted that if this change were introduced, the University would combine, to a much greater degree than at present, the two advantages of maintaining the stringency of its literary requirements, and of leaving the scientific curriculum unfettered, almost from the commencement of the student's residence. But if, as we have already recommended, a "Leaving Examination" should be instituted in connexion with the University, it would seem certain that the most satisfactory mode of securing these two objects conjointly would be to require

in that examination whatever amount of literary attainment might be thought desirable ; so that the scientific student who had shown the requisite literary proficiency in the "Leaving Examination" would find himself absolutely free, except so far as the examination in Divinity is concerned, from the first moment of his entrance to the University, to devote his whole time and energy to his scientific studies. And we are of opinion that any system which does not concede, from the first, this freedom to those students of science who have given proofs of sufficient literary acquirements, involves an interference with their course of study which in many cases is prejudicial.

15. In the University of Cambridge a wide option as to choice of subjects of study on the part of the students already exists. After passing the "Previous Examination" including certain additional subjects for candidates for honours, such students are free to devote themselves entirely to that branch of study in which they aspire to honours ; and should they succeed in obtaining them, or even be declared by the examiners to have answered sufficiently well to deserve an ordinary degree, they may obtain their degree without the necessity of reverting to any other branch of study. And the tendency which of late years has existed to allow a student to pass the previous examination at a continually earlier period of his course has culminated in a regulation recently passed whereby he can present himself for examination even in his first term of residence. By a regulation similar to that existing at Oxford, a Student of Natural Science who obtains honours in either mathematics or physics may offer himself for examination for honours in natural science a year later than the normal time.

16. It will be seen, from what has been said, that the arrangements of the University of Cambridge do allow, and those of the University of Oxford might, without much difficulty, be so modified as to allow, nearly complete freedom to scientific students. On the other hand, it is important to bear in mind that, if we except the requirement at Cambridge of Elementary Mechanics, nothing is done, at any part of the course in either University, to exact from all students alike any knowledge, however small, of the elements of the sciences of experiment and observation. Such obligatory subjects of study appear to be viewed with increasing disfavour by the authorities in the Universities. Nor is the reason far to seek. It is found that while work which a student chooses for himself is well done, that which he is forced to do, and does against the grain, is ill done, and is comparatively unprofitable to him. Indeed, if the Universities are left to themselves in the matter, it is much more probable that the literary tests now required from scientific students will be lowered, it may be even beyond what is desirable, than that any new requirement of a *minimum* of scientific knowledge will be imposed on Students of Classics, or Divinity, or Laws. For a body of teachers to maintain such a requirement would be very difficult, on account of the intense repugnance with which it would be regarded by a large number of the best students. If, in spite of the traditions of three centuries, it has become an open question whether Greek should be a compulsory subject of University education, it may well be considered that it would be difficult, if, indeed, it were desirable, to give an obligatory character to any other study. In all recent changes in the system of University teaching and University examinations, it is impossible not to recognise a tendency in the direction of that complete freedom of study which is so ably advocated in the evidence of Mr. Pattison ; nor can we escape the conclusion that this tendency will receive and ought to receive yet further development. We think, therefore, that the literary student should retain a freedom of choice similar to that which we have already insisted on as being of the first importance to the student of science. But, just as we should require the student of science to give evidence, in his "Leaving Examination," of sufficient literary culture, so we should expect the student of literature to give proof of corresponding scientific knowledge in the same examination ; failure to pass the examination involving, in the case of both classes of students alike, not exclusion from the University, but only the obligation to pass an equivalent examination at some subsequent period of the University course.

17. Should the Universities ultimately adopt the principle of allowing the student, on his first coming into residence, to choose for himself the branch of study to which he will devote himself, it is earnestly to be hoped that when that time arrives, the state of secondary education in the schools of the country may be such as to enable the student to exercise his choice with intelligence and discrimination. Some opportunity should have been afforded to him, during his work at school, of acquainting himself, to a certain degree, with the objects and methods of more than one of the typical branches of human knowledge. Unless some such breadth of view has presided over the teaching given to the student at school, the best-intentioned youth, when he comes to the University, is only too likely to run on in the old grooves of his school training, and, from the mere influence of habit, to forego the exercise of a well-advised choice between

the different lines of study that are put before him. It must always be remembered that up to a certain point in the pupil's development, the subjects of education are of necessity compulsory, and must be selected by the teacher for him; and while it is desirable that when this point is once passed, a wide latitude of selection should be allowed to the student, it is of no less importance that the compulsory subjects, in which he receives his previous training, should be rightly chosen for him. It is not easy to see how the Universities can retain any influence or control over that previous training if they allow themselves to become great schools of highly specialized branches of knowledge, without insisting, in the case of all their students alike, on certain elementary attainments which ought to be the common property of all educated men. Such influence and control over secondary education is an important function of the Universities, and we are of opinion that they ought to justify their claim to it by requiring certain definite literary and scientific attainments from all their students alike; although it should be left to the student himself to determine whether he will offer evidence of these attainments before entering the University, or as soon after entering it as he may see fit.

18. The separation of the scientific curriculum from the literary one, which, at both Universities, has almost become an accomplished fact, has given rise to the suggestion that in the case of science students, degrees in science might be taken in the place of degrees in arts. So far as the proposed substitution of the degree of Bachelor of Science for the present degree of Bachelor of Arts is concerned, the opinion of the witnesses whom we have examined does not appear to be favourable to the change. While attributing the utmost importance to the independent existence of a scientific curriculum, they regard the institution of separate degrees in science as a matter of very subordinate interest, and as turning, in fact, on the value likely to be attached to a new name in comparison with an old one. Viewing the matter in this light, they apprehend that it might be a positive disadvantage to the science students to give them the degree of Bachelor in Science instead of the old degree in Arts, the position of which, in the eyes of the public, has been established by long lapse of time. Moreover, there is reason to believe that the science students themselves would not care to see a line drawn between them and their fellow students in classics and literature.

19. These objections, however, do not apply to the institution of higher degrees in science, to be obtained only after the ordinary degree in arts. And it has been suggested, though not by witnesses specially connected with Oxford or Cambridge, that the older Universities might, at no very distant period, imitate the example of the University of London, by instituting a Doctorate in Science; requiring, however, that candidates for this degree should not merely show proficiency of knowledge as tested by examination, but should also offer some original contribution to science. We shall return to this suggestion, to which we attach much importance.

#### IV.—Proposed University Scholarships in Natural Science.

20. We are also of opinion that, in addition to the College Scholarships, University Scholarships in Natural Science should be founded at both Universities; scholarships comparable to those which already exist for various branches of classical learning, and, at Oxford, of mathematical science.

21. At Oxford the Hertford Scholarship for Latin Literature and the Ireland Scholarship for Greek and Latin, of which the first is accessible to candidates who have not been matriculated for more than two years, and the second to candidates who have not been matriculated for more than four years, have been found of the greatest use in maintaining a high level of Greek and Latin scholarship among the candidates for honours in the University. The same service is rendered to Mathematics by the Junior Mathematical Scholarship, for which candidates can compete until the end of their second year, and by the Senior Mathematical Scholarship, which is intended for students who have already taken their degree. It must be remembered that in the University of Oxford the examinations for honours are not competitive; and although there is no evidence before us to show a desire on the part of the University to abandon its present system, and to adopt a competitive one instead, it is felt that the introduction of the principle of competition by means of the examinations for the University Scholarships, reacts in a most favourable manner upon the examinations for degrees; and that the standard of merit to be expected from a candidate for a first class in the classical and mathematical examinations is maintained by means of the competition for the scholarships at a higher level than in all probability it would otherwise attain.

22. To carry out this principle with reference to the examinations in science, we should wish to see three University Scholarships offered every year; one in Physics, one in Chemistry, and one in Biology. It would probably be desirable to fix the time up to which candidates might compete for these scholarships somewhat late in the academical course. The prospect of obtaining an University Scholarship is so great an incentive to exertion, and the honour, quite apart from the pecuniary value, is so highly prized, that we should expect a considerable impulse to be thus given.

23. In connexion with this proposal it may be proper to mention three Foundations which already exist and which have for their object the encouragement of certain special branches of scientific study: (1) The Radcliffe Travelling Fellowships, of the value of 200*l.* per annum for three years, of which one is filled up every year by a competitive examination in Medicine. Candidates are required to declare that they intend to graduate in medicine and to travel abroad with a view to their improvement in that study; but if no candidate of sufficient merit complies with these conditions, the competition is thrown open to all candidates who have satisfied certain other academical requirements. (2) The Burdett Coutts Scholarships for Geology, of which one is offered every year, the subjects of examination being geology generally, and so much of experimental physics, chemistry, and biology as is necessary for the understanding of geological science. Candidates must have passed all the examinations required for the degree of Bachelor of Arts. (3) The Johnson Memorial Medal, which is awarded once in every four years for an Essay on some prescribed Astronomical or Meteorological subject.

Although all of these foundations appear to us useful in their different directions, they cannot be regarded as rendering the same services to scientific education which might be expected from the three University Scholarships which we should desire to see founded.

24. At Cambridge the system of arranging the names of those who obtain honours in the various triposes in order of merit renders the competition so keen in the cases of mathematics and classics, for which Honour Triposes have long been established, that in these subjects the additional stimulus of University Scholarships seems hardly required. There are various University Scholarships for Classics, but none for Mathematics, and yet there is no lack of energy in the prosecution of mathematical study. Indeed, until lately the Mathematical Tripos was much more popular than the Classical, notwithstanding the disadvantage at which mathematics were placed as compared with classics in respect to University Scholarships: of late the numbers on the two lists have been more nearly equal. The Natural Sciences Tripos has not hitherto proved nearly so attractive. We think that until its position is more firmly established, the establishment of University Scholarships for Natural Science would foster its growth.

25. At Cambridge, as at Oxford, certain Foundations exist having for their object the encouragement of Scientific Study or Research:—(1) Two Smith's Prizes are awarded annually to the two commencing Bachelors of Arts who are deemed the best proficient in Mathematics and Natural Philosophy. (2) The Adams Prize is offered every second year to the author of the best Essay on some subject of Pure Mathematics, Astronomy, or other branch of Natural Philosophy. (3) The Sedgwick Prize is offered every third year for the best Essay on some subject in Geology or the kindred sciences. (4) The pensions charged by Mr. Worts upon his estate for the remuneration of two Travelling Bachelors of Arts, have been converted into a fund from which the University may make grants from time to time, by Grace of the Senate, for the promotion or encouragement of investigations in foreign countries.

Of these foundations the first is so far blended with the Mathematical Tripos that it seems to exert little independent influence; the second and third are rather of a nature to reward study, pursued subsequently to the regular Academical Course, than to operate as a stimulus to undergraduates; the fourth is exceedingly wide in its scope, and rather enables the University to carry out, from time to time, certain desirable objects than acts directly as a stimulus to exertion. Hence none of these foundations, useful as they are in their way, fulfil in any degree the office of an University Scholarship.

## II.—THE PROFESSORiate.

26. Our attention has been especially directed to the following questions relating to the Professoriate:—

I. What should be the number of Professors, and with what assistance should they be provided?

II. What duties should be assigned to them, with special reference to the question whether both teaching and original research should be included in those duties?

III. What should be the mode of their appointment?

IV. What should be their emoluments, and how should such emoluments be provided?

V. Should a Council of Science be organized for University purposes?

## I.—Present and Proposed Professoriate.

## (A.) PRESENT SCIENTIFIC TEACHING STAFF AT OXFORD.

*Existing Professorships.*

27. The following is a schedule of the Scientific Professorships in the University of Oxford:—

Regius Professorship of Medicine	- - -	Founded temp. Henry VIII.
Savilian Professorship of Geometry	- - -	1619.
" " of Astronomy	- - -	1619.
Sedleian Professorship of Natural Philosophy	- - -	1621.
Professorship of Botany	- - -	1622.
" " of Experimental Philosophy	- - -	1749.
Professorship of Clinical Medicine	- - -	1780.
Professorship of Mineralogy	- - -	1813.
" " of Geology	- - -	1818.
Waynflete Professorship of Chemistry	- - -	1854.
Linacre Professorship of Physiology	- - -	1857.
Hope Professorship of Zoology	- - -	1861.

28. Certain older Professorships have now disappeared: thus the Aldrichian Professorship of the Practice of Medicine is now united with the Regius Professorship of Medicine, but although the Clinical Professorship is at present held by the Regius Professor of Medicine, the two offices are not united.

The Tomlins Prælectorship of Anatomy and the Aldrichian Professorship of Anatomy are now united with the Linacre Professorship, their joint stipends being charged with the salary of a Demonstrator of Anatomy, who is also Keeper of the Physiological Collection in the University Museum.

The Aldrichian Professorship of Chemistry was suppressed at the time of the first appointment to the Waynflete Professorship in 1865, and its stipend is now applied to the payment of a Demonstrator of Chemistry.

Besides these two Demonstratorships of Anatomy and Chemistry, the University has also provided a Demonstrator of Experimental Philosophy.

*Instruction provided by the University.*

29. The following is a statement of the Professorial Lectures during the Academical year 1872-73.

Professor.	Subject.	Places, Days, and Hours.
MICHAELMAS TERM, 1872.		
Regius Professor of Medicine (H. W. Acland, D.M.).	Clinical Instruction at the Infirmary	The Radcliffe Infirmary, Tu., S.—11.
Savilian Professor of Geometry (H. J. S. Smith, M.A.).	Harmonic Properties of Figures -	The University Museum, M., F.—11.
Savilian Professor of Astronomy (C. Pritchard, M.A.).	Spherical Astronomy and Astronomical Instruments.	The University Museum, W., S.—11.
Sedleian Professor of Natural Philosophy (B. Price, M.A.).	Hydro-mechanics - - -	The University Museum, Tu., Th., S.—1.
Professor of Experimental Philosophy (R. B. Clifton, M.A.).	Optical Instruments and Physical Optics.	W., S.—12.
Professor of Botany (M. A. Lawson, M.A.).	Minute Anatomy of Plants; including Practical Demonstrations in Microscopical Manipulation.	The Herbarium, M., F.—1.15.
Waynflete Professor of Chemistry (W. Odling, M.A.).	The Succession of Chemical Ideas -	The University Museum, M., Th.—12.
Linacre Professor of Physiology (G. Rolleston, D.M.).	Explanatory and Catechetical Lecture Human Anatomy and Physiology, with special reference to Ethnology.	The University Museum, Tu.—11. The University Museum, M., F.—12.

Professor.	Subject.	Places, Days, and Hours.
Deputy of the Professor (E. Ray-Lankester, M.A.).	General Classification of the Animal Kingdom.	The University Museum, S.—1.
Professor of Geology (J. Phillips, D.C.L.).	The Successive Conditions of Land and Sea, taken in order of Geological Time.	The University Museum, M., W.—12.
Hope Professor of Zoology (J. O. Westwood, M.A.).	Structure and Classification of Articulated Animals.	The University Museum, Hours to be arranged.
Professor of Mineralogy (M. H. N. S. Maskelyne, M.A.).	—	—
LENT TERM, 1873.		
Regius Professor of Medicine -	Clinical Instruction - Sanitary Defects in a Village or Town; illustrating thereby the principles of General and Sanitary Administration.	The Radcliffe Infirmary, S.—10. On the spot, at times to be fixed.
Savilian Professor of Geometry, Sedleian Professor of Natural Philosophy.	Pure Geometry (in continuation) - Dynamics of Rigid Systems -	The University Museum, M., F.—11. The University Museum, Tu., Th., S.—1.
Savilian Professor of Astronomy	Ninth and Eleventh Sections of the Principia, and the Lunar and Planetary Theories.	The University Museum, Tu., W., S.—11.
Professor of Experimental Philosophy.	Optical Instruments and Physical Optics.	Physical Laboratory, University Museum, W., S.—12.
Professor of Botany - -	Continuation of subject begun last term.	The Herbarium, to be fixed.
Waynflete Professor of Chemistry.	The Succession of Chemical Ideas (in continuation).	The University Museum, M., Th.—12.
Demonstrator of Chemistry (W. W. Fisher, M.A.).	Elementary Organic Chemistry -	The University Museum, Tu., F.
Deputy of the Professor (W. F. Donkin, B.A.).	Elementary Inorganic Chemistry -	The University Museum, W., S.
Linacre Professor of Physiology	Nervous system - -	The University Museum, Tu., F.—12.
Deputy of the Professor -	General Classification of the Animal Kingdom.	The University Museum, S.—1.
Professor of Geology - -	Will assist Students in Geology <i>sine ulla solennitate</i> .	The University Museum, M., W.—12.
Hope Professor of Zoology -	Entomology: four Lectures—(1), Structure; (2), Transformations; (3), Economy; (4), Classification of Articulata.	The University Museum, F.—2.
Professor of Mineralogy -	—	—
EASTER TERM, 1873.		
Regius Professor of Medicine -	Clinical instruction (in continuation) Demonstration of sanitary defects in a village or town as illustrating general principles of sanitary administration.	The Radcliffe Infirmary, S.—10. To be fixed.
Savilian Professor of Geometry	Pure Geometry (a continuation of the courses given in Michaelmas and Lent Terms).	The University Museum, M., F.—11.
Savilian Professor of Astronomy Sedleian Professor of Natural Philosophy.	Problems in Applied Mathematics -	The University Museum, Tu., S.—1.
Professor of Experimental Philosophy.	Optical Instruments (conclusion of course).	The University Museum, W., S.—12.
Professor of Botany - -	Structural, Systematic, and Economic Botany.	The Herbarium, M., W., F.—11.
Waynflete Professor of Chemistry Demonstrator of Chemistry -	Elementary Organic Chemistry -	The University Museum, Tu., F.
Deputy of the Professor -	Elementary Inorganic Chemistry -	The University Museum, W., S.
Linacre Professor of Physiology	The Circulation - - -	The University Museum, Tu., F.—12.
Deputy of the Professor -	General Classification of the Animal Kingdom.	The University Museum, S.—1.
Professor of Geology -	Theoretical Geology. Interior of the Earth. Land and Sea. Physical Geography. Succession of life. Geological Time.	The University Museum, M., W.—12.
Hope Professor of Zoology -	Will not lecture, but will see gentlemen desirous of advice and direction in the study of Zoology daily.	The University Museum—Every day between 1 and 4 p.m.
Professor of Mineralogy - -	Minerals of Lithological importance -	The University Museum, Tu., Th.—8 p.m.



30. In addition to these Professorial lectures, arrangements were made during the same Academic year for Practical Instruction in Anatomy and Microscopy in the work rooms of the Anatomical Department; in Chemistry and Physics, in the University Laboratories; in the detection of the adulterations of food, in the Laboratory of the Medical Department; in the use of Astronomical Instruments, in the Museum Observatory; and in Botany at the Botanical Garden.

*Instruction provided by the Colleges.*

31. In addition to the above courses of instruction which are provided by the University, a certain amount of scientific teaching is given in the Colleges. The lectures, enumerated in the lists which follow, are those which are advertised as public lectures, and which are understood to be accessible to all members of the University. A very large amount of private instruction, in addition to the lectures, is of course given by the lecturers in their respective colleges. There are several Mathematical Lecturers in the various colleges, besides those whose names appear in list (1.), but there are no College lecturers in Natural Science besides the Lee's Readers and those whose names appear in list (3).

(1.) COMBINED MATHEMATICAL LECTURES.

Subject	Lecturer.	Places, Days and Hours.
<b>MICHAELMAS TERM, 1872.</b>		
Higher Algebra (Determinants and Theory of Numbers).	H. J. S. Smith, M.A. -	Balliol, Tu, Th.—9 a.m.
Analytical Geometry (Modern Methods, &c.).	C. J. C. Price, M.A. -	Exeter, Wed, Fri.—a.m.
Differential Calculus (Geometrical Applications).	C. J. Faulkner, M.A. -	University, Wed., Fri.—10 a.m.
Integral Calculus (Higher Course)	H. J. S. Smith, M.A. -	Balliol, Th., Sat.—11 a.m.
Dynamics of a Particle	G. Edmundson, B.A. -	Brasenose, Tu, Th.—9 a.m.
Rigid Dynamics	W. Chadwick, M.A. -	Corpus Christi, Wed., Fri.—10 a.m.
Optics	C. J. Faulkner, M.A. -	University, Tu, Th.—12 a.m.
Problems in Pure Mathematics	W. Esson, M.A. -	Merton, Mon, Wed.—11 a.m.
Problems in Mixed Mathematics	W. Chadwick, M.A. -	Corpus Christi, Tu, Th.—10 a.m.
<b>LENT TERM, 1873.</b>		
Higher Algebra (Series).	C. J. C. Price, M.A. -	Exeter, Tu, Th.—9.
Methods of Projective and Reciprocal Polars.	W. Esson, M.A. -	Merton, Wed., Fri.—10.
Solid Geometry (Elementary)	W. Chadwick, M.A. -	Corpus Christi, Wed., Sat.—9
Calculus of Finite Differences	H. J. S. Smith, M.A. -	Balliol, Mon.—9.
Calculus of Variations	Ditto -	Balliol, Fri.—9.
Dynamics of a Particle	C. J. C. Price, M.A. -	Exeter, Wed., Fri.—11.
Hydrostatics	C. J. Faulkner, M.A. -	University, Tu, Th. 12.
Problems in Pure Mathematics	W. Esson, M.A. -	Merton, Tu, Th.—10.
Problems in Mixed Mathematics	W. Chadwick, M.A. -	Corpus Christi, Tu, Th.—9.
<b>EASTER TERM, 1873.</b>		
Analytical Geometry (General Equation of the second degree, &c.).	C. J. Faulkner, M.A. -	University, Tu, Th.—9.
Reciprocal Polars	W. Esson, M.A. -	Merton, Tu, Th.—10.
Higher Integral Calculus	H. J. S. Smith, M.A. -	Balliol, Mon., Fri.—9.
Dynamics of a Particle, (continued)	C. J. C. Price, M.A. -	Exeter, Tu, Fri.—10.

## (2.) LECTURES by DR. LEE'S READERS (Christ-Church).

Subject.	Reader	Places, Days and Hours.
<b>MICHAELMAS TERM, 1872.</b>		
The Elements of Inorganic Chemistry (as required for the Preliminary Honour Examination).	In Chemistry (A. G. Vernon-Harcourt, M.A.).	The Laboratory, Christ-Church, Tu., Th., Sat.—10.
Comparative Anatomy of the Higher Vertebrata.	In Anatomy (J. Barclay Thompson, M.A.)	The University Museum, Tu., Th., Sat.—11.
Heat - - - - -	In Physics (A. W. Reynold, M.A.).	The Laboratory, Christ-Church, M., W., F.—10.
<b>LENT TERM, 1873.</b>		
Inorganic Chemistry - - -	In Chemistry - - - -	The Laboratory, Christ-Church, Tu., Sat.—10.
Anatomy of the Vertebrata (continued from last term).	In Anatomy - - - -	The University Museum, Tu., Th., Sat.—11.
Heat (continued from last term)	In Physics - - - -	The Laboratory, Christ-Church.
<b>EASTER TERM, 1873.</b>		
Comparative Anatomy of the Vertebrata (continued from last term).	In Anatomy - - - -	The University Museum, Tu., Th., Sat.—11.
Electricity - - - - -	In Physics - - - -	The Laboratory, Christ-Church, M., W., F.—10.

## (3.) COMBINED LECTURES in NATURAL SCIENCE.

Subject.	Lecturer.	Places, Days and Hours
<b>MICHAELMAS TERM, 1872 (Merton, Magdalen, and Jesus Colleges).</b>		
The Outlines of Zoological Classification.	E. Chapman, M.A. - -	The Laboratory, Magdalen College—To be arranged.
The Facts on which the Modern Studies of Chemistry are founded.	T. H. G. Wyndham, M.A. -	Merton College Science Lecture Room, Tu., Sat.—9.
<b>LENT TERM, 1873 (Merton, Magdalen, and Jesus Colleges).</b>		
Outlines of Zoological Classification (in continuation).	E. Chapman, M.A. - -	Magdalen College Laboratory, M., W., F.—10.
Minerals which are of importance as the Constituents of Rocks.	T. H. G. Wyndham, M.A. -	Magdalen College Laboratory, Tues., Sat., at 9.
The Mineral of Coal and Saline Deposits.	- - - - -	- - - - -
The course will be in connexion with a practical class for the recognition of the Minerals mentioned in the lecture.	- - - - -	Mineralogical Laboratory, University Museum.
<b>EASTER TERM, 1873 (Merton, Exeter, New, Magdalen, and Jesus Colleges).</b>		
Outlines of Zoological Classification (concluded). On the Chemistry and Physiology of the Albuminates (commenced).	E. Chapman, M.A. - -	Magdalen College Laboratory, Mon., Wed.—10.
Typical Rock Specimens, continuation of course of last term.	T. H. G. Wyndham, M.A. -	Magdalen College Laboratory, Tu., Fri.—9.
The Cell Theory in relation to Animal Structure.	E. Ray-Lankester, M.A. -	Exeter College Laboratory, Mon., Wed.
Mechanics for the Preliminary Honour Examination.	C. E. Bickmore, B.A. -	New College, Mon., Th.—9.

32. It will be seen from these lists that (with the exception of Pure and Applied Mathematics) nearly the whole of the Science teaching in the University devolves upon the Professors and their Demonstrators. The two Professors of Pure and Applied Mathematics (the Savilian Professor of Geometry, and the Sedleian Professor of Natural Philosophy) occupy a position in some respects different from that of the other Professors, in consequence of the fact that a large amount of mathematical instruction is given in

the different Colleges by Mathematical Lecturers. Thus, the position of these two Professors with regard to the teaching of Mathematics in the University can hardly be said to be different from that which is held, for example, by the Professor of Greek, or of Latin, or of Moral Philosophy, with regard to the teaching of those subjects. Again, Christ-Church has the advantage of its three Lee's Readers in Physics, Chemistry, and Physiology; and in a few of the Colleges arrangements have been made for supplying the scientific students with a certain amount of tutorial assistance. But after making every allowance for the help thus afforded, the fact remains that the main responsibility of teaching Natural Science within the University is thrown upon the Professors. It is not surprising, therefore, that we have found a general agreement among the witnesses whom we have examined as to the necessity of increasing the number of University Teachers of Science. This necessity arises not so much from the number of students at present attending the courses, as from its being essential that all the principal scientific subjects should be properly represented, and that teaching in any one of them should be accessible to any student who may need it.

## (B).—PRESENT SCIENTIFIC TEACHING STAFF AT CAMBRIDGE.

*Existing Professorships.*

33. The following is a schedule of the Scientific Professorships in the University of Cambridge, and of the Demonstratorships attached to them:—

Regius Professorship of Physic	- - - -	Founded 1540.
Lucasian Professorship of Mathematics	- - - -	" 1663.
Professorship of Chemistry	- - - -	" 1702.
(A Demonstrator is appointed to the Professor of Chemistry.)		
Plumian Professorship of Astronomy and Experimental Philosophy	- - - -	" 1704.
Professorship of Anatomy	- - - -	" 1707.
(A Demonstrator is appointed to the Professor of Anatomy.)		
Professorship of Botany	- - - -	" 1724.
Woodwardian Professorship of Geology	- - - -	" 1727.
Lowndean Professorship of Astronomy and Geometry	- - - -	" 1749.
Jacksonian Professorship of Natural and Experimental Philosophy	- - - -	" 1783.
Downing Professorship of Medicine	- - - -	" 1800.
Professorship of Mineralogy	- - - -	" 1808.
Sadlerian Professorship of Pure Mathematics	- - - -	" 1863.
Professorship of Zoology and Comparative Anatomy	- - - -	" 1866.
(A Demonstrator is appointed to the Professor of Zoology and Comparative Anatomy.)		
Professorship of Experimental Physics	- - - -	" 1871.
(A Demonstrator is contemplated for the Professor of Experimental Physics.)		

*Instruction provided by the University.*

34. A tabular statement is appended of the lectures of the Scientific Professors for the Academical year 1872-3, extracted from the programme published by the Vice-Chancellor at the beginning of the October Term.

Professor.	Subjects.	Places, Days, and Hours.
<b>MICHAELMAS TERM, 1872.</b>		
Regius Professor of Physic (G. E. Paget, M.D.).	Clinical Medicine - - - -	Addenbroke's Hospital, M., W., Th., F.—10 a.m.
Professor of Chemistry (G. D. Liveing, M.A.).	Chemistry - - - -	Chemical Lecture Room, M., W., F.—12 m.
	Practical Chemistry - - - -	University Laboratory, M., W., F.—1 p.m.
Plumian Professor of Astronomy and Experimental Philosophy (J. Challis, M.A.).	Practical Astronomy and Magnetism - - - -	Astronom. Lect. Room, M., Tu., W., Th., F.—1 p.m.
Professor of Anatomy (G. M. Humphry, M.D.).	Anatomy and Physiology - - - -	New Museums, Tu, Th., S.—1 p.m.
	Practical Anatomy - - - -	Anatom. School, Daily.
Professor of Geology (Deputy of A. Sedgwick, LL.D.).*	Geology and Paleontology - - - -	Geol. Lect. Room, M., W., F.—12 m.
Jacksonian Professor of Natural and Experimental Philosophy (R. Willis, M.A.).	Mechanics and Mechanism - - - -	New Museums, M., Tu., W., Th., F.—1 p.m.
	The Steam Engine, &c. - - - -	

\* The Woodwardian Professorship of Geology, which became vacant by the death of Professor Sedgwick, is now filled by Mr. T. McK Hughes.

Professor.	Subjects.	Places, Days, and Hours.
Downing Professor of Medicine (Deputy of W. W. Fisher, M.D.).	Materia Medica and General Therapeutics.	Downing College, Tu., Th., S.—9 a.m.
Professor of Mineralogy (W. H. Miller, M.A.).	Elementary Crystallography - - -	Mineralogical Lecture Room, T., S.—12 m.
Sadlerian Professor of Mathematics (A. Cayley, M.A.).	Elliptic Functions - - -	New Museums, M., W., F.—12.15 p.m.
Professor of Zoology and Comparative Anatomy (A. Newton, M.A.).	Zoology and Comparative Anatomy - - -	New Museums, M., W., F.—1 p.m.
Professor of Experimental Physics (J. Clerk Maxwell, M.A.).	Heat and Elasticity - - -	Chemical Lecture Room, Tu., Th., S. 12 m.
LENT TERM, 1873.		
Regius Professor of Physic -	Principles and Practice of Physic -	Anatomical School, M., W., F.—9 a.m.
Professor of Chemistry -	Chemistry - - - -	Chem. Lect. Room, M., W., F.—12 m.
	Practical Chemistry - - -	
Professor of Anatomy -	Practical Anatomy - - -	Anatom. School, daily.
Lowndean Professor of Astronomy (J. C. Adams, M.A.).	Anatomy and Physiology - - -	New Museums, Tu., Th., S.—1 p.m.
	The Figure of the Earth - - -	New Museums, Tu., Th., S.—12.15 p.m.
Professor of Mineralogy -	Crystallography and Mineralogy -	Mineral. Mus., M., Tu., W., F., S.—1 p.m.
Professor of Zoology and Comparative Anatomy.	Zoology and Comparative Anatomy -	New Museums, M., W., F.—1 p.m.
Professor of Experimental Physics.	Electrostatics and Electrokinetics -	New Museums, M., W., F.—12 m.
EASTER TERM, 1873		
Lucasian Professor of Mathematics (G. G. Stokes, M.A.).	Hydrostatics, Hydrodynamics, and Optics.	New Museums, M., Tu., W., F., S.—1 p.m.
Professor of Chemistry -	Chemistry (Special Departments) -	Chem. Lect. Room, M., W., F.—12 m.
	Practical Chemistry - - -	
Professor of Botany (C. C. Babington, M.A.).	Botany - - - -	Bot. Lect. Room, M., Tu., Th., F.—1 p.m.
Downing Professor of Medicine (Deputy).	Materia Medica and General Therapeutics.	Downing College, M., W., F.—9 a.m.
Professor of Experimental Physics.	Electromagnetism - - -	New Museums, M., W., F., 12 m.

35. In considering the list of the scientific Professors' lectures, it must be remembered that Pure and Applied Mathematics have for a long time been zealously studied at Cambridge. The Mathematical Tripos was in existence long before the Classical Tripos was established, and even after its establishment continued for many years to form the chief road to academical distinction. These subjects are accordingly taught, at least in all their ordinary branches, in every College. The Mathematical Professors being thus relieved from all elementary teaching, their lectures are devoted to some of the higher branches, followed only by the more advanced students, and are not, for the most part, of a nature to attract large classes. And, as the information to be obtained in a professor's lecture does not come and ought not to come in a shape in which it is immediately available for rapid production in a written examination, it does not seem probable, considering the keenness of the competition for high places on the Mathematical Tripos, that students would be willing to interrupt their more direct preparation for examination by attending numerous courses of professors' lectures. Whether the influence which this examination exerts on the studies of the students may not be excessive, is a question which seems to deserve the serious attention of the University.

*Instruction provided by the Colleges.*

36. In addition to these courses of instruction which are provided by the University, a certain amount of scientific teaching, available beyond the limits of individual Colleges, is given by certain Colleges which have combined into groups, as shown in the subjoined lists. These Lectures are open to the students of the respective groups of Colleges, either gratuitously or on payment of a certain fee; but other Matriculated Students of the University may attend on payment of a fee, or of an increased fee, as the case may be.

## (1.) INTER-COLLEGIATE LECTURES.

Subject.	Lecturer.	Places, Days, and Hours.
<b>MATHEMATICS.</b>		
<b>MICHAELMAS TERM, 1872.</b>		
Analytic Geometry - - -	Mr. Caldwell - - -	Corpus Christi College, T., Th., S.—10 to 11.
Differential Calculus - - -	Mr. Miller - - -	S. Peter's College, M., W., F.—10 to 11.
Solid Geometry - - -	" - - -	S. Peter's College, T., Th., S.—10 to 11.
Rigid Dynamics - - -	Mr. Pirie - - -	Queen's College, M., W., F.—10 to 11.
Statics - - -	Mr. Stephen - - -	Corpus Christi College, M., W., F.—9 to 10.
<b>NATURAL SCIENCE.</b>		
Comparative Anatomy and Physiology	Dr. Bradbury - - -	Downing College, T., F.—9 to 10.
Chemistry - - -	Mr. Lewis - - -	Downing College, M., W., S.—9 to 10.
<b>MATHEMATICS.</b>		
<b>LENT TERM, 1873.</b>		
Differential and Integral Calculus -	Mr. Caldwell - - -	Corpus Christi College, T., Th., S.—10 to 11.
Diff. Equat. (one independent variable)	Dr. Campion - - -	Queen's College, T., Th.—11 to 12.
" " (two or more independent variables.)	" - - -	Queen's College, W., Th.—11 to 12.
Statics (advanced) - - -	Mr. Miller - - -	St. Peter's College, T., Th., S.—10 to 11.
Optics - - -	Mr. Pirie - - -	Queen's College, M., W., F.—10 to 11.
Thermo-dynamics - - -	" - - -	Queen's College, T.—9 to 10.
Lunar Theory - - -	Mr. Porter - - -	St. Peter's College, T., Th.—9 to 10.
Plane Analytic Geometry (advanced) -	Mr. Stephen - - -	Corpus Christi College, M., W., F.—9 to 10.
<b>NATURAL SCIENCE.</b>		
Comparative Anatomy and Physiology	Dr. Bradbury - - -	Downing College, M., W., F.—9 to 10.
Chemistry - - -	Mr. Lewis - - -	Downing College, T., Th., S.—9 to 10.
<b>MATHEMATICS.</b>		
<b>EASTER TERM, 1873.</b>		
Elementary Optics - - -	Mr. Caldwell - - -	Corpus Christi College, T., Th., S.—10 to 11.
Astronomy - - -	Dr. Campion - - -	Queen's College, T., Th., S.—11 to 12.
Hydro-mechanics - - -	Mr. Miller - - -	S. Peter's College, T., Th., S.—10 to 11.
Dynamics of a Particle	Mr. Pirie - - -	Queen's College, M., W., F.—9 to 10.
Newton, §§ I., II., III. - - -	Mr. Porter - - -	St. Peter's College, T., Th.—9 to 10.
Hydrostatics - - -	Mr. Stephen - - -	Corpus Christi College, M., W., F.—9 to 10.
<b>NATURAL SCIENCE.</b>		
Chemistry - - -	Mr. Lewis - - -	Downing College, T., F.—9 to 10.
Botany - - -	" - - -	Downing College, W., S.—9 to 10.

(2.) LECTURES IN THE NATURAL SCIENCES.

Open to Students of Trinity, St. John's, and Sidney Sussex Colleges.

Subject.	Lecturer.	Places, Days and Hours.
<b>MICHAELMAS TERM, 1872.</b>		
Electricity and Magnetism - - -	Mr. Trotter - - -	Trinity College, M., W., F.—11.
Chemistry (including instruction in Practical Chemistry).	Mr. Main - - -	St. John's College Laboratory, T., Th., S.—12.
Palaontology (the Protozoa and Cœlenterata).	Mr. Bonney - - -	St. John's College, T., Th.—9.
Geology (Preliminary matter and Petrology).	" - - -	St. John's College, M., W., F.—10.
Botany (Morphology of Phanerogamia)	Mr. Hicks - - -	Sidney Sussex College, T., Th., S.—11.
Physiology of the Organs of Sense -	Dr. M. Foster - - -	} New Museums.
Physiology (practical) - - -	" - - -	
<b>LENT TERM, 1873.</b>		
Electricity and Magnetism for Natural Sciences Tripos.	Mr. Trotter - - -	Trinity College, M., W., F.—11.
Electricity and Magnetism for first part of Natural Sciences Tripos, and special examination for the ordinary degree.	" - - -	Trinity College, T., Th., S.—11.
Chemistry (including practical instruction).	Mr. Main - - -	St. John's College Laboratory, T., Th., S.—12.
Palaontology (the Anneloids) - - -	Mr. Bonney - - -	St. John's College, T. Th.—9.
Geology - - - - -	" - - -	St. John's College, M., W., F.—10.
Elementary do. - - - - -	" - - -	St. John's College, T., Th.—11.
Botany (Vegetable Histology and Physiology).	Mr. Hicks - - -	Sidney Sussex College, T., Th. S.—11.
Physiology of the Senses - - - -	} Dr. M. Foster - - -	New Museum { M., W.—1. Th.—11. T.—11.
Practical Physiology - - - - -		
Advanced Practical Histology - - -		
<b>EASTER TERM, 1873.</b>		
Heat (advanced) - - - - -	Mr. Trotter - - -	Trinity College, M., W., F.—11.
" (elementary) - - - - -	" - - -	Trinity College, T., Th., S.—11.
Chemistry (including Practical Chemistry).	Mr. Main - - -	St. John's College, T., Th.—12.
Palaontology (the Mollusca, &c.) -	Mr. Bonney - - -	St. John's College, T. Th.—9.
Geology (advanced) - - - - -	" - - -	St. John's College, M., W., F.—10.
" (elementary) - - - - -	" - - -	St. John's College, T., Th.—11.
Botany (Cryptogamia and Classification).	Mr. Hicks - - -	Sidney Sussex College, T., Th., S.—11.
Biology (elementary) - - - - -	Dr. M. Foster - - -	New Museums, M., T., W.—11.

37. The Inter-Collegiate Lectures on Pure and Applied Mathematics contained in list (1) by no means represent the whole of the teaching on those subjects given by the Colleges. The lectures which the Colleges provide for their own students are not publicly advertised.

The students of Natural Science are at present much less numerous than those of Mathematics, so that it is not probable that an individual College would establish lectures in a branch of Natural Science merely for its own students. Thus the lists of lectures given may be taken as fairly representing the amount of teaching in Natural Science which is given outside the Professoriate.

These lectures for the most part are on the footing of ordinary College lectures, but the position of the Trinity Prælector of Physiology closely resembles that of an University Professor. He is allowed by the University the use of a room in the New Museums for a temporary laboratory, and his lectures are open to all members of the University.

(C.) COMPARISON WITH THE INSTRUCTION PROVIDED BY THE UNIVERSITY OF BERLIN.

38. In comparison with the lists of Professors and Lectures in the two Universities which we have given, we would place the following list of the Scientific Professors and Scientific Lectures in the University of Berlin. As this list does not include the lectures given by the Faculty of Medicine, the principal courses on Anatomy and Physiology are not included. It may also be observed that the list conveys the impression that the organisation of the instruction is in some respects incomplete; for example, while the supply of lectures in Chemistry may be said to be profuse, there is not a single lecture in the Philosophical Faculty on any part of Electricity, theoretical or practical. But, notwithstanding this and some other obvious defects, it is impossible not to be impressed with the evidence which

the list affords of the abundance and variety of the scientific teaching given in the University of Berlin by Professors of great eminence. We would particularly call attention to the fact that the list includes not merely general courses adapted to the requirements of those students who are interested in science only as a part of a liberal education, but also special courses on subjects taken from some of the newest and most interesting fields of scientific inquiry; so that instruction of the kind most likely to develop a scientific spirit in the mind of the learner, and given by the most competent teachers, is put within the reach of every student.

LIST of the SCIENTIFIC LECTURES announced to be given in the UNIVERSITY OF BERLIN in the ACADEMICAL YEAR, 1872-73

Lecturer.	Subject	Days and Hours.
<b>MATHEMATICAL SCIENCES.</b>		
<b>WINTER SEMESTER.</b>		
Oct. 16, 1872—Mar. 29, 1873.		
Prof. Kummer -	Theory of Numbers - - -	M., Tu., Th., F.—10-11.
Dr. Kronecker -	Theory of Algebraic Equations - - -	W., Th., Sat.—11-1
Prof. Thomé -	Differential Calculus - - -	M., Tu., Th., F.—9-10.
Prof. Weierstrass -	Theory of Elliptic Functions - - -	M., Tu., F.—11-1
Dr. Pockhammer -	Select Portions of the Theory of Partial Differential Equations.	M., Tu., Th., F.—9-10.
Dr. Hoppe -	Analytical Geometry - - -	M., Tu., Th., F.—2-3.
Ditto -	Integral Calculus - - -	M., Tu., Th., F.—3-4
Prof. Thomé -	Select Portions of Analytical Mechanics, particularly the Hamiltonian Theory.	W., Sat.—9-10.
Prof. Forster -	Method of Least Squares - - -	M., Tu., Th.—1-2.
Ditto -	Select Portions of Celestial Mechanics - - -	Tu.—12-1; F.—1-2.
Dr. Tietjen -	Determination of the Orbits of the Heavenly Bodies.	Tu., Th., F.—3-4.
Ditto -	Exercises in Astronomical Computations - - -	Twice a week, at hours to be fixed.
<b>NATURAL SCIENCES.</b>		
Prof. Du Bois-Reymond -	On Some Results of the Recent Developments of Natural Science.	Monday—6-7.
Prof. Pogendorff -	General History of Physics, from Galileo to the Present Time.	Wed., Sat.—11-12.
Prof. Helmholtz -	Theoretical Physics (using the Elements of the Differential Calculus).	M., W., F.—2-3.
Prof. Dove -	Experimental Physics - - -	Daily, except Saturday—12-1.
Prof. Eiman -	Terrestrial Physics; or, Mathematical and Physical Explanations of Geographical Phenomena.	Tu., Th., F.—11-12.
Prof. Dove -	Meteorology - - -	Tuesday—6-7
Prof. Helmholtz -	Acoustics and the Physiological Theory of Music - - -	M., Tu., F.—3-4
Dr. Warburg -	Theory of Heat - - -	M., Tu., W., F.—4-5
Dr. Sell -	The recent History of Chemistry - - -	Once a week, at an hour to be fixed later.
Prof. Sonnenschein -	The History of Chemistry - - -	Wednesday—6-7.
Prof. Rammelsberg -	The first part of Inorganic Chemistry (with experiments)	Daily (the hour to be fixed later).
Dr. Pinner -	Theoretical Chemistry - - -	Saturday—4-5.
Prof. Schneider -	Organic Chemistry, with special reference to Medicine and Pharmacy.	Daily, (except Saturday)—8-9.
Dr. Liebermann -	Organic Chemistry (second part) - - -	Four times a week.
Dr. Oppenheim -	Organic Chemistry (with experiments) - - -	Daily except Tuesday—5-6.
Dr. Pinner -	Organic Chemistry - - -	Five times a week (hours to be fixed).
Prof. Hofmann -	Experimental Chemistry - - -	Tu., W., Th.—9-11.
Prof. Rammelsberg -	Chemical Nature of Minerals - - -	Saturdays—5-7.
Do. -	Chemical Principles of Metallurgy - - -	Twice a week.
Dr. Liebermann -	Chemistry and Technology of Dyeing - - -	Twice a week (hours to be fixed).
Dr. Oppenheim -	Poisons and their Detection in the Body (for Medical and Pharmaceutical Students), illustrated by experiments.	Saturday—4-5.
Prof. Schneider -	The Organic Bases - - -	Saturday—8-9.
Prof. Sonnenschein -	Forensic Chemistry (with experiments) - - -	Three times a week (hours to be fixed).
Do. -	Chemical Conferences - - -	Hours to be fixed.

Lecturer.	Subject.	Days and Hours.
Prof. G. Rose	Mineralogy	Daily—12-1.
Do.	Crystallography	Sat.—10-11.
Dr. Sadebeck	Mineralogical Topography of Germany	Sat.—6-7.
Do.	Mineral substances employed in the Arts	F., Sat.—2-4.
Prof. Roth	General and chemical Geology	Tu., F.—2-3
Dr. Kayser	General Geology	Three times a week (hours to be fixed).
Dr. Lossen	Petrography	M., Th., F.—11-12; Tu.—11-1.
Do.	Petrographical Exercises on the Determination of Rocks, in the Museum of the Academy of Mines.	Th.—12-1.
Prof. Beyrich	Palaontology	Daily (except Saturday), 10-11.
Do.	Geognosy (with special reference to the stratified rocks).	W., F.—2-4.
Prof. Koch	General Botany ( <i>i.e.</i> , History of the Development of the Vegetable Kingdom).	M., Th.—5-7.
Prof. Braun	Special Botany, on the Natural System, with special reference to Plants of Medicinal and Economical importance.	Daily (except Saturday)—8-4.
Do.	Botanical Conference	F.—6-7.
Dr. Kny	On the Anatomy and Development of Plants, with microscopic demonstrations.	M., Th., Sat.—8-9.
Dr. Ascherson	Geographical Distribution of Plants	W., Sat.—6-7.
Prof. Garcke	Pharmacology	M., F.—9-11.
Do.	Official Plants	W., Th.—2-3; Sat.—9-11.
Do.	Official Resins	Once a week (hour to be fixed).
Prof. Peters	General and Special Zoology (with demonstrations in the Zoological Museum).	Daily—1-2.
Do.	Comparative Anatomy	Hours to be fixed.
Dr. Gerstaecker	General and Special Entomology (with microscopic demonstrations).	Three times a week, at hours to be fixed.
<b>MATHEMATICAL SCIENCES.</b>		
SUMMER SEMESTER, April 21—Aug. 15, 1873.		
Prof. Kummer	Theory of Curved Surfaces and Lines of Double Curvature.	M., Tu., Th., F.—10-11.
Prof. Weierstrass	Elements of Modern Synthetic Geometry Use of Elliptic Functions in Select Geometrical and Mechanical Problems.	M., F.—11-1. M., Th.—11-1.
Prof. Förster	Spherical Astronomy and Theory of Instruments, with Astronomical Exercises	M., Tu., Th., F.—1-2.
Prof. Thomé	Fourier's Series Integral Calculus	W., Sat.—9-10. M., Tu., Th., F.—9-10.
Dr. Hoppe	Differential Calculus and Theory of Series	M., Tu., Th., F.—2-3
Ditto	Analytical Mechanics	M., Tu., Th., Sat.—3-4.
Ditto	Elliptic Functions	Tu., F.—5-7.
Dr. Pochhammer	Select Portions of the Theories of Elasticity, and of Small Oscillations.	W.—10-12.
Dr. Thetjen	Correction of the Orbits of the Heavenly Bodies with Reference to the Perturbations.	M., Tu., Th., F.—3-4.
Ditto	Exercises in Astronomical Computations	Twice a week at hours to be fixed.
<b>NATURAL SCIENCES.</b>		
Professor Dove	Optics, with Experimental Illustrations	M., F.—5-6.
Prof. Helmholtz	Experimental Physics	M., W., F., 12-2, Sat.—11-12.
	Mathematical Optics	W., Th., Sat.—9-10.
Prof. Erman	Theory of Geographical and Geographico Physical Observations.	W., Th., F.—9-10.
Prof. Poggendorff	Physical Geography	—
Prof. Hofmann	Organic Chemistry	M.—9-11; Tu., W.—10-12.
Prof. Rammelsberg	Chemical Principles of Geology Second Part of Inorganic Chemistry	Once a week. Six times a week.
Prof. Schneider	Iron, Nickel, Cobalt Experimental Inorganic Chemistry	Sat.—6-7 a.m. Daily—8-9.



Lecturer.	Subject.	Days and Hours.
Dr. Liebermann	- Conference on the most recent Chemical Investigations.	Twice a week at hours to be fixed.
Dr. Pinner	- Organic Chemistry (First Part) - - -	Th., Sat.—10-12.
Do.	- Analytical Chemistry - - -	Hours to be fixed.
	- Inorganic Chemistry - - -	Daily—8-9.
	- Inorganic Part of Pharmacology - - -	Three times a week at hours to be fixed.
Dr. Oppenheim	- General and Theoretical Chemistry - - -	M.—11-12.
	- Chemical Toxicology - - -	Sat.—12-2.
	- Chemical Technology, with Experiments - - -	W., T.—12-2.
Dr. Sell	- Inorganic Chemistry, with Experiments - - -	Four times a week at hours to be fixed.
Prof. Sonnenschein	- Analytical Chemistry (with experiments) - - -	Three times a week at hours to be fixed.
Do.	- Chemical Conferences - - -	Hours to be fixed.
Professor G. Rose	- Outlines of Mineralogy - - -	M., W., F.—12-1.
Prof. Roth	- Select Portions of Geology - - -	Twice a week at hours to be fixed.
Prof. Braun	- On the Natural System of Plants (with occasional Botanical excursions). General Botany (the Morphology and Physiology of Plants), with Demonstrations in the Botanical Gardens.	W.—5-6. Daily—7-8
Professor Koch	- Economical Botany (with demonstrations in the Botanical Garden).	M., W.—5-7, p.m.
Do.	- Vegetable Physiology (with experiments) - - -	Tu., Th., F.—8-9.
Prof. Peters	- General and Special Zoology (with Repetitions) - - -	Daily—1-2.
Do.	- Comparative Anatomy - - -	Hours to be fixed
Dr. Gerstaecker	- Insects Beneficial or Injurious to Agriculture - - -	W., Sat.—8-9.
Do.	- The Morphology, Anatomy, Development, and Natural History of the Articulata, with Microscopic Demonstrations.	Three times a week, 8-9.
Dr. Mertens	- The Mollusca of Germany - - -	W., Sat.—9-10.
Do.	- General and Special Conchology (with occasional Excursions).	M., Tu., Th., F.—5-6.

39. Besides these courses of lectures the following arrangements for practical work were carried on throughout the academical year.

The Physical Laboratory of the University was open daily from 10 to 4 for practical work, under the direction of Professor Helmholtz.

Theoretical and practical exercises in Optics, and other parts of Mathematical Physics, were conducted by Professor Erman in his laboratory, on Wednesdays from 11 to 12, and at other times to be agreed upon later.

Practical work in Chemistry, under the direction of Professor Hofmann, daily from 9 to 5 (on Saturdays from 9 to 2).

Practical work in Chemistry, under the superintendence of Professor Sonnenschein in his laboratory daily from 8 to 12 and from 2 to 6.

Chemical investigations under the direction of Professor Wichelhaus in his laboratory (daily).

Practical exercises in Organic Chemistry, under the direction of Dr. Liebermann, in the Laboratory of the Academy of Manufactures.

A "Repetition" in Inorganic and Organic Chemistry, in the form of a conference, illustrated by experiments, by Dr. Sell (four times weekly).

Exercises in Zoology and Zootomy, by Prof. Peters.

Botanical Investigations, under the direction of Professor Braun.

Anatomical and Physiological Investigations, under the direction of Dr. Kny.

Exercises on the determination and description of plants, by Dr. Ascherson.  
In addition to the above there were, in the Winter Semester :—

Repetitions in Organic and Inorganic Chemistry, by Dr. Pinner; and  
Introductory Exercises on the use of the Microscope, by Dr. Kny.

In the Summer Semester :

Mathematical Exercises under the direction of Professors Kummer and Weierstrass.

Practical Exercises in Mineralogy, by Dr. Bauer.

Practical work in Botany under the direction of Professor Garcke.

Botanical Excursions with Professor Garcke, and also with Dr. Ascherson.

40 The Principal of Owens College and Professor Roscoe (in a Report which was submitted by them to the Extension Committee of Owens College, and which is given at length in Professor Roscoe's Evidence before this Commission) have made some important observations with reference to a similar list (that of the Berlin lectures for the Summer Semester of 1868). "It is unnecessary to say that we do not set forth this list of teachers and lecturers as a pattern for us to follow in Owens College or in English Universities generally. We only desire to point out and emphatically to press the importance of the principle that the existence (in due proportions) of a plurality of teachers is an indispensable prerequisite both for breadth and depth of instruction. Where only one teacher is charged with one leading branch of study, it is barely within his power to provide the systematic teaching necessary for pass-men; whereas, if, as in German Universities, several teachers lecture concurrently on subdivisions of a subject, the more advanced students have the opportunity of studying more thoroughly some one section of their subject. The teachers are also induced, by the opportunity of lecturing on special subjects, to engage in profounder investigations; and thus that other aim of University institutions—the advancement of science and the promotion of a learned class—is furthered."

With the general tendency of these remarks we entirely concur; and although there is evidence to show that the scientific teaching at present supplied by the Universities has attained a high degree of excellence, so far as is compatible with the limits within which it has been confined, we are, nevertheless, of opinion, that it is inadequate in amount, and that due attention has not been paid to the principle that "the existence of a plurality of teachers is an indispensable pre-requisite both for breadth and depth of instruction."

#### (D) PROPOSED ADDITIONS TO THE SCIENTIFIC PROFESSORiate AT OXFORD.

41. At Oxford the position of the Chairs of Experimental Philosophy, of Chemistry, and of Physiology furnishes conclusive evidence that some further subdivision of the subjects must be introduced before the system of instruction can be regarded as having attained that standard of perfection which we have a right to expect in a great English University.

42. The Professor of Experimental Philosophy has the duty of teaching the subjects of Experimental Mechanics, Sound, Heat, Light, and Electricity; and it is impossible that any one man should give courses of lectures with sufficient frequency on all these parts of Physics. In a School of Science in which the teaching is completely organized it would be proper that in each year, or, at any rate, in each two years, an adequate course of lectures in each of these subjects should be open to every student. With only one professor to lecture in them it is impossible that the cycle can recur within four or even five years.

43. The extent of the subjects practically assigned to the Linacre Professor of Physiology is also far too great. Upon him devolves the duty of teaching the whole of the science of Biology, so far as the animal kingdom is concerned; the duties of the Hope Professor of Zoology being confined, partly by statute, and partly by custom, to the care of the Hope Collections, and to lecturing on certain parts of invertebrate zoology which are not admitted as fundamental subjects into the University examinations, and which, consequently, are not taken up by students who have to pass those examinations. The imperative necessity for a division of the subjects of the Chair of Physiology, and at least for the separation of the Anatomy from the Physiology, has been urged by the Linacre Professor, in his Evidence before this Commission, and also in a letter addressed to the Vice-Chancellor of the University of Oxford, which is printed at length in the Appendix to this Report, from which the following is an extract :—

"I will conclude by stating, in the third place, what, in the event of any larger plan being brought under consideration for the rearrangement of the several Chairs

“ connected with Biology, should, in my opinion, be the division of the subject. If it should be thought that the University should aim at developing the study of Biology mainly in relation to the purpose of general as opposed to that of professional education, and should lay weight, therefore, mainly upon the anatomical and morphological aspects of the subject, it is still no exaggeration to say, that the subject, even when thus limited, is now far too large to be entrusted to the care of any single professor. Two professors, one with the title and duties of Professor of Comparative Anatomy, Zoology, and Histology, the other with that of Professor of Human Anatomy and Physiology and Ethnology, ought at once to divide the field at present in charge of the Linacre Professor. The scientific appropriateness and the economical advantages of combining the subjects of Zoology, Comparative Anatomy, and Histology are sufficiently obvious. Ethnology again, or ‘ Anthropology,’ is a subject which, however vast and growing, is nevertheless one which the Professor of Human Anatomy and Physiology in Oxford should fairly be expected to deal with, if not from its historical and philological, still, at all events, from its Natural History side. The development within late years of collections illustrating this latter aspect of Anthropology is no less remarkable than that of literature treating of it from every point of view; and the establishment in Oxford of a professorship with such duties as those indicated would cause such collections to gravitate hither as being a place eminently fitted, by reason of the many and various departments of human knowledge, as of art, of history, and of ethics, represented within its precincts, to be a home for their preservation and utilization. But Biology would bear still further division with much advantage, and a third Chair should be established to represent and expound the Physiological as opposed to the Anatomical and Morphological division of Biology. With this Chair the Professorships of Medicine and the duties of teaching what has elsewhere been called the Institutes of Medicine might, I would suggest, be combined.”

44. We are disposed to go further than the Linacre Professor, While agreeing with him as to the necessity of charging one Professor exclusively with Physiology; another with Zoology including the Comparative Anatomy of both recent and fossil forms; and the geographical and geological distribution of animal; and a third with Anthropology and Ethnology; we must demur to the proposal to combine the Chair of Medicine with that of Physiology. The science of Physiology is more than enough to occupy the energies of any one man, however great his abilities, and the Professor of Medicine, as a practical physician, could not be expected to find time to keep up a real knowledge of any science save that of Medicine.

45. We would further suggest that provision should be made for the instruction of those members of the University who are unable or unwilling to undergo a complete technical training in Botany or Zoology, in the broad principles and large truths of Biological Science. For the purposes of general culture an acquaintance with the principles of Biology is of more importance than a knowledge of special Physiology, Zoology or Botany, nor is it of less moment that the Botanical, Zoological or Physiological Specialist shall have acquired a familiarity with those principles at an early period of his career. The establishment of a Chair of General Biology, with appropriate practical instruction, is probably the only means of attaining the object here indicated.

46. As a Chair of Botany already exists, there would thus be five chairs in the department of Biology. But if, as we shall hereafter recommend, Oxford should undertake to furnish the preliminary scientific discipline which is necessary for the student of Medicine, it will become necessary to establish, in addition, a special Professorship of Human Anatomy. This Chair, however, we should regard as belonging to the Faculty of Medicine, and not to the Department of Biology.

47. We do not think it would be necessary to require complete academical residence from the Professor of Anthropology and Ethnology. A full course of lectures on these subjects, delivered once a year, would probably suffice for the requirements of University students.

48. Again, in the case of Chemistry, it is of great importance that the cycle of lectures should recur each year; but considering the vast extent of the subjects which, in the present state of science, must be included in a chemical course, it is manifestly impossible that this should be effected by one professor. The courses have accordingly been hitherto chiefly biennial; and even with this extension of their duration, a large part of the science has inevitably been excluded from the syllabus.

49. It is not less evident that the Chairs of Pure and Applied Mathematics are over-weighted with the number of subjects assigned to them: it must however be remembered that the deficiency thus occasioned in the University teaching of these subjects is of less immediate consequence, on account of the instruction in them which is supplied by the Colleges.

50. Without, therefore, attempting to decide what should be the ultimate organisation of the Scientific Faculty in Oxford, we are of opinion that arrangements should be made at the earliest possible opportunity for the establishment of two Professorships in Physics and two in Chemistry, in addition to those already existing; for the redistribution of the Biological subjects (exclusive of those assigned to the Faculty of Medicine) in such a manner as to secure their being represented by five independent professors; and for the addition of two Chairs, one in Pure Mathematics and one in Mathematical Physics. Lastly, on grounds to which we shall hereafter refer, we are disposed to recommend the establishment of a Chair of Applied Mechanics and Engineering.

(E.) PROPOSED ADDITIONS TO THE SCIENTIFIC PROFESSORiate AT CAMBRIDGE

Qu. 4552.

51. In the University of Cambridge the whole of the Science of Chemistry in its now vast extent is represented by only one Professor. We think that Chemistry can not be represented with any approach to adequacy by fewer than two Professors, and that it would furnish ample occupation for three.

52. There are already four Professorships which are regarded as Mathematical, but it should be remembered that the care of the Observatory has from the first been attached to one of these. Two of these professorships are by the original foundations in part astronomical, and the care of the Observatory has naturally been associated with one of them. When it is remembered how totally different are the methods by which the results are arrived at in Physical and Practical Astronomy, it will be seen that there is ample room for two Astronomical Professorships, especially if the care of the Observatory is associated with one. The distribution which would abstractedly be the most desirable would evidently be that the care of the Observatory should be associated with the teaching of Practical Astronomy and Geodesy, while the other Astronomical Professor should represent Physical Astronomy. One of the Mathematical Professorships is expressly devoted to Pure Mathematics by the terms of its foundation; and in the application of Mathematics to certain branches of Physics other than Astronomical, there is sufficient occupation for a fourth Professor.

53. As to Experimental Physics, the Jacksonian Professorship is denominated a Professorship of Natural and Experimental Philosophy, but the terms of the original foundation are exceedingly wide. The present Professor, following the direction given to the Jacksonian Professor's lectures by his predecessor, lectures on Mechanism and the Steam Engine. Such lectures are plainly required, whatever may be the designation of the Professor who gives them; but while belonging to general culture, they are imperatively required from the student of Civil Engineering. They do not at any rate fall under the head of Experimental Physics, which, therefore, is at present represented by a single Professor, except in so far as the lectures of some of the Mathematical Professors may be of an experimental character.

54. We think that, considering the great range of subjects embraced in Experimental Physics, that subject and Civil Engineering could not be adequately represented by less than three Professors.

55. There is at present no Professorship of Physiology, though the Trinity Praelector of Physiology discharges in great measure the duties of an University Professor. We think that a Professorship of Physiology ought to be established in a permanent manner, which, along with existing professorships, would make four for Biological subjects, exclusive of the Regius and Downing Professorships of Medicine; and, generally, that the arrangements of professorships as regards the Biological subjects should be rendered as complete as we have recommended for Oxford.

(F.) ADJOINT PROFESSORS, DEMONSTRATORS, AND ASSISTANTS.

56. Although the witnesses have been unanimous as to the necessity of strengthening the professorial staff, they do not entirely agree as to the way in which this should be done. Mr. Pattison would increase the number of independent Chairs of Science to twenty or even to thirty. On the other hand, there appears to be a feeling that the principal subjects should not be too much divided, although it is admitted that at present they are too much grouped together.

57. It must not be forgotten that an increase in the number of independent Chairs would render it necessary for the Universities to provide increased accommodation in laboratories, and additional apparatus. With the view of utilizing to the utmost the existing appliances of this sort, some of the witnesses have suggested that the increase of the Professoriate should, as far as possible, be provided for by an abundant supply of skilled assistants,

of demonstrators, and of assistant professors, rather than by increased numbers of independent lecturers.

58. The necessity for skilled assistants and for demonstrators of course made itself felt at a very early period, and though a certain number of such assistants and demonstrators have been supplied, yet the need for an increase in the number of these subordinate offices has already become apparent. It may be mentioned, for example, that at neither University is any assistance of this kind at present afforded to the Chair of Geology, or to that of Botany.

59. A Natural Science Professor should have, in the first place, sufficient skilled assistance to relieve him from all mere drudgery in the preparation of his lectures. In the second place, he should have such further assistance as may be necessary to enable him to carry on original researches. And, thirdly, although no professor would wish to hand over the superintendence of the practical teaching in his laboratories entirely to others, he should be enabled to discharge this duty of superintendence without an undue sacrifice of time. The work should be done under the professor's eye, but its details should be entrusted to competent demonstrators, appointed by and responsible to him.

60. So far there is a general agreement; but the question whether assistant professors should be appointed at all, and if so, how far the dependence of the assistant professor upon the principal professor of the subject should be carried, has given rise to some divergence of opinion. We have already stated that we regard as indispensable the establishment of a certain number of new Chairs, to be independent of, and to take equal rank with, the existing Chairs. If the Universities are to become great Schools of Science, it is of the first importance to secure for them the permanent services of a very considerable number of scientific men of established reputation; and we cannot perceive how this object is to be attained otherwise than by offering to such men, without any reservation whatever, the same academical *status* which has hitherto been enjoyed by the University Professors. We consider, therefore, that in any extension of the Professoriate, this is, without doubt, the first point to be attended to. But we are also disposed to attach great weight to the suggestion that, in addition to the Professorships representing the great divisions of Natural Science; University Teachers, who might be termed Adjoint Professors or Readers, should be appointed to undertake the instruction in special branches. It would be undesirable to place an Adjoint Professor in a position of complete subordination to the Principal Professor of the subject; and it would probably be very difficult to arrange any plan of partial subordination which could work satisfactorily. We are, therefore, of opinion that the Adjoint Professors should not be regarded as assistants to the Professors, but should be responsible for the due discharge of the duties assigned to them to a Board or Council, appointed by the University, and not to any individual Professor.

61. It is important that the Universities should be able to secure the services of men who have shown their ability to promote science, and to become successful teachers of it, by offering them places, such as the Adjoint Professorships, which would give them an opportunity of distinguishing themselves; and, with this view, it is very desirable that as much independence as possible should be allowed to the Adjoint Professors, in order to make the appointments attractive to the best men. On the other hand, as it is obvious that the perfection of the means and system of instruction in the Universities is of primary importance, an organisation of, and control over, the courses of instruction would be necessary, as otherwise there might be an excess of lectures in some subjects, and a deficiency in others. We are of opinion that these difficulties might be overcome, and a sufficient amount of liberty combined with systematic organisation, if, as we shall presently recommend, a Central Board, or Council, should be formed, representing the Scientific Faculty, and having definite functions with regard to the scientific teaching within the Universities.

62. We may observe that the financial argument in favour of extending the Professoriate (at least in the first instance) by the institution of offices not intended to take equal rank with the existing Chairs, rather than by increasing the number of the Principal Professorships, will probably lose some of its force when a careful estimate is made of the difference which the adoption of the one plan or the other would make in the charge to be laid upon the funds of the Universities. It is quite true that the emoluments of an Adjoint Professor need not be so great as those of one of the Principal Professors; and that to this extent there would be a saving. But whether an additional professor of any subject be termed an Adjoint Professor, or whether his Chair be regarded as co-ordinate with the existing Chairs, the difficulty would always remain that if he is to be of any use at all he must be furnished with the necessary apparatus; he must have a room to lecture in, a room or rooms to work in, and the classification of the

students will also probably require additional space. Laboratories of chemistry, physics, and physiology have been already provided; it would, therefore, not be necessary to create a large establishment for any new professor. But it is certain that the only way in which the Universities can increase the usefulness, at the same time that they increase the number of the professors, is by being ready to make, from time to time, such moderate additions as may be necessary to the buildings which they appropriate to science.

## II.—Duties of Professors.

63. The duties actually assigned in the University of Oxford to the Scientific Professors are very different in different cases. The number of lectures required from any professor is not more than 40 or 50 in the year, so that, in the case of a professor who has no laboratories to superintend, the duties of the office cannot be described as onerous, and might, perhaps, be increased without any disadvantage; but the case is very different with the Professors of the three leading subjects of Physics, Chemistry, and Biology, whose time during the University Terms is almost entirely occupied by their work as teachers. No doubt by supplying these Professors with more assistance than they at present have, their duties might, to a certain degree, be lightened; but the difference will, nevertheless, always remain considerable between a professor whose duties consist only in lecturing, and one who has also to superintend a great department in a scientific institution in which practical work is carried on.

64. In the University of Cambridge the duties of the Scientific Professors are regulated, so far as relates to the general scope of the respective Professorships, by the terms of the foundation, but so far as relates to lectures and residence, by Statutes made under the Act 19 & 20 Vict. c. 88. The University Statutes contain a provision, to which we shall have occasion presently to refer at greater length, that the University shall appoint Boards for reviewing the more important departments of study. The Statutes of each individual Professorship enact that it shall be the duty of the Professor to give lectures in every year, and to order as well the subject of such lectures as the times and places of delivery, according to a scheme to be approved from time to time by the Board of Studies connected with his particular department, of which Board the Professor shall be a member; and that it shall be the duty of the said Board to provide that the subjects of the said lectures be determined with regard to the objects of each particular Professorship.

65. The Statutes also prescribe a minimum amount of residence in the University. For the Mathematical Professorships the minimum prescribed by statute is six weeks in the Michaelmas Term in every year, and twelve weeks in the Lent and Easter Terms. In the other cases it is enacted that the University shall have power to determine from time to time, by Grace of the Senate, the time for which the Professor shall be required to reside in the University in every year, such time not to exceed eighteen weeks. In neither case is there any precise definition of what constitutes residence. The minimum determined by Grace has usually been fixed at eighteen weeks. It may be remarked that the new Statutes have practically had the effect of abolishing non-residence on the part of the Scientific Professors, so that actually the question whether the minimum is satisfied, is not likely to arise.

66. While the Statutes throw upon the Board of Studies the duty of approving, or otherwise, the schemes of lectures of the Professors, the University has in a few instances prescribed a minimum. Thus the Professor of Experimental Physics is to deliver at least one course of lectures in each of two Terms, the total number of lectures delivered in the whole year being not less than forty; and the Woodwardian Professor is to deliver at least one course of lectures in each of two Terms.

67. It has been suggested that, in the case of certain professorships at both Universities, the functions of Original Research might be separated from direct instruction. To a professor the duty of teaching is a matter of daily routine; whereas, Original Research is a duty which belongs to no day in particular, and which is, therefore, very likely to be neglected in comparison with the other. Nevertheless, we cannot see any just and sufficient reason, in the case of the professorships, for a total separation of the two functions; and even Sir Benjamin Brodie, who has supported the view that some distinction should be made between offices appropriated to teaching and those appropriated to original research, would not have the separation absolute, and would consider it of importance that even a professor whose chair was founded chiefly with the latter view, should be called upon to produce, from time to time, in the form of lectures, the results of investigations in new departments of science. Lecturing is not the only mode in which scientific instruction may be imparted. A professor who should undertake the

direction of a laboratory in which advanced students were to be trained in the methods of scientific research, would be very far from holding a sinecure office, and would be rendering the highest, as well as the most direct, service to scientific education.

68. We have no doubt that for a professor the duty of teaching is indispensable, but we agree with the witnesses whom we have examined that Original Research is a no less important part of his functions. The object of an University is to promote and to maintain learning and science, and scientific teaching of the highest kind can only be successfully carried on by persons who are themselves engaged in original research. If once a teacher ceases to be a learner, it is difficult for him to maintain any freshness of interest in the subject which he has to teach; and nothing is so likely to awaken the love of scientific inquiry in the mind of the student as the example of a teacher who shows his value for knowledge by making the advancement of it the principal business of his life.

69. It has been, to a certain extent, a complaint against the School of Natural Science in Oxford that hitherto it has produced but very few original workers. The complaint (if well founded) may, perhaps, be accounted for by the circumstance that the school has not been long in existence; but there can be no question that it is of the utmost importance to impress upon teachers and learners alike that one, and, perhaps, the chief criterion of success in the teaching of science is its leading to new discoveries. To promote this end the Universities probably can do nothing more useful than to increase the number of persons employed, under whatever name, in the teaching of science, taking care at the same time that while such duties are assigned to them as may prevent their offices from being sinecures, they shall be left with time and energy enough to carry on original work. We consider this to be a point of great importance, and we should regret to see any scientific office whatever established in either of the Universities without its being understood that it is expected from the holder that he shall do what is within his power, not only for the diffusion, but also for the increase of scientific knowledge.

70. It has been stated in some parts of the evidence which we have taken, that the duties of lecturing and teaching which are required from the Professors are such as seriously to interfere with their leisure for original investigation, and a wish has, therefore, been expressed that the provisions of the Professorial Statutes as to the number of lectures to be given should be relaxed. We cannot concur with this suggestion. In estimating the amount of teaching and lecturing which can properly be required from a Professor, we do not forget that he is expected to keep himself well acquainted with all the latest advances in some very wide department of knowledge, a task which, at the present rate of scientific productiveness, is no light one. But, on the other hand, we cannot leave out of sight that the University duties of a Professor last for only six months, and that he has thus the invaluable privilege of being master of his own time for fully one half of the year. It is, therefore, only reasonable that during the University Terms he should devote a fair proportion of his time to the work of teaching. And we feel it to be our duty to say that, in recommending, as we have done, the foundation of a considerable number of new Scientific Professorships, our intention is that duties of a very substantial kind should be attached to each of these offices, with a view to the establishment of an efficient and complete course of instruction.

### III.—Appointment of Professors.

71. The mode in which the University Professors should be appointed has given rise to much discussion. It need hardly be stated that to secure a right mode of appointment is a matter of the most vital consequence; and this is strongly felt at Oxford and Cambridge, where the numbers of the Professoriate are so limited that a single inefficient or unsuccessful appointment might cause very serious detriment to the whole system of instruction.

72. There is a very general agreement that a Scientific Professor should be appointed by a Board constituted *ad hoc*; and it may be mentioned that at Oxford the Clinical Professorship is the only Scientific Professorship the election to which is now vested in the Convocation of the University. What should be the precise composition of an Electing Board is a very debatable question. Sir Benjamin Brodie has expressed a decided opinion that an Electing Board should be composed entirely of men of science. "I, myself," he says, "have come to the conclusion that by far the best mode of making scientific appointments is to make them by a small board of persons who understand the special subject in reference to which the appointment is to be made, and the sort of board which I would suggest would be this: In the first place I would put two professors, say, of the subject in the University. I would begin with them; then I would put on the board another official person, another professor, for example, of some other

" University, to be associated with the two professors that I have mentioned, and would allow those three persons to nominate two other members of the board, individuals to be selected not with reference to a particular professorship, but to be nominated for some time prior to any appointment, men distinguished in science and eminent for their knowledge of the subject of the Chair. We have had some experience at Oxford of this mode of constituting a board, and of the way in which it works, and I have come to the conclusion that it is a very good mode of making such appointments." A feeling, however, has been expressed by other scientific men that in certain cases the interests of science are more safely entrusted to a board in which some kind of neutral and businesslike element is represented; or at least that appointments made by such a board would be above all suspicion of scientific chiqueism which might possibly attach to a board consisting entirely of men eminent for their knowledge of the subjects of the Chair. Perhaps the general opinion would be in favour of combining several different elements upon the Electing Board, in some such manner as that suggested in the evidence of Professor H. Smith :

Qu. 3517. " Can you give us your views as to how an Electing Board should be constituted?—I should certainly wish an Electing Board not to be a large one, so that there might be a sense of responsibility attaching to the individuals composing it. I should like to see three elements represented upon it; first, the local scientific element, on account of the keen interest which scientific men resident in an University are sure to take in the appointment of those who are to be their fellow workers; secondly, I should like to see the outside scientific world also represented upon such a board; and, thirdly, I should wish to see some impartial and simply business-like element also present. A board so constituted would, I believe, work well. A purely local board would be objectionable, on account of the difficulty of passing over local claims."

Qu. 3518. " Do you think that the Professors themselves should have seats in the Electing Board?—I think that one or two of the local Professors ought to be upon every board, but I do not think that they should form the majority of any board. I ought to explain that I should not wish to have one and the same Electing Board for all professorships. I should have different boards for different groups of professorships."

73. The evidence of Dr. Rolleston is to the same general effect; and we are disposed to concur in the view taken by these two witnesses. The preponderance in any electing board should unquestionably be given to the scientific element, which should be represented by scientific men both within and without the University. The presence of scientific men belonging to the University itself is evidently necessary, not only because they are well acquainted with the working of their own system, but also because they are certain to attach the greatest importance to the choice of the persons with whom they will have to work, and on whose fitness the success of the work in which they are themselves engaged in a great measure depends. The feeling of the University itself would probably be adverse to the proposal that an Electing Board should consist entirely of their own Professors. It is not safe to allow any body of men to perpetuate itself by co-optation, however desirable it may be that it should have some share in the appointment of its new members. And since, at Oxford, the endowment of several of the Professorships has been in part obtained from the Foundation of a College, it would probably be thought right that in such cases the College should have some voice in the Electing Board.

74. Each of the Scientific Professorships in the University of Oxford has its own special Statute, assigning the duties of the professor, and fixing (except in the case of the two Chairs of Geology and Mineralogy) the mode of appointment to the office. A tabular statement of the different modes of appointment will be found in the subjoined note.\* As

\* Modes of appointment of Professors in the University of Oxford :—

1. Regius Professorship of Medicine.—The Crown.
- 2, 3. Savilian Professorships of Geometry and Astronomy.—The Archbishop of Canterbury, the Lord High Chancellor of Great Britain, the Chancellor of the University, the Bishop of London, the Secretary of State for the Home Department, the two Chief Justices, the Chief Baron of the Exchequer, the Dean of the Arches, and the Warden of New College, taking into their counsel the Vice-Chancellor of the University.
4. The Sedleian Professorship of Natural Philosophy.—The Vice-Chancellor, the Provost of Queen's College, the President of the Royal Society, the Astronomer Royal, and, alternately, the President of Magdalen College and the Warden of All Souls' College.
5. The Professorship of Botany and Rural Economy.—The College of Physicians.
6. The Professorship of Experimental Philosophy.—The Vice-Chancellor, the Warden of Wadham College, the Savilian Professor of Astronomy, the Sedleian Professor of Natural Philosophy, and the Waynflete Professor of Chemistry.
7. The Clinical Professorship.—The Convocation of the University.
- 8, 9. The Professorships of Geology and Mineralogy.—The Vice-Chancellor; no mode of appointment being provided in the Statute.
10. The Linacre Professor of Physiology.—The Visitor and the Warden of Merton College, the President of the College of Physicians, of the College of Surgeons, and of the Royal Society.



it is desirable, on the one hand, that the board appointing to any professorship should be small, and, on the other hand, that it should be mainly composed of persons well acquainted with the actual state of those branches of science which form the subject of the Chair; we are of opinion that in reconstituting the electing bodies it would be advantageous to adhere to the precedent afforded by the existing Professorial Statutes, and to provide by separate enactment for the mode of appointment to each professorship; except in any case in which it might be found that the circumstances of two or more Chairs were so precisely similar as to render the same electing body equally suitable to each. It would be natural that the new statute of any chair should place on the Electing Board, as the representatives of science outside the University, the Presidents for the time being of certain scientific societies, or the holders for the time being of certain important scientific offices, such as that of Astronomer Royal or Professor at a sister University. Similarly, the representatives upon the Electing Board of the Scientific Faculty of the University itself might be either the holders for the time being of certain professorships, or they might be persons nominated to serve on the Electing Board by the "Council of Science," which, as we shall presently propose, might be organized within the University. Lastly, it would be in accordance with academical tradition that the University at large should be represented by the Chancellor or by the Vice-Chancellor, or, in certain cases, by a person nominated by the College which had contributed to the endowment of the Chair.

75. From a list already given it will be seen that there are twelve Scientific Professorships in the University of Cambridge, exclusive of the two Medical Chairs. The four Mathematical Professors are elected, one by the Heads of Colleges, the other three by special boards.\* The eight remaining Scientific Professors are elected by the members of the electoral roll (with the addition, in one case, of a few privileged individual†), that is, mainly by the resident members of the Senate.

76. A Statute passed under the authority of the Act 19 & 20 Vict. c. 88. not only governs many of the existing professorships, but also has been held to be binding in case of the endowment of new professorships out of funds available to the University. This statute provides that "the appointment to every such new professorship shall be made by vote of the members of the Senate on the electoral roll."

77. This mode of election has been much discussed, and is very generally disapproved of. The electing body consists indifferently of those who are and those who are not specially acquainted with the subject to which the professorship relates. It is too large to meet together and elect by repeated scrutinies in case the votes should in the first instance be divided between several candidates, a circumstance which is liable to render the election a matter of chance. The electing body is so large that the sense of individual responsibility is enfeebled, and there is danger that considerations of personal friendship may outweigh the claims of public duty; and such considerations are all the more likely to intervene since so large a proportion of the electing body consists of residents.

78. On this point Mr. Bonney remarks:—"I think a change is very desirable. Though Qu. 5326. the result of the elections that I have seen has always been that which the University might be thoroughly satisfied with, I do not think that the body which elects is a good one; it is too large. It is very difficult to get men fairly and well to weigh the attainments of the candidate; they feel their individual responsibility to be small, and I think it would be far better that comparatively small boards, mainly composed of persons experienced in the particular science, where the sense of personal responsibility would be very great, should elect." In this opinion we entirely concur; and we think that in the formation of any new Board of Electors, the recommendations which we have made with respect to Oxford should apply equally to Cambridge.

11. The Hope Professorship of Zoology.—The Hope Curators, viz., the Vice-Chancellor, the two Proctors, the Regius Professor of Medicine, the Keeper of the Ashmolean Museum, and two co-opted members.

12. Waynflete Professorship of Chemistry.—The Chancellor of the University, the Visitor and the President of Magdalen College, and the Presidents of the Royal Society and of the College of Physicians.

\* Modes of appointment of the Mathematical Professors in the University of Cambridge.

The Lucasian Professor is elected by the Heads of Colleges. The Boards for the other three are: For the Plumian, the Vice-Chancellor, the Masters of Trinity, Christ's, and Caius Colleges, and the Lucasian, Lowndean, and Sadlerian Professors—if either of the Masters be Vice-Chancellor, the Master of St. John's acts in his stead. For the Lowndean, the Vice-Chancellor of the University, the President of the Royal Society of London, the President of the Royal Astronomical Society of London, the Astronomer Royal, and the Lucasian, Plumian, and Sadlerian Professors. For the Sadlerian, the Vice-Chancellor of the University, three Heads of Colleges, to be elected by the persons on the Electoral Roll, and to hold office as long as they continue to be Heads of Colleges, and the Lucasian, the Plumian, and the Lowndean Professors.

† The Archbishop of Canterbury, the Bishop of Ely, the Members of Parliament for the University, and the Presidents of the Royal Society and of the College of Physicians are also electors in the case of the Woodwardian Professorship.

79. The opinion entertained as to the best constitution of an electing body has been shown in a very substantial form by the regulations which govern those professorships which have been founded by bequest or subscription subsequently to the enactment of the general statute above referred to. Three such have been founded since the statute was passed, two by bequest and one by subscription; it matters not for our present purpose that they are not scientific. The model of the statute has in no instance been copied, but in every case the election has been vested in a small special board.

80. We do not anticipate that any great difficulty would be experienced in carrying out the proposed alterations in the Professorial Statutes. In the case of some of the Oxford professorships the change in the mode of appointment could be made by the University itself, acting with its existing powers; in other cases the consent of the College which had contributed to the endowment would have to be obtained; while in a third class of cases the consent of the Queen in Council, or even additional Parliamentary powers would be necessary. In the case of the University of Cambridge, we believe that the consent of the Queen in Council to a petition of the University would in every case be necessary and sufficient.

#### IV.—Emoluments of the Professors.

81. The emoluments of nearly all of the Professors in either University originally depended upon ancient endowments, and, with the exception of those of most of the Professors of Divinity, were of very small amount. In the course of the last twenty years these emoluments have been raised, and the average stipend of the Scientific Professors at Oxford is now a little above 500*l.* a year, and about 450*l.* at Cambridge, exclusive of Fellowships, which may be held by professors under exceptional conditions. At Oxford, a Fellow of a College who becomes a professor, does not thereby acquire the right of holding his fellowship free from the restriction of celibacy, but he becomes eligible to a fellowship free from this restriction, at his own or any other College. Two of the Scientific Professors have been thus elected to fellowships; but no account has been taken of these fellowships in the above estimate of the average professorial stipends. At Cambridge a Fellow who obtains a professorship does not as a rule vacate his fellowship by marriage, and a married professor may be elected to a fellowship.

82. It is of great importance in the interest of the Universities that these places should be such as to render them attractive to the most eminent scientific men that can be found to take them, and it may be doubted whether the amount which has been named is sufficient for the purpose. When an office is offered to a man, the duties of which are to form the business of his life, it is certainly right that the remuneration accompanying it should be such as to enable him to marry and maintain a family in a suitable manner.

83. Another point to which our attention has been strongly directed is the desirability in the interest of the Universities of obtaining retiring pensions for professors. The system at present existing in both Universities is, that if a professor, from age or from declining health, should become incompetent to perform the duties of his office, a certain portion of his stipend is assigned to him by the University, and a Deputy Professor is appointed to discharge the duties of the office in the interim. As an arrangement intended to meet the case of temporary illness, this plan would appear to work well, but it does not appear to be very suitable in the case of a long-continued incapacity from ill health or old age. It would seem desirable that when a professor is permanently disabled from discharging the duties of his office, he should be superseded, and that a new election should take place at once; and it is disadvantageous that the incoming professor should be burdened with a payment to his predecessor, because it is the interest of the University that the place when it is vacant should be made as attractive as possible to candidates. We should, therefore, wish to see a well-considered system of retiring pensions instituted in the Universities, and we believe that this would be conducive, not only to the comfort of the professors themselves, but also, which is of more importance, to the maintenance of an uniformly high standard of instruction.

84. There is but one quarter to which we can look for the funds which would be necessary in order to introduce improvements in the directions which we have indicated. The Universities themselves (considered as distinct from the Colleges which they contain) are not very wealthy bodies. The University of Oxford is the richer of the two, but the funds at its disposal are almost completely appropriated, and there does not appear to be any probability of an immediate or rapid augmentation. The revenues of the Colleges are, therefore, the only available source for any increased expenditure for University purposes. To a certain extent the Colleges at Oxford have already contributed to the University, the increase that has taken place in the emoluments of the scientific and other professors having been derived almost entirely from their funds. At Cambridge

the Colleges have contributed to the University by taking upon themselves a tax formerly defrayed by the University. It is not improbable that further demands of the kind may be made upon the Colleges of both Universities, nor are we led to suppose by the evidence before us that they would regard such demands as conceived in a spirit of hostility.

85. It has been suggested, and the proposal seems a very reasonable one, that the Colleges should annex fellowships to the professorships, the restriction as to celibacy being of course withdrawn. This has already been done in a few cases, and there would seem to be no reason why it should not be done in all. The advantage would be a reciprocal one, because in most cases the College would be as likely to obtain a valuable member of its governing body, as it would be by an election founded on a competitive examination; and, on the other hand, the advantage to a Professor who becomes a member of one of these Corporations is very great indeed, and is not to be measured by the pecuniary advantage alone, as he thus acquires an increased interest in the studies and business of the University, and increased opportunities of becoming acquainted with the requirements of the students. The evidence of Professor Fowler on this point is deserving of Qu. 13,737. attention.

86. At Cambridge there appears to be an unwillingness to allow a Professor to become, *ex officio*, a Fellow of a College; but, as already mentioned, nearly all the Colleges have accepted a Statute enabling a Fellow who is a Professor to retain his fellowship after marriage, and allowing the Governing Body to elect a professor, though married, to a fellowship. If this plan has the advantage of being more acceptable to the Colleges, it has the obvious disadvantage that the University does not make the most of the money virtually bestowed upon it, since the uncertainty of election to a fellowship might prevent an eminent man from standing for a professorship for which he would have become a candidate if he had been sure of holding a fellowship with it.

#### V.—Proposed Council of Science.

87. There is already more than one body within the University of Oxford which, to a certain degree, discharges administrative duties in connexion with science. The first of these is the Delegacy of the University Museum. This body consists of the Vice-Chancellor and Proctors for the time being, and of six other persons elected by the Congregation of the University. No professor lecturing within the Museum is eligible as a member of the Delegacy, but all such professors have the right to be present at its meetings, as assessors, without a vote. The duties of this Delegacy refer exclusively to the financial and other arrangements requisite to carry on the business of the Museum. Any proposal for new expenditure upon the Museum is brought before them in the first instance, and if approved of by them is passed on to the Hebdomadal Council, who have the power of rejecting or modifying it, as they may think proper. But, as great weight naturally attaches to any measure sanctioned by the Delegacy, the Hebdomadal Council, as a general rule, do not withhold their approbation, but submit the proposition of the Delegates to the Convocation of the University, with whom the ultimate decision upon it rests. The Delegates of the Museum, however, have no educational functions, and they have no control of any kind over the teaching given by the professors.

88. The other administrative bodies are of quite recent creation. The Board of Studies of the Natural Science School was instituted by a statute passed only at the commencement of the year 1872. The Scientific Professors (with the exception of the two Savilian Professors) are *ex officio* members of the Board, which also contains the Examiners for the time being in the Natural Science School, and all persons who have served as examiners in the School within the two years preceding. The duties assigned to this body are, to exercise a general supervision over the subjects of examination in the Natural Science School. They have no power of controlling in any manner the courses of instruction given by the professors, or of interfering with the examiners in the conduct of any particular examination; but they may frame from time to time regulations as to the conduct of the examinations; and, within the limits prescribed by the University statute, they may issue notices explanatory of the range of the subjects included in the examination, and may recommend treatises to be studied in connexion with them. These powers they have already exercised, in publishing a complete syllabus of the subjects of examination in the Natural Science School, accompanied with a list of works to be studied. This list does not appear to have been drawn up upon any uniform principle; no books whatever being recommended in some subjects, while in others the list is so extensive that it can hardly serve as a guide to the ordinary learner, though it may be very valuable to some advanced students.

89. The Board of Studies of the School of Mathematical and Physical Sciences is composed of the two Savilian Professors; the Sedleian Professor; the Professor of Experimental Philosophy; the Examiners for the time being in the School; all persons who have served in that capacity within the two years preceding and three persons added by co-optation. The duties of this Board are similar to those of the Board of Studies of the School of Natural Science. The Medical Examinations are not under the supervision of a Board.

90. From the limited scope of the functions of these various bodies, as well as from the constitution of the first of them, it is evident that they cannot be regarded as representing, in any adequate manner, the Scientific Faculty of the University. We are of opinion that the best mode of providing for this important object would be to replace them by a Single Administrative Body, representing every department of science, and having wider but still definite powers entrusted to it. Without attaching any importance to the name, we shall, for the purposes of the present Report, designate this proposed administrative body as "the University Council of Science."

91. The duties of the Council would, we conceive, be two-fold—educational and financial.

92. If, as may be expected, the number of Professors and Adjoint Professors, engaged in the teaching of science should hereafter be considerably increased, it would become indispensable that the arrangements for the discharge of their educational duties should be made, not altogether independently, but as the result of mutual agreement. The task of co-ordinating these arrangements would not always be an easy one, and would, we think, be most safely entrusted to a Council of Science. It would be of great importance that the supervision exercised by the Council should not assume even the most distant resemblance to a vexatious interference; but it should be carried at least to such an extent as to provide that the teaching in the different subjects should be duly co-ordinated, so as to prevent, for example, a plurality of courses upon one subject, while others equally important were neglected. It is impossible not to apprehend that if the teaching staff should become very large, some inconvenience might arise from a continuance of the almost unrestricted freedom at present allowed to a professor of choosing the time at which he will lecture as well as the parts of his subject which he will include in his course; and we cannot but think that some attention to united action in these respects is essential to the establishment of a School of Science which it is intended should be worked upon a large scale.

93. A further educational duty might eventually devolve upon such a body, that of endeavouring to co-ordinate such scientific instruction as might be given within the Colleges with that given in the University. At the present moment, however, it must be admitted that this duty would be a light one, because the amount of such instruction, except so far as it is mathematical, which is at present given in the Colleges is so small as to be in the last degree unlikely to interfere with that provided by the University Teachers. But if, as may be hoped, the scientific instruction given in the Colleges should receive a considerable development, it would become very desirable that such a co-ordination should be attempted to prevent the waste of teaching power which must otherwise ensue.

94. The main financial duty of the Council of Science, would be one which now (within a limited sphere) falls upon the Delegates of the University Museum, that of taking into consideration all applications which require the expenditure of money for scientific purposes, and of determining whether such applications should be brought before the University with the weight of their recommendation. It is difficult to see how, without such a preliminary scrutiny by a competent body, the demands of different individuals and of various scientific subjects can be dealt with by the University in an uniform and satisfactory manner. It would be desirable that the Council of Science should have a discretionary power of making grants, up to a certain moderate amount, in aid of original researches, or to obtain the temporary assistance of a lecturer. But in all cases in which a larger expenditure was required the consent of the University would no doubt have to be obtained in the usual manner.

95. What the precise composition of the Council of Science should be, and within what limits its powers should be confined, are important questions, which, however, we may leave to be discussed within the University itself. It would probably be best that the numbers of the Council should be considerable, in order to ensure a fair representation of all the interests concerned, it being intended that a great part of the work should be done by Committees according to the usual practice of Academical Delegacies. If this view of the composition of the Council should be adopted, all the Professors and Adjoint Professors might be made members of it *ex officio*; a certain proportion of non-official members, elected possibly by the Congregation of the University, being added

in order to represent the instruction given in the Colleges. The infusion into the Council of Science of such an elective element would tend to give the University at large an increased interest in the proceedings of the Council; and it would also provide a mode of admitting to the Council, from time to time, a certain number of persons who, not happening to hold any academical office, might nevertheless be eminently fit to take part in its deliberations. It may be added that a Council, containing such a representative element, would be more likely to deal successfully with the complicated questions relating to the co-ordination of University and College instruction.

96. With respect to bodies exercising administrative duties in connexion with Science, the arrangements of the University of Cambridge bear a strong general resemblance to those that have been now adopted in the University of Oxford. The Museums and Lecture-rooms Syndicate at Cambridge is analogous to the Delegacy of the University Museum at Oxford, while the Board of Mathematical Studies and the Board of Natural Sciences at Cambridge answer to the corresponding Board at Oxford.

97. The Museums and Lecture-rooms Syndicate is a permanent Syndicate, which was formed in connexion with the establishment of the new Museums. All the members are appointed by Grace of the Senate, and vacate their seats by rotation, the retiring members not being re-eligible at that election. There is no provision excluding Professors, as at Oxford, and, in point of fact, the Syndicate usually consists in part of Professors, in part of other Members of the Senate. The Syndics have no educational control, and their duties are mainly financial. The University has set apart 1,500*l.* a year to the maintenance of the Museums, and out of this sum the Syndicate defray the ordinary expenses of management, on their own responsibility as regards smaller sums, subject to the sanction of the Senate as regards the larger.

98. The University Statutes made under the Act 19 & 20 Vict. c. 88, after providing for the establishment of a Board of Theological Studies, enact that "the University shall appoint Boards for reviewing the more important departments of study recognised in the University, and reporting thereon to the Senate, which Boards shall severally comprise the Professors and Public Lecturers, whose duties connect them with such departments, as well as such other persons as may be determined from time to time by Grace of the Senate; and it shall be the duty of such Boards to consider the schemes for lectures submitted to them in every year by such Professors and Public Lecturers, and to approve of the same, or to remit them from time to time for further consideration or revision, with amendments or alterations therein."

99. In accordance with this Statute the University has appointed among others (1) a Board of Mathematical Studies; (2) a Board of Natural Sciences; to which, in consequence of its close connexion, in many respects, with the Board of Natural Sciences, we must add (3) a Board of Medical Studies. These Boards are composed, first, of certain Professors as required by the Statute; secondly, in the case of the Board of Mathematical Studies, of the Moderators and Examiners of the current and two preceding years; and, in the case the two other Boards, of the Examiners of the current and last preceding years; and, thirdly, of a certain number of members appointed by Grace of the Senate, who retire by rotation.

100. So far the machinery for co-ordinating the lectures of the different Professors appears to be complete; but it may be questioned whether the provisions relating to the Boards are not too stringent, and, consequently, not easily carried out. It seems probable, therefore, that additional provisions will be required for securing greater regularity and unity of action, and should any considerable modifications appear desirable, we are disposed, for the reasons we have given above, to recommend the establishment of an University Council of Science at Cambridge, similarly constituted and with similar powers to that which we have suggested for the University of Oxford.

### III.—THE SCIENTIFIC INSTITUTIONS WITHIN THE UNIVERSITIES OF OXFORD AND CAMBRIDGE.

#### I.—Oxford.

101. The following scientific institutions exist within, or in connexion with, the University of Oxford:—The University Museum, the Clarendon or Hyde Institute, the Botanical or Physic Garden, the Radcliffe Library, and the Radcliffe Observatory. Of these, the last two do not belong to the University, but are under the absolute control of Dr. Radcliffe's Trustees. The University Act of 1854 has however given to the Radcliffe Observer the status of a Professor within the University, and has so far recognized, greatly to the advantage of the University, the connexion between the Radcliffe Observatory and the University.

102. It is unnecessary to say that the Bodleian Library is as invaluable to the scientific as to the literary student. But, as it is not exclusively, or even principally, a scientific institution, we have not included it in the preceding enumeration.

103. The evidence of Dr. Acland contains an interesting account of the movement which led to the erection of the University Museum. From his evidence and that of Professor Price, it appears that a large sum, amounting to nearly 85,000*l.*, was originally expended in the purchase of the site, in the erection of the building, and in providing a certain proportion of the fittings, and that since that time further sums, amounting in the whole to nearly 15,000*l.*, have been expended upon the completion of the internal arrangements and on additional fittings.

104. The collections at present comprise (1) A cabinet of Pathological Anatomy, formed by the present Regius Professor of Medicine, to which has recently been added the Collection of Schroder Van der Kolk, which has been purchased by the University; (2) A Collection of Comparative Anatomy and Physiology; (3) A Collection of Zoology, including the extensive Hope Collection of Invertebrate Zoology; (4) Collections of Geology; and (5) of Mineralogy.

105. Continual additions are being made to these collections; but even in their present condition they may probably be described as adequate for the ordinary requirements of students, while in some directions they are sufficient for the purposes of the most advanced investigators. As instances of this larger development may be mentioned the Craniological collection formed by Professor Rolleston, and included in the collection of Comparative Anatomy and Physiology, the collection of Saurian remains in the department of Geology, and, above all, the Hope Collection of Invertebrate Zoology.

106. A great part of the collection of Comparative Anatomy and Physiology, is the property of Christ-Church, and has been lent to the University on condition of its being freely accessible to members of Christ-Church.

107. It appears from the evidence that the space in the Museum which can be devoted to the exhibition of specimens is almost completely occupied.

108. The Laboratories for Pathology and Physiology, and Chemistry, which surround the central court of the Museum, are described as just sufficient for all present requirements. Sometimes, however, there is a little difficulty in finding room for all the students who want places in the practical laboratory of Chemistry. The rooms originally appropriated for Physics, which, however, were very inadequate for the purposes of that branch of Science, have, since the building of the Hyde Institute, been placed at the disposal of the Professor of Chemistry, and it is in consequence of this accession that the space allotted to Chemistry has become sufficient for immediate purposes. The Laboratory attached to the Department of Medicine is at present chiefly used by the Deputy of the Regius Professor of Medicine for sanitary investigations, such as analyses of water, adulterated food, and the like. The Physiological Laboratories, though sometimes overcrowded, may in the main be described as sufficient for the present, because certain parts of the instruction are given in the central court, where a considerable number of the specimens are placed.

109. Some of the architectural peculiarities of the Museum have, perhaps, rendered its original construction, and its present maintenance, more costly than they might have been. The expense of warming the great central court, roofed as it is with glass, is very considerable, and the cost of lighting it would be so great that this part of the building is not used at night. It has also been found that the repairs of a building constructed as it has been, are likely from time to time to be very heavy. Care, however, was taken in the original design to provide for the possibility of future extension, the back of the building having been left in an unfinished state, so that whenever the necessity for extension shall arise, as it must at no very distant period, it can be carried

out without any great cost, and without interfering with the architectural arrangements of the building.

110. The Hyde Institute for Experimental Philosophy was built by the Clarendon Trustees out of a fund amounting to about 12,000*l.*, which had accumulated under the provisions of the will of Henry, Lord Hyde, who died in 1753, and of which the original destination was to found a Riding School. The building, when completed and fitted up, was made over by the Trustees to the University. The whole sum of 12,000*l.* was expended upon the building and the fittings, so that the cost of maintenance and of providing apparatus devolves entirely upon the University funds. The most minute attention to all the details of the building was given by the present Professor of Experimental Philosophy, and the result is described by persons competent to judge as eminently satisfactory. The Institute, though separate from the Museum, is close to it, and is connected with it by a covered passage, so that no time is lost by students in passing from one department to another.

111. We think it necessary to call attention to the condition of the Cabinet of Physical Apparatus placed in the Hyde Institute. The University granted, when the present Professor came into office, a sum of 1,000*l.* in aid of the formation of such a cabinet, and there is in addition a benefaction, conferred by Edward, fifth Lord Leigh of Stoneleigh, High Steward of the University, who died in 1786, which is entirely appropriated to this object, and which now amounts to 90*l.* a year. But the collection of apparatus existing at the time when the University grant was made was extremely antiquated and imperfect; and those who are acquainted with the costliness of physical apparatus when made with the precision which the accuracy of modern observations requires; and also with the number and variety of the instruments which are necessary for experimental work in the many different sciences included under the name of Physics; will have no difficulty in conceiving that this amount has not been found sufficient to establish a really satisfactory or complete Cabinet. A comparison of the apparatus in the Hyde Institute with that at the College de France or the Ecole Polytechnique in Paris would serve to show how much more must be done with the Oxford collection before it can be regarded as worthy either of the building in which it is placed or of the University to which it belongs.

112. A collection of scientific Books has been obtained for the purposes of the Museum, without any cost to the University, through the wise liberality of the Radcliffe Trustees, who have allowed their Library to be transferred from its former place in the Radcliffe Dome to the Museum, placing, at the same time, the Radcliffe Dome at the disposal of the Bodleian to be used as a Reading Room. A great advantage has thus been secured, both for the Bodleian and for the students at the Museum; an advantage which, so far as the latter are concerned, has been turned to the best account by the Radcliffe Librarian (Dr. Acland), who has arranged a well-selected Students' Library in the Reading Room, which also contains all recently purchased works, and a large collection of scientific periodicals. It is, perhaps, to be regretted that there is at Oxford no students' lending library except a very imperfect one of small extent which has been formed by the Ashmolean Society. It would be a great additional benefit to the Students of Natural Science if, under certain conditions and with proper exceptions, books were permitted to be taken from the Radcliffe Library, as is at present the case with the University Library at Cambridge.

113. The annual cost of the Museum, including the Hyde Institute, but not including the Radcliffe Library (the cost of which is entirely defrayed by the Radcliffe Trustees), amounts to 2,451*l.* Of this 376*l.* is defrayed out of certain trust funds — the Aldrichian Fund, the Tomlins Fund, the Hope Fund, and Lord Leigh's Fund. The remainder constitutes a charge upon the yearly income of the University. The annual expenditure is distributed as follows: for the Chemistry Department, 626*l.*; for the Physical Department, 655*l.*; for the Department of Zoology, 85*l.*; for the Physiological Department, 90*l.*; for General Purposes, 995*l.*; but, as a large proportion of the expenses of the Physiological Department and of the Zoological Department are defrayed under the item General Purposes, this statement can only be regarded as giving precise information with regard to the Departments of Chemistry and Physics.

114. The fees charged to the students in the laboratories for practical work are as follows: in the Department of Physiology, two guineas a term; in the Departments of Chemistry and of Physics, three guineas a term in each. The fees for lectures are in every case small, and many of the courses given by the professors are entirely gratuitous. The fixed salaries of the Demonstrators and Assistants, but not those of the Professors, are included in the above gross expenditure of 2,451*l.* a year.

115. The present condition of the Botanic Garden requires, and we have no doubt will receive, the immediate attention of the University.

Qu. 13,792. The Garden was founded in the year 1622 by Henry Danvers, Earl of Danby, and is said to be the oldest in the country. The Professor states: "The total area is under five acres, but that includes a great deal of ground which is made no use of at all for growing plants; it contains also the Professor's residence and the library, the museum, and the herbarium."

Qu. 13,757. "For the purposes of teaching, it is necessary, certainly, that we should have a garden of moderate size. I believe that a large garden is not required, but it should be a larger one than we have already. I believe also that we ought to have a large number of herbaceous plants, which are easy to keep up at a small expense. We ought also to have a large area covered with glass, but these houses ought to be low. \* \* \* They would not be expensive to keep up, while they would be cheap to build and cheap to keep in repair, and they would grow a great number of plants for us."

Qu. 13,755. "Financially it is in a bad condition. The keeping up of the garden has cost hitherto to considerably more than there are funds for its maintenance, or, rather, I ought to say, it has done so up to the present time, for there has been a considerable increase of nearly 100% a year, which would, under ordinary circumstances, be sufficient for all purposes; but owing to the great rise in the cost of labour and in the price of coal, particularly the latter, I am afraid that that sum will be eaten up, and we shall have nothing left for the repairs of the garden without further grants from the University."

Qu. 13,756. The state of efficiency of the garden for the purposes for which it was founded "is at present very bad. The gardens contain a large number of plants, but they are in very bad order, owing to the want of larger houses and more room. The gardens and houses are very small for the number of plants which we have got crowded into them. The houses also are in exceedingly bad repair, and in some cases they are absolutely falling to pieces."

The Herbarium contains (besides ancient collections made previous to the time of Linnæus, and now kept separate in order to illustrate the history of Botanical Science) a British Herbarium, intended as an herbarium of reference for students, and a General Herbarium, the gift of the late Mr. Fielding. This herbarium is described as being now in a good condition and as being one of the largest and most valuable in England, after those at Kew and in the British Museum. The cabinets in which it is placed are, however, "bad, and utterly unsuited for the purposes to which they are applied." It is now being rapidly arranged, and the post-Linnæan collections are being incorporated with it. The museum, containing collections of such parts of plants as cannot conveniently be incorporated with the herbarium, is in a bad condition, owing to the ravages of insects, and is so ill lighted as to be almost useless to students. The Professor thinks "it ought to be entirely remodelled." The library is "a very good one indeed, but it cannot be made of much use at present, at least not nearly of the use of which it ought to be capable, because it is separated from the Museum and from the Herbarium by the whole length of the garden; consequently, if you want any books at all to compare plants with, you have to go right through the garden to get them. It ought to be placed under the same roof with the Herbarium and with the Museum, in order to make it really useful." It further appears from the Professor's evidence that it is under the consideration of the University whether the garden might not be removed to the Park, where it would be in the immediate neighbourhood of the University Museum. The cost of putting the present garden into good working order is estimated at between 3,000% and 4,000%; the cost of removing would, of course, be greater.

Qu. 13,759.

Qu. 13,794.

\* See Appendix II.

116. We print, in the Appendix to this Report,\* a paper transmitted to us by the Rev. R. Main, the Radcliffe Observer, containing an outline of the history of the Radcliffe Observatory from its first foundation, in 1771, to the present time. From this paper it appears that the expenditure for the year 1870-1, which may be taken as an average year, amounted to 1,265*l.* 8*s.* 5*d.*, and that the present staff (which has never been exceeded) consists of the Observer, two Assistants, and one Computer. With this limited staff, Mr. Main has provided (1) for the prosecution of regular meridional observations of stars and certain planets; (2) for the tolerably constant use of the heliometer; (3) for the prosecution of the system of photographic meteorology, in addition to the usual eye observations of standard instruments; (4) for the regular reduction and publication of the Observations. The volume of observations annually published by the Radcliffe Trustees furnishes ample evidence of the great amount of successful work that is done at their Observatory.



117. The duties of the Radcliffe Observer are not educational, although the present Observer has at all times shown the greatest willingness to admit advanced and meritorious students to the benefits of practical instruction within the Observatory. Indeed, the great success of the Institution dates from the time when the offices of Radcliffe Observer and Savilian Professor of Astronomy were separated from one another; although, in consequence of the separation, the Savilian Professor of Astronomy was left but poorly supplied with instruments for educational purposes, and with none whatever suitable for research. The Professor states,\* however, that the University has recently granted the sum of 2,500*l.* for the purchase of a refracting telescope, of 12½ inches aperture, and for the erection of a suitable building to contain it; and that, at a still more recent period, Mr. Warren De La Rue has offered to the University "his well known reflecting telescope, together with all its valuable appurtenances, including " among them no less than four mirrors, each excellent of its kind, besides all the " mechanical means necessary for the most accurate grinding, polishing, and testing, " after Foucault's method, of large mirrors and object glasses;" so that the deficiency of appliances, under which the study of Astronomy at Oxford has hitherto laboured, may be regarded as on a fair way to be completely remedied.

\*Appendix  
III.

118. The general impression which has been made upon us by the evidence relating to the Scientific Institutions at Oxford is, that the University in recent times has acted with great liberality to Natural Science, and has shown the utmost willingness to recognize its claims as a great branch of education. But considering the great position so justly allowed to our ancient Universities, and the great opportunities of usefulness which their wealth and their prestige confer upon them, we think it would be a matter of regret if they should allow their Scientific Institutions to fall short of that standard of excellence which has been attained elsewhere; and we are obliged to say that although nothing can be more admirable, in many respects, than the arrangements of the Oxford Museum, as far as they have yet been carried, yet that in extent of appliances, and in completeness of range even for purely educational purposes, they are at the present moment far outdone by many Institutions upon the Continent of Europe.

## II.—Cambridge.

119. The following Scientific Institutions exist within, or in connexion with the University of Cambridge:—The Botanic Garden, the Observatory, the Cambridge Philosophical Society, the Woodwardian Museum, the New Museums, and the Physical Laboratory.

120. The Botanic Garden was founded by the Rev. Richard Walker, D.D., in 1762. The original site having been deemed unsuitable, both from size and position, a new garden was many years ago formed, a little outside the town. It is managed by a permanent Syndicate. The old site is partly occupied by the New Museums and lecture rooms.

121. The Observatory was erected in 1822–4, at an expense of upwards of 18,000*l.*, about one-third of which was raised by subscription, and the rest was granted out of the University chest. The transit instrument has recently been replaced by a very fine transit circle. There is also an excellently graduated mural circle of 8 feet diameter, and a large equatorially mounted refractor of nearly 12 inches aperture, the gift of the late Duke of Northumberland, Chancellor of the University. The other instruments need not be enumerated. The care of the Observatory was formerly attached by Grace of the Senate to the Plumian Professorship, but has now been attached to the Lowndean Professorship. The observations made at the Observatory are regularly reduced and published.

122. The Cambridge Philosophical Society was established in 1819, and obtained a charter in 1832. Though an independent corporate body, it has from the first been closely connected with the University. It was originally established by members of the University, and the charter provides that the fellows shall be graduates of the University. It publishes Transactions, which form a convenient vehicle in which members of the University can make known their original investigations to the scientific world. Eleven volumes of these important Transactions have already appeared. The evening meetings afford opportunity of scientific discussion and of making known original investigations, even though they may not afterwards be published in the Transactions. A few years ago the Society parted with its house, on being permitted by the University to occupy with its library a room in the New Museum. The evening meetings are held in a lecture room in the same building. A fine collection of stuffed British birds and one of British insects, formerly the property of the Society, have been given by the Society to the University, and now form part of the Zoological Museum.

Qu. 5108. 123. Ten years ago the geological and mineralogical collections were contained in two rooms under a wing of the University Library. A building on the side of the old Botanic Garden contained a single lecture room, which was used by the Professors of Chemistry and Botany and by the Jacksonian Professor. An adjacent room served as a laboratory for the Professor, but there was no students' laboratory. The botanical collection was contained in a store room, where nothing could be displayed, and the collection of comparative anatomy was contained in a small adjacent building where the specimens were most inconveniently crowded.

124. But about the year 1865, the University expended a sum of about 30,000*l.* in the erection of museums and lecture rooms in connexion with Natural Science, which have been built on the site of the old Botanic Garden. The mineralogical collection has been removed into a spacious and well-lighted room in this building, and the well-known Woodwardian Collection has expanded into the space formerly occupied by Mineralogy. The Botanical Collection, which, as we have explained, was formerly contained in a mere store room, is now arranged in the new building, to which also is removed the collection of apparatus belonging to the Jacksonian Professor. The building on the side of the garden, which formerly was used by three professors, is now entirely devoted to Chemistry, and, with certain additions and adaptations, now includes proper Laboratories both for the professor and for students. The collection of Comparative Anatomy, formerly so much crowded, is now properly displayed in a wing of the new building, and the building which formerly contained it is now devoted to Human Anatomy.

125. The New Museums contain no sufficient provision for the study of Experimental Physics. This want, which of late years has been strongly felt, has been met by the establishment of a Physical Laboratory, now being erected at the expense of the Chancellor.

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IV.—THE COLLEGES!

126. In relation to the Colleges, our attention has been principally directed to the following points :—(I.) The Scholarships; (II.) The Fellowships; (III.) The Organisation of the Instruction given in the Colleges in relation to the Instruction given in the Universities; (IV.) Contributions from the Colleges to a fund for University purposes.

I.—The Scholarships.

127. The following is a list (extracted from the *Oxford University Gazette*) of the whole number of scholarships filled up in the Colleges of the University of Oxford during the year 1872, and of the number of such scholarships appropriated to the various subjects of academical study. It should be observed that in the examination for classical scholarships, a mathematical paper is often set, which has some weight in the determination of the result, particularly when the classical merits of the candidates are nearly equally balanced. The exhibitions are so frequently filled up on the ground of merit shown in more than one direction that no attempt to classify them is made in the list.

128. The number of scholarships and exhibitions offered for competition may differ slightly from the number actually filled up, because no candidate of sufficient merit may present himself, or because, on the other hand, the College may be induced, by the excellence of the competitors, to give an additional scholarship or exhibition. Thus it would appear that in the year 1872, to which the following list relates, six Natural Science Scholarships were filled up, whereas only five were offered.

SCHOLARSHIPS filled up in Oxford from January to December 1872.

College.	Classics.	Mathematics.		Nat. Science		History.	Exhibitions.		Total No. of Scholarships and Exhibitions	Observations.		
		Value.	One	Value	One		Value	One			Value.	One
University Balliol	Two	£80	One	£80	—	£—	—	One	£—	4	*Local Examinations.	
	Two	80	One	80	One	80	One	80	—	12		
Merton	Two	80	One	80	One	80	—	—	—	4		
Exeter	Two	80	One	—	—	—	—	One†	64	4	†Theological.	
Oriel	Two	80	—	—	—	—	—	One	40	5	} Limited to Oriel.	
								One	21			
Queen's	One	75	One	75	—	—	—	Three	90†	5	†Two Classical and one Mathematical.	
								—	—			
New	One	100	—	—	—	—	—	Two	—	3	Does not include the Scholarships from Winchester.	
Lincoln	Five	80	—	—	—	—	—	—	—	8		
Magdalen	Three	95	Two	95	Two	95	**	One§	75	8	§Mathematical.	
Brasenose	Two	80	One	80	—	—	—	—	—	3		
Corpus Christi	Four	80	One	80	—	—	—	Four	50	9		
Christ-Church	Four	75	One	75	Two	75	—	—	—	7		
Trinity	Three	80	—	—	—	—	—	—	—	3		
St. John's	Two	100	—	—	—	—	—	—	—	8	Does not include the Scholarships from Merchant Taylors' School.	
	One	80	—	—	—	—	—	—	—			
Jesus	Six¶	80	—	—	—	—	—	Five¶	40	11	¶Confined to Wales for this turn.	
Wadham	Two	80	One	80	—	—	—	—	—	3		
Pembroke	Two	72 or	One	60	—	—	—	—	—	3		
	—	80	—	—	—	—	—	—	—			
Worcester	One	120	—	—	—	—	—	Three	—	6	Local Examinations.	
	One	75	—	—	—	—	—	One	—			
Keele	Two	50	—	—	—	—	—	—	—	2		
Magdalen Hall	Five	40 or	One	40	—	—	—	One	25	7		
		55	—	18	—	6	—	1	—	32	—	107

\*\* Questions are set in Modern History and Literature, with translations from French and German into English, and vice versa, as an alternative for the Classical papers.

129. It is evident upon a comparison of the numbers contained in this list that the Scholarships offered for Natural Science are but a small fraction of the whole number.

The state of the case appears to be that the Colleges do not offer Scholarships for Natural Science because they fear they would not get good candidates from the Schools; and the Schools do not teach Natural Science because they are afraid of injuring the prospects of their pupils by diminishing their chances of obtaining a Scholarship. It cannot be doubted that the effect upon the schools of this unequal distribution of rewards has been, and is, very discouraging to scientific study; and that it has exerted a most unfavourable influence upon the number of Natural Science Students. So important has this point appeared to some of the witnesses that we find Professor Clifton expressing the feeling that Scholarships for Natural Science are even more needed than Fellowships. "We want," he says, "more scholarships, and perhaps more fellowships. " I am not so certain about the fellowships, but certainly more scholarships are required " for science." In the same spirit Professor Jowett observes: "I think that there should be a much greater proportion of Scholarships [for Science] compared with " Fellowships. It appears to me much more important to make a number of students " than to reward a few, because what you want is to increase the supply of students."

Qu. 3011.

Qu. 3890.

130. Without being prepared to concur in this estimate of the relative value of the two objects, we are nevertheless of opinion that it is of great importance, with the view of promoting the study of Natural Science in the First Grade Schools throughout the country, that there should be an immediate, and ultimately a large, increase in the number of Scholarships offered for this subject by the Colleges.

## II.—The Fellowships.

131. The number of Fellowships in the University of Oxford is about 370. The number till recently was somewhat larger, and probably exceeded 400; but a reduction was effected by the changes introduced by the University Commission of 1854. Of these Fellowships, at the date of the return printed in the Appendix to Vol. 1\*, 120 were held in connexion with educational offices within the Colleges, and 23 in connexion with offices, such as bursarships, which, though not directly educational, are indispensable for the purposes of the college business and government. The remaining Fellowships are chiefly held by non-residents, and must be regarded as almost, if not entirely, sinecure offices.

\* See Appendix, vol. 1., pp. 25-27.

132. The condition of the University of Cambridge is not very different in this respect. The number of fellowships is about 350.† Of these about 120 are held by persons holding educational offices in the Colleges or the University, or other college offices similar to those just described, while the remaining 230 are chiefly held by non-residents.

† Appendix, vol. 1., p. 28.

133. Whether the existence of these sinecure fellowships is defensible is a question upon which the witnesses whom we have examined are not unanimous. Mr. Pattison is of opinion that the system should be entirely changed, as the following extracts from his evidence will show. *Qu.* "Do I understand that your proposal would be to suppress all " fellowships the holders of which are not employed in teaching, or in doing University " work of some kind?—I am afraid that if I were to say that 260 fellowships " should be suppressed, I might throw ridicule upon the whole proposal. \* \* \* \* \*

Qu. 3791.

Qu. 3792.

Qu. 3793.

*Qu.* Is it your opinion that a considerable proportion of them might be suppressed? "—I think that we are all prepared for a further very large suppression of fellowships, " but there is a great difference of opinion as to how far that should go. *Qu.* But you " are of opinion that men's minds are prepared for a very large suppression of non- " working fellowships?—I think that a large majority of the residents in the University " would be in favour of a further large suppression of fellowships."

Qu. 13,573.

Qu. 13,573.

Again, in reply to the question "I may say that the great preponderance of opinion " amongst the witnesses from the Universities who have been examined is, that a larger " amount goes in mere rewards than is at all called for, or is desirable—would you " be so good as to give us your view upon that point?" Lord Salisbury, the " Chancellor of the University of Oxford states, "Considering the amount of controversy " that prevails on University questions, it is astonishing how great an agreement there " is upon that point. I have heard from all schools, theological and political, in the " Universities, a coincidence of opinion that the present application of the revenues of " fellowships is exceedingly unsatisfactory."

Qu. 3975.

134. On the other hand, Professor Jowett observes, "I think that fellowships fulfil a " very important purpose, partly in supplying teachers to the University and still " more in supplying to young men the means of passing through the University into " a profession. That is a very great good which they do at present, and I should not " like to see it materially infringed upon. That a number of highly educated young " men are able to go to the bar or to some other profession, having leisure and being free " from pecuniary anxiety, and not being compelled to slave for the press, or lose their " time for the sake of making money for seven or eight years of their life, seems to me

“ to be a very great national good, and I should not wish to see that use of fellowships  
 “ infringed upon; but the property of the Colleges is greatly increasing, and I think we  
 “ can afford to supply a considerable sum for University purposes, without seriously  
 “ affecting the number of the fellowships.”

135. Whilst giving every weight to the considerations urged by Professor Jowett, and admitting to the fullest extent the great stimulus which the higher education has received at Oxford from the system of election to fellowships by open competition, we are nevertheless satisfied by the evidence laid before us that an unduly large proportion of the revenues of the Colleges is expended in sinecure fellowships; and we have reason to believe that this opinion is shared by a large and increasing number of the resident members of both Universities. We believe that if those fellowships which may properly be described as prize fellowships, were made terminable, so as to secure a rapid succession, it would be possible to effect a great reduction in their number, without weakening, to any important extent, the stimulus to education which is afforded by the present system. We also think their value might be diminished, at least in some cases.

136. It is doubtless advantageous to the country at large, as has been urged by some of our witnesses, that young men of ability, who choose to enter into one of the great professions, should be supported, or nearly so, in the early years of their professional career, and thereby be enabled to apply themselves at once to the higher studies of their profession, instead of wasting their energies in drudgery of some kind, for the mere purpose of obtaining a temporary livelihood. But this end may be secured by means of fellowships tenable only for a limited period. It has been urged that the feeling of security given by the system of unlimited tenure greatly enhances the value of a fellowship. No doubt it is a very comfortable thing for a young man to feel that, come what may, he is secure of an income so long as he chooses to remain single. But we can see no adequate reason why he should be thus comforted at the expense of the College, when he has preferred the more attractive prospect of a professional career in the outer world to the work of the College. And although there is a natural wish to deal tenderly with ill health, yet we cannot see that a general rule of unlimited tenure can be justified on the ground that it affords a provision in the exceptional cases of a failure of health, to the consequences of which men in general are exposed.

137. It has further been urged that the conditions under which a non-resident fellowship is at present held are such as sometimes to enervate rather than to stimulate the holder. A man who holds a fellowship is likely to feel that he is not absolutely dependent upon his professional work; and this feeling sometimes prevents him from throwing himself upon his own exertions. There are many instances of young men who persuade themselves that they have given their profession a fair trial, and make up their minds to abandon it, simply because, being in possession of a fellowship, they find that it is possible for them to lead a comfortable existence without going through the long-continued exertion and the tedious waiting which success in one of the great professions requires. To such men a moderate emolument, held for a limited period, might be even more advantageous than a fellowship held under its present conditions. Nor in estimating the use to the public of the fellowship system can we leave out of sight the loss of time that it entails to many men who ultimately fail to get a fellowship at all, but who linger on at the Universities for two or three years, after taking their degree, in the vain hope of obtaining one of these great prizes.

138. We are therefore decidedly of opinion that the fellowships awarded as prizes are excessive in number if not in value, and that the system ought to be remodelled. We are further of opinion that in any such remodelling a considerable proportion of the fellowships should be suppressed or consolidated for the purposes of contributing to the general fund of the University, and of endowing, within the Colleges and the University, new institutions, or new offices, in aid of Education or Research. But it must be remembered that, as Professor Jowett has stated, the property of the Colleges at Oxford, in some instances at least, is greatly increasing, so that quite independently of the suppression of fellowships there will in all probability be considerable sums available for these purposes. In any case, therefore, we are prepared to admit that a great part of the fellowships ought to be retained as fellowships, and the problem that has to be solved is how to employ those which are so retained in the most useful manner possible.

139. The following are the chief purposes to which, in our judgment, the fellowships should be applied:—

In the first place a certain but not a very large proportion of the fellowships will be always required, as at present, for the payment of the persons entrusted with the management of the college estates, and with the government and administration of the colleges themselves.

Secondly, a large number of the fellowships is at present employed, and probably a still larger number ought hereafter to be employed, in connexion with the Instruction given in the Colleges.

Thirdly, a smaller, but still a considerable number of fellowships ought to be employed as Terminable Prize Fellowships.

Fourthly, a certain number of fellowships ought, as we have already said, to be united with Professorships in the University; the University professor becoming *ex officio* a Fellow of the College and a member of its governing body.

Lastly, it is, in our opinion, most important that a certain number of fellowships should be appropriated to the Direct Promotion of Learning and Research in various directions. It has been objected to this proposal that the fellowship system, as hitherto administered, has not shown any great tendency to encourage Original Research, either in the field of learning or in that of science; that, when an office is created simply and solely with the view of giving a man leisure and opportunity for original research, there is always the appearance, to say the least, of creating a sinecure; and that it is impossible, as Professor Jowett has said, to get a man for money who can make a discovery. But, though you cannot get a man for money to make a discovery, you may enable a man who has shown a special capacity for research to exert his powers; and we are of opinion that, unless an effort is made to do this, one of the great purposes for which learned bodies, such as the Colleges, exist, may run the risk of being wholly lost sight of. Scientific discoveries rarely bring any direct profit to their authors, nor is it desirable that original investigation should be undertaken with a view to immediate pecuniary results. "Research," as Lord Salisbury has observed, "is unremunerative: it is highly desirable for the community that it should be pursued, and, therefore, the community must be content that funds should be set aside to be given, without any immediate and calculable return in work, to those by whom the research is to be pursued."

Qu. 13,566.

It may be that properly qualified candidates for such scientific offices would not at first be numerous, but we believe that eventually a considerable number of Fellowships might be advantageously devoted to the encouragement of Original Research.

140. We think that such fellowships as might be expressly destined for the advancement of Science and Learning should only be conferred on men who by their successful labours have already given proof of their earnest desire, and of their ability to promote knowledge; and we believe that appointments, made with a due regard to this principle, would be abundantly justified by results. A man who has once acquired the habit of original scientific work, is very unlikely ever to lose it excepting through a total failure of his health and strength; and even if it occasionally happened that a fellowship awarded on the grounds of merit, as shown in original research, should only contribute to the comfort of the declining years of an eminent man of science, there are many persons who would feel that it could not have been better expended in any other way.

141. We should not wish to attach any educational duties properly so called to a fellowship awarded with a view of encouraging Original Research in Science. But for many reasons we should think it desirable that the holder of such a fellowship should be expected to give an account, from time to time, in the form of public discourses, of the most recent researches in his own department of science.

142. We now proceed to offer some suggestions with regard to one of the most difficult questions relating to the Fellowships, the Conditions of their Tenure. In doing so, we think it desirable to treat separately the cases of fellowships held by those who aspire to make their way in the outer world, and by those who look to an University career.

143. In the case of the former, or non-resident class, the tenure of the fellowship should, as we have already said, be limited to a term of years; and we are disposed to think that a term of seven years would suffice for every useful purpose. In the case of such terminable fellowships, held by non-residents; the restriction of celibacy which, originating doubtless in the celibacy of the clergy, has been very generally retained as a means of leading to a more rapid succession, becomes unmeaning, and ought we think to be removed.

144. The most important use of the latter, or resident class of fellowships, is to enable the Universities to retain a large staff of able teachers and workers.

Qu. 3976.

145. From the evidence before us it appears that the colleges find some difficulty in obtaining efficient tutors and lecturers. Professor Jowett observes, "We have always a great difficulty about teachers. In fact, at Oxford the whole thing seems to require to be re-constituted; there is such a difficulty in keeping the best men there, and they stay for so short a time. If we are to keep men as teachers, we must get rid of the condition of celibacy."

146. There are other difficulties, which are not adverted to by Professor Jowett in these remarks, besides that occasioned by the restriction to celibacy. One of them is that in endeavouring to obtain teachers not only do the Colleges, to a certain extent, bid against one another, but each College bids against itself. A College offers a distinguished man, shortly after he has taken his degree, an income say of 250*l.* a year as a Fellow, and of 250*l.* a year additional as a Lecturer, so that, in fact, the College offers him 500*l.* a year if he will stay and be a teacher, but at the same moment it offers him 250*l.* a year even if he goes away. Under these circumstances we can hardly wonder that the inducements offered by tutorships and lectureships are not sufficient even in the first instance to command the services of the men whom it would be most desirable to retain; and the difficulty is greatly increased by the further fact that as the University system is at present organized the teaching offices in the Colleges do not offer any very inviting prospect of further advancement.

147. A man who accepts a fellowship and a lectureship in a college will find that at the end of 20 years' of service he is much less fit for the special work in which he has been engaged than he was when he began it, and probably he will also find that he has not been in the meantime preparing himself for any other occupation for which he would be more suitable, and in which he might obtain larger emoluments. In former times, when the connexion between fellowships and the obligation to take holy orders was almost universal, the difficulty which is here referred to did not arise. It was met by the system of College Livings. It was then the most natural thing in the world for a young clergyman to devote himself for nine or ten years to giving instruction in Classics and Theology, and if work of this kind was not continued too long it was generally thought to form no bad preparation for the duties of a parish priest. But at the present time, the Fellowships are very largely held by laymen, and there appears, for some reason, to be a growing disinclination on the part of the men who now engage in tuition in the Colleges to take Holy Orders. Thus the layman who becomes a college tutor or lecturer finds himself entirely cut off from every other profession, and dependent exclusively upon that of teaching, the great prizes of which are to be found in the Public Schools and not in the Colleges, inasmuch as the professorships are too few in number to offer much prospect of promotion within the University, while the headships are still to a great extent restricted to clergymen. It is not surprising under these circumstances, that there is a widespread feeling in the Universities that the tutorial system is falling into a state of disorganization. It is felt that the college tutorships and lectureships do not lead to any permanent positions in the end, although they are, perhaps, a little too highly paid at the beginning, if, at least, we regard the fellowship as part payment for the work done. What is wanted is a graduated succession of offices, such as would make the business of a College Tutor a profession which an able and distinguished young man might embrace without imprudence.

148. To a certain extent this want has been already supplied, in both Universities, by the increase which has recently taken place in the number and value of the Professorships. But, as we have already seen, these offices are still so few, and, in some cases, so poorly endowed as to offer little inducement to a man to look forward to an University career. Further do we not think that an University office is in every case the most fitting reward for a man who has shown himself eminently useful in College work.

149. We are, therefore, of opinion that it is to Offices within the Colleges that we must mainly look for inducements to able and useful men to devote themselves to College work. We think that one who has proved his success as an Educator, might fitly be elected to a Permanent (or, as we shall here call it, a Senior) Fellowship, which should be free from the restriction of celibacy, though subject, as a rule, to the condition of residence in the University and of readiness to take some part in the work of the College or the University.

150. A Senior Fellowship would also (in accordance with the recommendation already made) be fitly conferred on the ground of services rendered to Science or Learning by Original Research.

151. The question remains, what should be the status of a resident fellow who aspires to a senior fellowship?

152. An advantage attending the old system of tenure undoubtedly is, that while it does not offer a man a permanent provision unless he looks forward to leading a life of celibacy, it yet permits him to apply his mind to any course of study, free from all care as to his immediate future. We fear that the anxieties attending a short tenure would have the effect of discouraging men from engaging in Original Research; and even in the less uncertain career of Education, we fear that the prospect of election to a senior fellowship would be so uncertain that unless a considerably longer tenure were allowed

to Probationary (or, as we will now call them, Junior) Fellows than would suffice for non-residents engaging in professions, the University would be drained of its best men.

153. On the other hand, if there were no counterbalancing advantages in a non-resident fellowship, we fear the effect might be to cause men to linger on at the University who would do better to engage at once in a profession. We think, therefore, it might be advisable for the individual colleges to make such an adjustment between the advantages of the two kinds of fellowships as should preserve a due balance in their attractiveness.

154. The Junior Fellows might be expected to reside in college, and thereby aid in preserving the discipline of the place. Accordingly, the retention of a junior fellowship might in the discretion of the college be subject to the restriction of celibacy.

155. While it is only right to give a junior fellow ample time for exhibiting his capacity for an University career, it seems highly desirable to allow a fellow who had preferred the junior to the non-resident tenure, but who afterwards found that he was not suited for University Work or Original Investigation, and had small chance of promotion, to engage without delay in some profession independent of the University. We should, therefore, allow a junior fellow the option of stepping on to the non-resident tenure, in which case the same proportion of the whole time of tenure of a non-resident might be allowed to him as remained to him of his time of tenure as a junior. The option of a newly-elected fellow to be placed on the non-resident tenure, or of a junior to transfer himself to the non-resident class, should be limited by the restriction that there be at least a certain number of juniors, so as to preserve a sufficient staff of fellows resident in college.

156. The questions relating to the tenure of Fellowships, which we have now discussed, have been incidentally brought under our notice in various parts of the evidence which we have taken. These questions are also raised in a Memorial submitted to the First Lord of the Treasury, by a large number of influential resident members of the University of Cambridge, a copy of which has been forwarded to us, and will be found in the Appendix to this Report.\*

\* See Appendix IV.

157. We are convinced that the future interests of Scientific Study and Research at the two Universities must of necessity be greatly affected by any changes that may be made in the tenure of the Fellowships, and, consequently, in the Constitution of the Governing Bodies of the Colleges. But as we have not taken a complete body of Evidence on this subject, and as we consider that any attempt to do so would lead us into inquiries beyond the scope of our Commission, we shall abstain from offering any detailed recommendations with regard to these important questions. We desire, however, to express our conviction that if the Colleges are to become, to a greater degree than in times past, the homes of men distinguished for Original Research in Science, provision must be made for attaching such men in a permanent manner to the College Foundations, and for rendering them permanent members of the Governing Bodies.

158. The following proposals appear to us to sum up the results of the preceding discussion. To adapt them to the case of some of the smaller foundations, important modifications would be required; and, even in the case of the larger Colleges, we should wish them to be regarded only in the light of suggestions, which we feel to be worthy of attention, but at the same time to be by no means free from objection.

(1.) That there should be three classes of fellows, which we have distinguished as senior, junior, and non-resident.

(2.) That the senior fellowships should be permanent, and free from the restriction of celibacy, but subject, as a general rule, to the condition of residence in the University and readiness to take some part in the work of the College or University.

(3.) That the elections to the seniority should, in ordinary cases, be made from the class of juniors, but should not be limited to that class.

(4.) That the junior fellowships should be tenable for, say fourteen years, and should be subject to such restrictions as to residence in college and duties as may appear desirable to the several colleges.

(5.) That the non-resident fellowships should be tenable for about half that time, free from all restrictions.

(6.) That a person elected to an ordinary (as distinguished from a senior) fellowship should have the option of being placed on the junior or non-resident tenure, and that a junior fellow should at any time be at liberty to place himself on the non-resident tenure (but not conversely), with a proportionate allowance for the unexpired portion of his time of holding his fellowship as junior fellow; provided that the number of junior fellows be not suffered to sink below a certain minimum.

159. The effect of these proposals would be to constitute in each College a seniority of a very permanent kind, because its members would hold their places for life, and would be free from the restriction of celibacy. Whatever share in the government of the College it might be thought proper to assign to the holders of the terminable junior fellowships,



it is evident that the influence of such a permanent seniority would be very great, and that the prosperity of the College would depend in great measure on its constitution. According to the above proposals (taken in connexion with the recommendations we have already made), the seniority in each College would consist, (i.) of University Professors officially attached to the College; (ii.) of persons elected for eminent services to Learning or Science; (iii.) of men who had given some of the best years of their lives to the service of the College, and had proved their fitness for college work. It would be for the Universities, and the Colleges, to consider whether a body so constituted would be in all respects suitable for the important functions it would have to discharge. In particular, it would be worthy of careful consideration whether such a seniority should be allowed to appoint its own members by co-optation, or whether the whole body of fellows should elect, or whether the filling up of vacancies should be vested in some authority external to the College; or, lastly, whether some course intermediate between these several modes of procedure should be adopted.

160. With regard to the present system of appointment to fellowships in Oxford, we do not find that it has worked favourably for Natural Science. Until the last twenty years there were but few open fellowships, and of these none were offered in the University of Oxford for any subjects but those of Classical Literature, with a very rare exception in favour of Mathematics. A great change has taken place within the last twenty years, and the Statutes of most Colleges now require that their system of examination should be such as to render their fellowships accessible from time to time to proficiency in the various branches of study which are recognized in the Schools of the University for the time being. As Natural Science is one of these, it follows that it is the duty of every College which has this provision in its Statutes to offer from time to time a Fellowship for Natural Science. It is not easy to say how many fellowships have been given for Natural Science within the last twenty years, because fellowships are often given, and most properly so, not on the ground of merit in any one direction alone, but on the ground of proficiency in more than one subject. Roughly speaking, however, the number of fellowships that have been given exclusively, or principally, for all the subjects included under the general name of Natural Science, may be taken at twelve. The whole number of fellowships filled up by open competition during that time exceeded two hundred.

161. Although it thus appears that the number of fellowships given for Natural Science has been insignificant, we have evidence that there is no unwillingness on the part of the Colleges at Oxford to elect fellows in Natural Science; and we have repeated assurances from the Cambridge witnesses that no such reluctance is felt at that University. Since the system of open election to fellowships was introduced at Oxford, twenty years ago, the Colleges in general have carried it out in the most loyal spirit, and have shown themselves desirous of securing for their society the men of the most eminent ability whom they could obtain; and since the establishment of the Natural Sciences Tripos at Cambridge there have been several persons elected to Fellowships for proficiency in Natural Science. But the difficulty to which we have already referred with regard to the scholarships exists no less in the case of the fellowships. The Colleges at Oxford are afraid to offer fellowships for Natural Science on account of the smallness of the number of candidates; and the number of candidates is prevented from increasing by the uncertainty whether any fellowship will be offered. At Cambridge, on account of the smallness of the number of candidates, a high place in the Natural Sciences Tripos is not always by itself considered a sufficient guarantee of excellence, and the number of candidates is kept low partly by the uncertainty as to immediate reward in the shape of a fellowship, though in great measure, also, by the want of a promising career in after life. It must also be remembered that as the Colleges at Oxford have hitherto been literary rather than scientific societies, composed of persons well acquainted with certain branches of knowledge, and very competent to judge of literary ability in all its various directions, they have had a natural tendency to choose men of whose fitness to be fellows they could themselves form an opinion, rather than to take upon trust a man of whose merit they could only judge upon the testimony of others. But there is every reason to believe that if the electing body of any college in either of the two Universities were once satisfied of the eminent ability of a Natural Science candidate, they would be as glad to welcome him into their society as they would be if he had chosen to pursue one of the older branches of academical study. In the interest of Natural Science itself, it cannot be wished that fellowships should be rendered too easily accessible to Natural Science Students. A man who is elected as a Natural Science Fellow appears, in a certain sense, as a representative of science in a learned and very critical society; and it is extremely desirable that the representation should not be inadequate. What is to be desired in the interests of Natural Science Students

is not that the number of Fellowships appropriated to them should be immediately increased to any very great extent, but that they should be bestowed with more regularity than at present, and that their number should increase proportionately with the number and claims of Natural Science Students. It is very important for a Student to know that he will have a chance of obtaining a Fellowship within a year or two after taking his degree if he can show that he deserves one, and not to be perplexed by the feeling that, however fit he may be, he may not have a chance at all.

162. The evidence of Professor Clifton and Professor Jowett upon this point appears to us to deserve great attention.

163. At Cambridge the mode of awarding fellowships differs in some important particulars from that which prevails at Oxford. The most important difference is, that at Cambridge, as a rule, there are no Fellowship Examinations, but fellowships are awarded by the Colleges on the evidence furnished by the University Examinations. Trinity College, which forms about one-fourth of the whole University, is, indeed, an exception, for there fellowships are awarded by the result of a Fellowship Examination. At King's College also, admission to which formerly was confined to scholars coming from Eton, the present Statutes prescribe that the fellowships shall be awarded according to the result of a special examination. At St. John's College there is a Fellowship Examination, but the result appears to form only one element out of many whereby the electors judge of the merits of the candidates. At the smaller Colleges the merits of the candidates are judged of mainly by the results of the University Examinations.

164. This last remark leads us on to another important difference between the two Universities. At Oxford the Fellowships of each College are filled up in accordance with the results of a competitive examination held by the College, but open (when the fellowship is subject to no clerical restriction) to all members of the University who have passed the examinations required for the degree of Bachelor of Arts, and in many cases open also to all graduates of any University in the United Kingdom. At Cambridge, on the other hand, those Colleges which award their fellowships according to the result of a Fellowship Examination, open the examination, as a rule, only to members of the College, though the Statutes give power to the Governing Body, on any occasion when they think fit, to throw open the examination to members of the University. At the smaller Colleges it is generally understood that the electors look in the first instance to members of their own College; and in case there be no candidate of sufficient merit, or the needs of the College require a Fellow having some special qualifications not found among the otherwise eligible members of the College itself, they then "go out of college," as it is called, that is, elect to the Fellowship a member of some other College.

165. At Oxford, where the examinations for degrees are not competitive, it would be difficult to suggest any mode of electing to Fellowships other than that by competitive examination; but at Cambridge, where the names in the honour lists are arranged in order of merit, there is something to be said on both sides with respect to the desirableness or otherwise of special fellowship examinations. On the one hand, the wider study which such a system demands, enlarges the foundation which lies at the base of a subsequent career of professional activity or original research, as the case may be; and means are afforded of remedying the result of accidental failure in a final examination, such as might arise from temporary illness or other similar cause. On the other hand, it is urged with great force that by the time a man has taken his degree, supposing him to have been industrious while an undergraduate, he has had enough of study pursued with a view to the immediate production of his knowledge at a moment's notice; and that he should then be left free to pursue his studies in a more systematic and specialized manner, and his originality should be no longer cramped by preparation for an impending examination. We attach great importance to this freedom from the immediate pressure of examination at such a stage of the student's progress, and are disposed to regard the advantages which may attend the holding of special fellowship examinations as too dearly purchased by its sacrifice. But whatever differences may exist in the system of election to fellowships in the two Universities, we think it very desirable that in both of them alike original research should be encouraged by taking into account any evidence of power in this direction which a candidate for a fellowship is able to give.

### III.—The Organisation of the Instruction in the Colleges in relation to the Instruction given in the Universities.

166. The evidence before us is not favourable to the proposal that each college separately should institute a Laboratory for educational purposes. The reasons in favour of concentrating the practical instruction of the students to a considerable extent in a few institu-

tions are obvious. A considerable expenditure of time on the part of the Instructors, and of money on the part of the Colleges, would be occasioned if each College were to undertake a Laboratory of its own, and to teach its students in it. It is at once better for the students, and a more economical use of the funds of the Colleges, that the practical Instruction, so far as it is not given in the University Laboratories, should be given in Laboratories belonging not to a single College, but to a group of Colleges. It would be undesirable to prescribe, by any definite rule, what should be the division of labour between the University laboratories and the college laboratories, as this must depend on the discretion of the University Professors on the one hand and of the College authorities on the other. But the most convenient arrangement would probably be that the more elementary instruction should be given in the college laboratories, and that when the student had attained a certain degree of proficiency he should pass under the hands of the Professors in the central laboratories of the University.

167. There can be no doubt, however, that the institution of Separate College Laboratories might be of great use in promoting a spirit of Original Research among students who have already obtained their degree. It would probably be by no means either necessary or desirable, under existing conditions, that every college should contain a laboratory intended for purposes of this kind; but wherever it could conveniently be done, few things would be more to the credit of a College not merely as a place of education, but also as a Home of Learning and Science, than to have a place within its precincts in which any of its fellows or graduates who are inclined to devote their time to original inquiries should have opportunities of doing so with advantage. When the suggestion which we have already made, that certain Fellowships should be awarded with the express view of promoting original research and inquiry, is carried out, an immediate and obvious use for such laboratories will arise.

168. But whatever may be the case with the laboratories, it must be considered indispensable, so long as the present relations of the Colleges to the Universities continue, that the Colleges should appoint Lecturers in Natural Science. Without such Lecturers the students in Natural Science will be at considerable disadvantage as compared with their fellow students in classical or other literature. A great deal is done by a College Tutor for his pupils that cannot be expected from an University Professor. Every young man requires from time to time a certain amount of private instruction and private advice as to his studies, and also a certain amount of watchful control over them. Assistance of this kind is abundantly given by the college tutors to their pupils in mathematics, and in literature; and in every college in which there are Natural Science students it is extremely desirable that there should be some one capable of doing as much for them in regard to their scientific studies.

169. We are of opinion that the Lecturers in Natural Science, whom we should wish to see appointed in every college, might, besides giving private instruction to their college pupils, be most usefully employed in giving lectures, accessible to all the members of the University, upon various subjects of Natural Science. These lectures would probably be inter-collegiate, as are those already given by the existing College Lecturers on Natural Science.

170. As we have already stated at length with reference to the Scientific Subjects, a large proportion of the lectures, upon all subjects, which are now given in the Colleges are of an inter-collegiate character, three or four colleges uniting together and making a combined arrangement for their lectures, so that all the students of any one of the colleges are admitted to all the lectures of any other of the colleges entering into the arrangement. There exist already several groups of colleges formed upon this principle. The system, although of recent introduction, appears to have become firmly established, partly from the difficulty of supplying instruction in all the various subjects which are now admitted into the courses of study at the Universities, and partly from the feeling, that when the services of an able teacher have been secured by a college, his powers are, to a certain degree, wasted unless the advantage of his instruction can be extended beyond his own college.

171. The advantages of this united action, on the part of groups of colleges, are evident. It has not only rendered good instruction more widely available to the students, but it has done what is no less important—it has improved the quality of the lectures given. A college lecture given to the college pupils of the tutor was often given under rather depressing circumstances, and the result was not in every case satisfactory; but a lecture given to the students of three or four different colleges of necessity acquires a very different character. The lecturer has to do his best, and there can be no doubt that many of the inter-collegiate lectures are so excellent as to make it desirable that they should be delivered, not in a half private manner as College Lectures, but as public University Lectures.

172. But the disadvantages which arise from the incompleteness of the system are no less obvious. There are colleges included in these groups, but there are also colleges left out; and the system cannot be regarded as more than partially successful until some arrangements are adopted rendering possible the admission of these colleges into the existing groups, or the formation of new groups including them. In consequence of the incompleteness with which the principle of combination has been carried out, as well as in consequence of the great benefits which have resulted from its partial introduction, it is more and more generally felt that what has been done hitherto can be regarded only as the first step in the direction of a more regularly organized system of teaching in the Universities. The next step will probably be to give a recognized University position to the most eminent and successful of the College Lecturers, and thus to secure their services for the University at large.

173. The lectures which could most advantageously be given by the College Lecturers in Natural Science, would seem, under the present circumstances of the Universities, to be chiefly those which do not require experiments, or which require only very simple experiments, and very easily procurable specimens. Such lectures are of two very different kinds:—elementary lectures on various parts of Mechanical Philosophy, Chemistry, and Biology; and lectures suited to advanced students on the more theoretical parts of Natural Philosophy. It would be extremely desirable that lectures of both these kinds should be occasionally given in the colleges. Lectures of the first kind would supersede the necessity for elementary instruction in the same subjects being given by the Professors, and might thus relieve them in certain cases of a burdensome part of their duties. Lectures of the second sort would probably be given only at intervals and to small classes. Nothing could be more conducive to the usefulness of the Natural Science Lecturers, and, indeed, to their own improvement, than that they should be expected from time to time to give public instruction in special departments of Physical Science, and even in some of its most advanced theories; and it would be very undesirable, if indeed it were possible, to confine their duties to the giving of elementary lectures. As a general rule, the College Lecturers on Natural Science would be young men desirous of working their way upwards in the Universities; and it would be for their interest, as well as for that of the University at large, that they should have opportunities of showing, by their success as lecturers, their fitness for professorial offices. Their lectures would not necessarily have any formal University character, and might, or might not, be recognized by the University. They would be given by virtue of the right which the Universities have always recognized as belonging to every Master of Arts, that of giving public lectures, under what conditions he pleases, upon any subject included in the Faculty of Arts.

174. We have already referred to the existence at Christ-Church, Oxford, of the three Lee's Readerships in Physics, Chemistry, and Physiology. These Readers are supplied with working rooms and apparatus partly in Christ-Church itself, and partly in the University Museum, upon which Christ-Church has a claim for such accommodation, in consequence of its having lent to the University Museum a large number of biological specimens. It has been proposed that the Lee's Readerships should be made University offices; and there are certainly strong reasons in favour of the proposal, as the University would thus immediately gain what it greatly needs, an accession to its teaching power in these three branches. The change would involve a two-fold difficulty, which, however, need not be regarded as insuperable, partly on the side of the University and partly on the side of Christ-Church. Christ-Church might not wish to surrender the special advantage which its students derive from having their own Reader on the spot, and the University might not wish to accept as a Professor, or even as an Adjoint Professor, an officer elected by the governing body of Christ-Church.

Qu. 3815.

175. One other particular suggestion has been made to which we think it right to refer. It has been thought that it might be advantageous to devote one or more colleges separately, and especially to the Natural Sciences. We confess that we do not look upon this proposal with favour. If it were possible only in this way to obtain a home for Science and for scientific men within the Universities, we should have no hesitation in considering the plan one worthy of adoption; but as this is far from being the case, we consider that the objections to it outweigh the considerations that may be urged in its favour. In the first place there would be an almost insuperable difficulty in carrying out such a measure. It would probably be regarded as a very revolutionary proceeding to seize upon a particular college and to devote it to one particular branch of learning or science, although a precedent for such a measure has to a certain extent been furnished by the Commissioners of 1854, in the manner in which they dealt with the exceptional circumstances of All Souls' College. But we feel even more strongly that the interests of

Natural Science would be most imperfectly served by such a measure. Its position in relation to the various branches of learning is not one of separation or antagonism; it should rather be regarded as running through the whole of human knowledge, and as inseparably blended with every part of it. We think that it would be better both for science and for learning that they should be intermingled together in the different colleges in such proportions as the requirements of education in the Universities and in the country may, from time to time, seem to render necessary, rather than that an endeavour should be made to separate the one from the other in any arbitrary manner.

\* IV.—Contributions from the Colleges to a Fund for University Purposes.

176. We have already more than once referred to the proposal that a general University fund should be formed, to which the Colleges should contribute. It appears to be generally admitted that the Universities have a real claim (though one of a somewhat vague and undefined nature) to be supported or at least assisted by the Colleges; and the fact is unquestioned that while some of the Colleges are very wealthy the Universities are comparatively poor. The income of the University of Oxford is derived partly from endowment, partly from the profits of its Press, but, to a very great extent, from the taxation of its members. The gross amount of income in the year 1871-72 was 31,718*l.* 19*s.* 4*d.*, and the gross expenditure was 30,730*l.* 15*s.* 2*d.* The condition of the University of Cambridge is very similar to that of Oxford, but a larger proportion of its income is derived from taxation. The gross amount of income was, in the last year, 23,206*l.* 18*s.* 2*d.*, and the gross expenditure, exclusive of investment of a portion of the balance in the hands of the Vice-Chancellor, was 22,400*l.* 19*s.* 6*d.* So that it will be seen that although, in the case of both Universities, there is a certain surplus of income above expenditure, it is not greatly in excess of what, must necessarily be reserved for contingencies.

177. The evidence before us leads us to believe that, as soon as objects are clearly defined for which the Universities require assistance, the Colleges, generally speaking, would be ready to consider them favourably, but that they would be reluctant (and not unnaturally so) to contribute a fund until it was known for what purposes that fund was intended. So much depends upon the relations as to teaching that may ultimately be established between the Universities and the Colleges, that it is very difficult to say what sum may eventually be required by the Universities.

178. Besides the Professorships in Natural Science, the foundation of which we have already pointed out to be urgently necessary, it is probable that many Professorships, or Public Readerships, in other branches of Learning are indispensably required. In illustration of this remark it may be perhaps not improper to mention that no public lectureship on the English language or English literature exists at either University. But, without entering further upon matters which lie beyond our province, it is especially important for us to notice that in the case of the Natural Sciences a large outlay for Laboratories, and the other material appliances necessary for the cultivation of science, is required over and above the expenditure necessary for the payment of Professors, Adjoint Professors, and Demonstrators. This disadvantage in the position occupied by Natural Science is inherent in the nature of the case, and cannot be remedied; but it should be borne in mind that the difference between the Natural Sciences and the various Departments of Literature is to a certain extent more apparent than real. In former times the great libraries, which are indispensably necessary for the study of ancient literature and learning, were formed at a vast cost, and were placed in buildings not unworthy of the objects which it was sought to promote. The debt of gratitude which we owe to those who in past times rendered this service to their successors is very great; but while we acknowledge this debt, we must remember that on the present generation the duty has clearly devolved of imitating their example, and of setting by the side of those institutions which former ages created for the Advancement of Learning, other institutions founded in a similar spirit, and devoted to the Advancement of the Sciences of Observation and Experiment. In claiming for Natural Science a large share of whatever funds may be contributed to the Universities by the Colleges, we do so in no spirit of illiberality towards the older studies, but only from the feeling that they have been, to a great extent, provided for in the past, and that the time has now arrived in which the newer studies ought to be placed in a similar position of advantage.

## V. THE RELATION OF THE UNIVERSITIES TO TECHNICAL EDUCATION, AND TO EDUCATION FOR SCIENTIFIC PROFESSIONS.

179. If for the moment we regard the Universities simply as educational bodies, and leave out of sight their duties as upholders of learning and promoters of original inquiry and research, we can have no hesitation in admitting that their main function in relation to science is to maintain its position as a part of liberal education. How this is to be done is no doubt well understood at the Universities themselves, and it is only for the sake of completeness that we refer to it here. The art of doing it consists, in the first place, in teaching well whatever parts of science are taught at all, and, in the second place, in selecting for the instruction of the general student such parts of science as tend best to give him a correct idea of its whole structure, and are most likely to be useful to him in his subsequent course of life. But subordinate to this general function of maintaining science as a great and necessary part of liberal education, there are other more special considerations which ought not to be wholly lost sight of. Foremost amongst these is the immediate necessity which has arisen for supplying the country with a highly educated class of Teachers of Science. In consequence of the improvement which has taken place in the First Grade Schools, there is an increasing demand throughout the country for good scientific teachers, and it is probable that at the present moment the demand exceeds the supply. It is to the Universities that we must look to meet this demand, and to meet it in as perfect a manner as they can. The smallness of the number of science students at Oxford and Cambridge has been made, and with some justice, a ground of reproach; but it would not be fair to measure the usefulness of the Schools of Science at the two Universities by the number of their students. It must be remembered that more is done for the ultimate diffusion of scientific knowledge throughout the country by supplying the first grade schools with three or four first-rate teachers in the course of a single year, than by giving during the same time a good education in the elements of science to a much larger number of general students. It is, therefore, of much importance that the education of students of science should be such as especially to fit them to become teachers of it; and to this point, we believe, much attention is at present paid.

Qu. 3897.

180. But the profession of teaching is not the only profession for which science students should be prepared; although it is, perhaps, the only profession for which they should obtain a complete preparation at the Universities. Professor Jowett observes, "I am inclined to think that physical science can only be spread in one way, and that is by connecting it with the professions. There are two professions with which you would naturally connect it—the medical profession and the profession of an engineer; and if you want to increase the number of physical science students and to arouse the spirit of physical science in the University, you must draw from those two classes of students of medicine and engineering." Without altogether adopting this view, we are, nevertheless, prepared to admit that only a few young men are able to devote themselves for two or three years to any pursuit whatever without being able to see definitely whether the pursuit is one by which they will be able to live afterwards. Unless, therefore, science students can be made to feel that their study of science is leading them up to a profession in which they can maintain themselves, their numbers are not likely to receive any large accession.

181. The principal professions for which extensive preliminary scientific studies are required, are, the profession of medicine, the professions of consulting and manufacturing chemistry, and of civil, mechanical, and telegraphic engineering in all its various branches. With regard to all of these the tendency of a great amount of the evidence which has been laid before us is to show that the Universities ought not to undertake to give direct professional or technical instruction. For example, the difficulties in the way of making either Oxford or Cambridge into a great School of Medicine are very considerable. It is sufficient to advert to the size of the towns, and the consequent smallness of the hospitals that could be placed at the disposal of the students, as one circumstance amongst many which would render such an attempt unadvisable. Nor are the difficulties less which stand in the way of any attempt to give a complete education in civil engineering at these Universities. According to the evidence which we have taken, so much of this education must of necessity be practical, that a complete technical education in engineering cannot possibly be given in a town in which there are no manufactures. On the other hand, the professions of medicine and of civil engineering both require, though in different directions, very thorough and very extensive preliminary scientific training; and in these professions the feeling appears to be

growing that the highest possible development should be given to these preliminary studies. It is our opinion, therefore, that the Universities should provide to the fullest extent for the theoretical instruction of such professional students.

182. There would probably be no difficulty in securing this object, so far as the profession of Medicine is concerned, if the department of Biology in each of the Universities should hereafter receive an adequate organization,

183. With regard to Civil Engineering, at Cambridge the Jacksonian Professor gives a course of lectures on the Principles of Mechanism, and the Professor of Experimental Physics gives courses on different branches of that subject, but there is no Professor of Civil Engineering, unless the Jacksonian Professor can be regarded as such. The only preliminary instruction that is offered by the University of Oxford is that to be obtained in the Hyde Institute; and considering the great number of subjects which have to be taught in that Institution, it would be too much to expect that a course of instruction could be provided there exactly suited to the wants of professional students. The first step towards meeting these wants would be to provide a Professorship of Civil Engineering, and to place such appliances at the disposal of the Professor as would enable him to give to students intending to devote themselves to that profession the same kind of assistance which is now given with so much ability and success in Scotland at Edinburgh and Glasgow, and in Ireland at Trinity College, and in the Colleges of the Queen's University. The functions which might be usefully discharged by an University Professor of Civil Engineering are stated with great clearness in the evidence of the late Professor Rankine. Qn. 9506,  
9512.

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VI.—THE DUTY OF THE UNIVERSITIES AND COLLEGES WITH REGARD TO THE ADVANCEMENT OF SCIENCE.

*Research a primary Duty of the Universities.*

184. On no point are the witnesses whom we have examined more united than they are in the expression of the feeling that it is a Primary Duty of the Universities to assist in the Advancement of Learning and Science, and not to be content with the position of merely educational bodies. We entirely concur with the impression thus conveyed to us by the evidence, and we are of opinion that the subject is one to which it is impossible to call attention too strongly. We think that if the Universities should fail to recognize the duty of promoting Original Research, they would be in danger of ceasing to be centres of intellectual activity, and a means of advancing science would be lost sight of which, in this country, could not easily be supplied in any other way. There is no doubt that at the present time there is a very strong feeling in the country in favour of the wide diffusion of education, and of the improvement of all arrangements and appliances which tend to promote it, from the simplest forms of primary instruction up to the most advanced teaching that can be given in an University. But there is some reason to believe that the Preservation and Increase of Knowledge are objects which are not as generally appreciated by the public, and of which the importance is not so widely felt as it should be. On this point we would direct especial attention to the remarks of Sir Benjamin Brodie: "For education we construct an elaborate and costly machinery, and are willing, for this end, to make sacrifices; but, on the other hand, the far more difficult task of extending knowledge is left to the care of individuals, to be accomplished as it may; and yet it is this alone which renders education itself possible. I really am inclined to think that in former days a more real and earnest desire must have existed to preserve knowledge as a valuable national commodity for its own sake than exists now; and the reason that I say this is, that we have existing in the Universities of Oxford and Cambridge records of another condition of things with regard to knowledge than that which exists at present. In the first place we have extensive libraries which could only have been founded and preserved for the sake of the preservation of knowledge itself; and in the next place the collegiate foundations in the Universities were originally and fundamentally, although not absolutely and entirely, destined for the same objects. \* \* \* This object is certainly not less important in modern than in ancient society. I presume that in the middle ages knowledge would altogether have perished if it had not been for such foundations, and it appears that now from other causes the pursuit of knowledge and of general scientific investigation is subject to very real dangers, though of another kind to those which then prevailed, and which make it very desirable for us to preserve any institutions through which scientific discovery and the investigation of truth may be promoted. \* \* \* The dangers to which I refer, are dangers which arise partly even from the growing perception of the practical importance of knowledge, which causes a very great draught indeed to be made upon the scientific intelligence of the country. In the first place, almost every scientific man is caught up instantly for educational purposes, for the object of teaching alone; and, in the next place, a very great draught indeed is made upon science for economical purposes; I mean for purposes connected with practical life. In sanitary matters we have numerous examples of the vast amount of work done by scientific men for public and practical objects. So that the supply of scientific men is not equal to the demand for those objects alone. Manufactures offer another great field of scientific employment, and it is to be observed that these are the only ways through which an income can be obtained, the pursuit of scientific truth being an absolutely unremunerative occupation."

185. We believe that the dangers referred to in these remarks are real; and their existence induces us to lay down, as emphatically as possible, the position that the Promotion of Original Work in Science should be regarded as one of the Main Functions of the Universities, and should be specially incumbent upon the holders of those fellowships which, as we have already recommended, should be awarded with a view to encouraging original research. As regards the Professors, we have already insisted on the importance of so arranging their duties as to give them abundant leisure, and, what is no less indispensable, abundant opportunities for Original Investigation, by providing the external appliances necessary for it. We think that the great national interests connected with the advancement of science form one, although only one, of the grounds upon which the endowment of professorial offices is defensible, and regard it as a great advantage that



an opportunity is afforded by the peculiar circumstances of the Universities of giving encouragement and maintenance to a class of persons who are competent to advance science, and who are willing to make its advancement the principal business of their lives.

186 We have already stated, but we would repeat it here, that we would on no account have offices founded within the Universities without special duties attached to them. It is an absolute advantage, if not in all, at least in many cases, to a man who is engaged in some abstract part of science, to be compelled to produce, in the form of public discourses, the results of his labours; and it can be no disadvantage to him, under any circumstances, to be obliged to devote some moderate part of his time to showing, if it were only by the example of his own work, to younger men, how scientific studies should be carried on with the view of promoting human knowledge. We believe that in all ordinary cases a certain amount of educational work is of advantage to the scientific worker, and we also believe that for the promotion of the highest scientific education it is very desirable to bring the original worker into direct personal contact with the student.

187. We have also already spoken of the propriety of awarding Fellowships in certain instances, not, as at present, by an examination test, but for services rendered to Science in Original Research. Although we should wish, as we have already said, to see this done from time to time (as it has already been done at Cambridge) in the case of persons who have already made themselves eminent in science, and whose accepting the Fellowship is rather to confer an honour upon the office than to receive one from it, we also think that a wider application should be given to this principle; and, that whenever a Fellowship in Natural Science is offered for competition among the younger Graduates of the University, such evidence as any candidate can offer of his aptitude to become an useful worker in science, should always be taken into account in the award. Nothing, we believe, would tend to give the students at the Universities so just an idea of what science is, or of what the objects are which those who pursue it should have in view, as the adoption of the principle by the Universities and the Colleges, that the highest honours and rewards in Natural Science are to be conferred upon men who can offer some evidence that their names are likely afterwards to find a place on the list of those who have added to human knowledge.

188. The proposals to which we attach the most importance with a view to the Encouragement of Original Research at the Universities are the two to which we have just referred: (i.) the Establishment of a complete Scientific Professoriate; (ii.) the Appropriation, under certain conditions, of Fellowships to the Maintenance of Persons engaged in Original Research. But, in addition to these main proposals, other suggestions are contained in the evidence before us, to which we would call especial attention: (i.) that Laboratories should be founded expressly intended for Research, and for the Training of Advanced Students in the methods of research; (ii.) that Scientific Museums and Collections should be maintained to an extent beyond what is required for purely educational purposes; (iii.) that a Doctorate in Science should be instituted.

#### *Proposed Laboratories for Research.*

189. It is one of the disadvantages of an University course that a young man, up to the time of taking his degree, is straining every nerve in order to master a certain amount of knowledge in which he has to pass an examination; and however improving this process may be to him in certain respects, the impression is widely entertained that it is not calculated to develop the originality of his mind, or those peculiar qualities which fit a man to become a discoverer in Science. As it is indispensably necessary that the student should be well grounded in his work, and should have a thorough comprehension of the methods and principles of his branch of science, before he attempts to add to it, it is not easy to see how this disadvantage could be remedied during his undergraduate course; but as soon as his examinations are passed, it is surely time that he should be led to regard his studies from another point of view, and to give them a different direction. He should then be placed in a laboratory devoted to original research, and under the immediate care of persons who are principally engaged in work of that nature.

On this point we would again refer to the evidence of Sir Benjamin Brodie: "I should like (speaking of my own department and departments which are cognate with it, and I have no doubt that the same remark would also apply to Physiology and to other subjects) to see those professors have under their control laboratories suited for scientific research and investigation, in which they should take a certain limited number of students who would work, partly as their pupils and partly as their assistants, for those ends. And I should myself say that this is an educational

Qa. 3593.

“function of the most important character possible, because you would here really carry scientific education to its end. If you do not do this you stop short of the most important part of all in scientific education. Now the real perfection of science is shown only in scientific inquiry—the perfection of science not only in its general results, but the perfection of science as an instrument for education; and if you leave out in the University system any provision for scientific research, you are leaving out the most important feature of the subject. Those pupils would be persons who would ultimately pursue the science as their main business in life, and become in their turn the teachers and the professors of the subject. I am not giving a mere chimera or dream, but this is already, though not exactly in the way that I am suggesting, carried out to a great extent in Germany.”

Qu. 5867. No less important, as giving one view of this question, is the evidence which we have received from Dr. Frankland, who says, “In my opinion the cause of this slow progress of original research [in England] depends, in the first place, upon the want of suitable buildings for conducting the necessary experiments connected with research; secondly upon the want of funds to defray the expenses of those inquiries, these expenses being sometimes very considerable; but, thirdly and chiefly, I believe that the cause lies in the entire non-recognition of original research by any of our Universities. Even the University of London, which has been foremost in advancing instruction in experimental science, gives its highest degree in science without requiring any proof that the candidate possesses the faculty of original research, or is competent to extend the boundaries of the science in which he graduates. I consider that this circumstance is the one which chiefly affects the progress of research in this country, because if we inquire into the origin of those numerous Memoirs upon original investigations that come from Germany, we find that a considerable proportion of them are investigations made by men who are going in for their science degrees, and who are compelled, in the first instance, to make those investigations, and they attain by that means the faculty and liking for original research, and frequently follow it out afterwards; so that a considerable proportion of the papers themselves are contributed in the first place by those men going in for degrees, and a considerable proportion of the remainder are obtained, I believe, through the influence of this previous training in research upon the men who have taken the degrees. Further, the entire ignoring of research in the giving of degrees in this country diverts also, or has a tendency to divert, the attention of the professors and teachers in this country from original research. They have not to take it into their consideration in the training of their students; they have not to devise, as is the case in Germany, suitable subjects for research to be pursued by their students; and thus their attention is, as it were, taken away entirely from this highest field of science. And, indeed, if they themselves devote some of their time to original research, it almost appears to them to be a neglect of their class duties, because their class duties do not require it. Their students are to be trained for subjects which are foreign to original research; they are to be trained chiefly in subjects that are to be taught by lectures, and by what I should call ‘descriptive,’ as distinguished from ‘experimental’ or ‘practical’ teaching; and, consequently, I think that in both ways—both by not bringing students into contact with original experimental work, and by diverting the attention of the teachers and professors in this country from such work, great damage is done to the progress of investigation in Great Britain by the attitude of our Universities.”

190. Sir William Thomson has gone even further, and has expressed an opinion that the systems of examination in the Universities, as at present arranged, so far from doing anything to encourage the spirit of scientific research, have an exactly opposite tendency. Qu. 10,741. “That to some degree, competitive examinations produce an elementary smattering of science I have no doubt whatever, but I cannot see that they produce much beneficial influence; and in the higher parts especially, they have, I fear, a very fatally injurious tendency in obstructing the progress of science.”

191. The kind of assistance which we should desire to see given in the English Universities to young men who have completed their University course, and who propose to adopt a scientific career, has been from time to time afforded at various institutions in the United Kingdom, among which we may particularly mention the Laboratory of the University of Glasgow, under the direction of Sir W. Thomson. The plan has been adopted in some of the German Universities, and even in the great Polytechnic Schools of that country. In France it has recently been organized on a most complete and extensive scale. The *École Pratique des Hautes Études* is a Government Institution of which the object is to encourage young men to devote themselves to scientific research, and to give them

opportunities of learning its methods. The course pursued by this Institution is to take young men who have completed their preliminary scientific studies, and, allowing them an annual stipend to defray the expenses of their maintenance, to place them under the care of competent professors, who give them assistance and advice in their first researches, and to whom they afterwards become useful. This plan appears to us so excellent in itself, and at the same time so academic in its general character, that we desire to recommend it for adoption at Oxford and Cambridge. To insure due attention to both classes of students, it would be proper that the laboratories intended for training in the methods of research should be distinct from those in which more elementary instruction is given.

192. We are also of opinion that arrangements should be made, in some of the public buildings of the Universities, for giving opportunities to members of the Universities, no longer *in statu pupillari*, of prosecuting researches; although we should regard it of primary importance that these arrangements should be such as not to interfere with the teaching duties, or with the scientific work, of the Professors. We agree with Dr. Frankland that one "cause of the slow progress of original research" in England is "the want of suitable buildings for conducting the necessary experiments connected with research;" and we think that the Universities might, with great propriety, supply this want, so far as their own members are concerned. We also think that collections of apparatus should be formed, which should be available for the use of such independent workers in science. There are some obvious difficulties involved in this plan, which has been strongly recommended by some of our witnesses, but which, so far as we are aware, has not been anywhere practically tried. We should, however, look with confidence to such a body as the proposed "University Council of Science" to frame suitable regulations as to the fitness of the persons admitted to the privilege of working in an University laboratory, and as to the securities to be taken for proper care in the use of valuable instruments. We are disposed to think that, under the special circumstances of the Universities, they would do more to promote original work by offering facilities of the kind which we have described than by making grants of money similar to those which are made in aid of special researches by the Government Grant Committee of the Royal Society. The plan would have the collateral advantage of rendering residence at the Universities attractive to scientific men.

Qu. 3543-5.

Qu. 11,820-

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#### *Proposed Special Scientific Collections.*

193. Although we think it desirable that Scientific Museums and Collections should be maintained in the Universities to an extent which would render them available for original research, as well as for the purposes of education, we do not attach the same importance to this point as to the preceding, because museums and collections have been formed and will be formed in other places than in Universities, whereas laboratories adapted for the instruction of students in the methods of scientific investigation are not likely to be founded except in connexion with educational institutions; and although it is a disadvantage to a scientific man not to have all the collections that he desires immediately at his hand, yet, considering the proximity of the Universities to London, it cannot be said that this disadvantage amounts to more than an inconvenience.

194. We also are of opinion that it is very desirable that such more extensive collections as may be formed in the Universities should, as far as possible, be kept separate from the more limited collections intended for educational purposes. A Museum may be very easily made too large for these purposes, and instead of giving the student clearer ideas, may serve to confuse him.

#### *Proposed Doctorate in Science.*

195. We have already referred to the possibility of instituting Higher Degrees, to be conferred upon students, not in accordance with the results of an examination, but upon their giving proof of capacity for original research. The evidence of Dr. Frankland and of Sir William Thomson, which we have already quoted, and to which we might add that of the late Professor Rankine, appears to us conclusive upon the point that there is a real danger in the examination system; and in our opinion this danger might be guarded against by instituting a higher degree in science, the obtaining of which should be regarded as a great honour, and which should not be awarded except with reference to original work. The plan of requiring from a candidate for the Doctorate in Science a dissertation embodying an account of some original research of his own is strongly approved by such competent witnesses as Dr. Siemens, Dr. Carpenter, and Professor Frankland. This plan has been adopted in several of the German Universities, and has now become the established rule in France.

## VII.—CONCLUSION.

196. In concluding our report we beg leave to point out that in regard to many of the most important questions, the evidence of the witnesses is, on the whole, characterized by a remarkable unanimity; while with regard to a few points of primary interest, and a large number of details, there is a considerable divergence of opinion. Taken as a whole, the evidence has convinced us, that, although much has been done in the Universities towards the Promotion of Scientific Education and Research, much remains to be done; and that changes, or at least extensions, of no inconsiderable importance have now become indispensable, if the work, which has been so well begun, is to be continued successfully. We have endeavoured to indicate what, in our own judgment, should be the general direction of such changes, and we have not altogether abstained from offering suggestions as to particular modifications or improvements of existing arrangements: but we are sensible that questions of detail are likely to be best discussed in the Universities themselves, where they will come under the consideration of persons who have made the theory and practice of education the business of their lives, and whose judgment, on all points connected with the working of their own system, ought to carry great weight.

All of which we humbly beg leave to submit for Your Majesty's gracious consideration.

(Signed)      DEVONSHIRE.  
                   LANSDOWNE.  
                   JOHN LUBBOCK.  
                   \*J. P. KAY-SHUTTLEWORTH.  
                   B. SAMUELSON.  
                   \*W. SHARPEY.  
                   \*G. G. STOKES.  
                   HENRY J. S. SMITH.  
                   \*T. H. HUXLEY.

\* These Commissioners have authorized the Chairman to append their names to the Report, in consequence of their absence from London.

J. NORMAN LOCKYER,  
                   Secretary.

1st August 1873.

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# APPENDIX TO THIRD REPORT.

## APPENDIX I.

LETTER addressed to the VICE-CHANCELLOR of the UNIVERSITY of OXFORD by the LINACRE PROFESSOR of PHYSIOLOGY in the UNIVERSITY.

" Oxford, May 7, 1873

" DEAR MR. VICE-CHANCELLOR,

" MY knowledge of the active interest which you have for many years taken in the promotion of the study of the Natural Sciences, has made me think that a statement of the present position and requirements of Biology in Oxford might with some appropriateness take the form of a letter addressed to you

" I wish, in the first place, to give a sketch of the plan in conformity with which the work done in my Department of the University Museum is carried on at present, and with this sketch I will combine a statement of the cost at which that work is accomplished. Having done this, I propose, in the second place, to point out in what directions the plan in question admits of, or rather calls for, expansion, and at what increase in expenditure. Thirdly, I propose to give an outline view of what in my opinion should ultimately be the arrangement of the Department of Biology, including under this term Human and Comparative Anatomy, Zoology, and Physiology

" I. At the present time the principal work done in the Department of the University Museum which is entrusted to the Linacre Professor, consists in the provision of the means, material and other, required for the adequate preparation of Students for the Honour Examination in the Natural Science School. A large part of the Vacation-time of the Senior Demonstrator and the Professor is taken up in seeing to the material means necessary for the use of such Students, that is to say, to the procuring and preparation of Specimens, and during Term-time the needs of a class of about thirty Students, in the way of Lectures, Practical and Catechetical Classes and Demonstrations, leave little leisure for anything else to their Teachers. In addition, however, to Students preparing for the Natural Science School, we have from Term to Term Students working in the Department who, after taking their Degrees, stay in Oxford for the purpose of further study, and mostly for the special purpose of qualifying themselves to become Medical Practitioners. For such Students means for learning Anthropotomy have from time to time, as for example during the past year, been provided. Finally, a certain amount of original work has been carried on by Students and others working in the Anatomical Department, and employing the means there made available for purposes of research. The earliest paper of this kind was one written by Dr Church, formerly Lee's Reader in Anatomy at Ch Ch, shortly after the opening of the Anatomical Department in the University Museum; and the latest is one shortly to be published in the Royal Society's Transactions, written by Mr H W Moseley of Exeter College, now one of the Naturalists on H M S 'Challenger'. Thus it may be seen that there are three distinct lines of work carried on in the Anatomical Department of the University Museum; the first and the most engrossing of which aims at meeting the requirements of Students for the Natural Science School, whilst the second is intended to help men who, having passed that School, wish to prepare themselves by the practice of Human Dissection for the Medical Profession; and the third terminates in the production of Original Memoirs.

" The entire cost at which the work of the Biological Department is carried on is, exclusively of coal and gas in the way of outgoings, and of the fees of Students in the way of income, about 500*l* per annum; of which sum 300*l* only is paid by the University. The account of the Biological Department with the University stands thus: for 'the maintenance of Collections' and for 'current expenses,' including herein the wages of a servant, 225*l* is on an average required and expended, 145*l* is required for 'the maintenance of Collections,' that is to say, for the procuring and preparing of specimens, and is paid out of the quinquennial grant of 1,000*l* made to the Museum for those purposes; 80*l* is required for 'current expenses,' and a servant, and is paid out of the annual grant of 545*l* paid annually from the University Chest to the Museum for 'General Purposes.' In addition to this sum of 225*l* a sum of 75*l* per annum has been assigned by a grant, of date July 8, 1871, to the Linacre Professor for 'Assistance,'

and this sum is paid away by him partly to an Assistant Demonstrator for tutorial work during Term-time, and partly to a second servant, in the proportions of 45*l* and 30*l*, respectively. Thus the sum of 300*l* paid annually by the University is accounted for. Another sum of 200*l* from the Aldrichian-Tomlinsonian Fund, which is charged with and paid over as the stipend of the Demonstrator of Anatomy, Mr Charles Robertson, makes up the total of 500*l* specified above. The Senior Demonstrator receives, in addition to the stipend from the Aldrichian-Tomlinsonian Fund, one third of all the fees paid by students, the Junior Demonstrator receives, in addition to the 45*l* paid to him from the Fund of 75*l*, allowed by the University for 'Assistance,' another third of the Students' Fees, whilst the remaining third is paid to Mr E Ray Lankester of Exeter College, for the delivery of an extra course of Lectures. The Aldrichian-Tomlinsonian Fund of about 200*l* per annum and the 45*l* just specified, in all 245*l*, are all the means available from public sources for the payment of Demonstrators in Biology at Oxford; whilst at Cambridge as much as 400*l* is paid by the University alone for the same purposes. The sums paid at either University as stipends to teachers stand thus:—

" AT CAMBRIDGE

" From the University Chest.

" For a Demonstrator of Human Anatomy - - -	£150
" For the Superintendent of the Museum of Zoology and Comparative Anatomy, who holds an office analogous to that of Mr Charles Robertson at Oxford - - -	150
" For the Demonstrator of Comparative Anatomy - - -	100
	£400

" AT OXFORD.

" From the University Chest

" For a Second Demonstrator - - -	£45
" From the Aldrichian-Tomlinsonian Fund.	
" For the Senior Demonstrator - - -	200
	£245

" The annual expenses incurred at Cambridge in the Departments of Human and Comparative Anatomy for 'general maintenance' and servants' wages are, on an average of the last seven years, 411*l* 19*s* 8*d*

" The entire annual cost of the Biological Department at Oxford, exclusively, as above stated, of certain items in the way of outgoings and of income severally, stands thus in a tabular form

" From the University Chest

" By special Annual Grant of 75 <i>l</i> {		
For a second Demonstrator	£45	
For a second Servant	30	
" From Museum Quinquennial Grant for 'maintaining Collections'	145	
" From Museum Grant for 'general purposes'	80	
	300	

" From the Aldrichian-Tomlinsonian Fund.

For Demonstrator - - -	200
	£500

" I wish, in the second place, to define the directions in which the objects professedly aimed at in the working of the Biological Department of the Museum are incompletely attained, and to specify the means by which, and the minimum cost at which, they could be more thoroughly compassed. There is one direction in which at the present time

we suffer very considerably from deficiency in teaching-power, and the persons whom this deficiency affects are the important class of men who, having completed the Natural Science curriculum requisite for the Degree of B.A., wish to continue to reside in Oxford, and commence to prepare themselves for a Medical career. Considering, as I do, that my first duty is to the Natural Science School, and having now for several years back had as many Students working for that School in the Biological Department as could have anything like adequate supervision and assistance given to them by the Demonstrators and myself, I find it impossible to give any efficient superintendence even to the small number of persons who now for several Terms back have been practising Human Dissection in the Museum. Yet, though it would be in my judgment exceedingly inexpedient to encourage University Students who might be intending to enter the Medical Profession, but who had not been through the Biological Department of the Natural Science School, to begin their preparatory studies by Anthropotomy, the opportunity of pursuing that branch of Anatomy should, I think, be furnished to any of our Students who, having been through that course of preliminary training, wished to prolong their residence in the University. To meet their needs, however, another Demonstrator would be required, and as the whole of his time would not be taken up with the work in question, he might relieve the present Senior Demonstrator of some of the teaching-work for the Natural Science School which he now undertakes, and, by being relieved from which, he would have more time to give to his strictly statutable duties of Curator of Collections, duties, I may say, daily growing in importance and urgency, with the accessions made and with those required to be made to the Museum Series.

A second deficiency in the Biological Department of the University Museum as working at present lies in the fact that the sum of 145*l*. per annum, assigned to the maintenance of Collections and spent on the procuring and preparation of Specimens, leaves no margin for the purchase of instruments and apparatus, such as microscopes. The additional expense which the University would, in accordance with these suggestions, undertake, may be taken as about 30*l*. per annum for scientific apparatus, and for the stipend of a Demonstrator about 120*l*.; in all 150*l*. per annum; a sum which, when added to that already paid by the University Chest for the stipend of a Demonstrator and for the procuring of Specimens, would amount to something about 350*l*. a year, a sum less by 50*l*. than the sum which the University Chest at Cambridge pays to Demonstrators alone. And the sum total of public money which would, including this addition, be expended upon the Anatomical Department of the University Museum, would be considerably less than that which is expended in each of the other two Departments, that of Physics and that of Chemistry, which correspond to the two other Divisions of the Natural Science School.

"The making of the addition indicated to the teaching and working-power of the Biological Department is, I must say, urgently necessary, if the study is to be prosecuted here upon a scale commensurate either with its intrinsic importance, or with what the dignity of the University and the examples and precedents of other Institutions suggest.

"I will conclude by stating, in the third place, what, in the event of any larger plan being brought under consideration for the rearrangement of the several Chairs connected with Biology, should, in my opinion, be the division of the subject. If it should be thought that the University should aim at developing the study of Biology mainly in relation to the purpose of General as opposed to that of Professional Education, and should lay weight therefore mainly upon the Anatomical and Morphological aspects of the subject, it is still no exaggeration to say, that the subject, even when thus limited, is now far too large to be entrusted to the care of any single Professor. Two Professors, one with the title and duties of Professor of Comparative Anatomy, Zoology, and Histology, the other with that of Professor of Human Anatomy and Physiology and Ethnology, ought at once to divide the field at present in charge of the Lunatic Professor. The scientific appropriateness and the economical advantages of combining the subjects of Zoology, Comparative Anatomy, and Histology are sufficiently obvious. Ethnology again, or 'Anthropology,' is a subject which, however vast and growing, is nevertheless one which the Professor of Human Anatomy and Physiology in Oxford should fairly be expected to deal with, if not from its Historical and Philological, still at all events from its Natural History side. The development within late years of collections illustrating this latter aspect of Anthropology is no less remarkable than that of literature, treating of it from every point of view, and the establishment in Oxford of a Professorship with such duties as those indicated would cause such collections to gravitate hither as being a place eminently fitted, by reason of the many and various departments of Human Knowledge, as of Art, of History, and of Ethics, represented within its precincts, to be a home for their preservation and utilization. But Biology would bear still further division with much advantage, and a third Chair should be established to represent and expound the Physiological as opposed to the Anatomical and Morphological Division of Biology. With this Chair the Professorships of Medicine and the duties of teaching what has elsewhere been called the Institutes of Medicine might, I would suggest, be combined.

"What I have felt myself bound to state I have put in the fewest possible words, knowing as I do, that no one is better able than yourself to supply what from various causes I may have left unsaid.

"I am, dear Mr. Vice-Chancellor,

"Yours very truly,

"GEORGE KOLLESTON."

"The Very Rev. The Vice-Chancellor."

## APPENDIX II.

STATEMENT of the REV. R. MAIN, M.A., F.R.S., F.R.A.S., Radcliffe Observer.

The building of the Radcliffe Observatory at Oxford was begun in 1771, and active observing was commenced at the beginning of 1774 under Dr. Hornsby. Its foundation was due to the zeal of Dr. Hornsby, and to the munificent liberality of the Radcliffe Trustees, who consented to bear the entire expense of building it and furnishing it with instruments, and ultimately of providing the funds for the maintenance of the observer and his assistants. It was under the direction of Dr. Hornsby from its foundation till the year 1810, under that of Dr. Robertson from that time till 1827, and under that of S. Rigand, Esq., from 1827 till 1839; all these gentlemen holding successively the office of Savilian Professor of Astronomy in the University.

Up to the close of Mr. Rigand's directorship, the observations made (chiefly with the transit instrument and mural quadrants or meridian circle) were not reduced and were not printed or published, though a large and continuous series exists in MS., chiefly of the sun and moon and principal stars. Four copies were required to be made of them, of which one was kept at the Observatory, and the others were sent respectively to the Bodleian Library, the Radcliffe Library, and the Royal Society.

It is doubtful in the present state of Astronomy, and since the reduction and publication of the Greenwich planetary and lunar results, by the present Astronomer

Royal, whether they are worth the expense and trouble of reduction and publication; but this detracts nothing from their original value, or from the good use which might have been made of them if they had been reduced and published at a time nearer their own epoch.

Mr. Rigand was succeeded in 1839 by Manuel Johnson, Esq., and with his directorship began a totally different system, and the scientific history of the Observatory, as known to the public, dates from this time.

Two changes were made at this time which have greatly contributed to the success of the Observatory, the first being the disassociation of the offices of Savilian Professor and Radcliffe Observer, and the second the regular reduction, printing, and publishing of the observations. With a view also of still increasing the usefulness of the Observatory, the Trustees ordered a heliometer of large size and the best possible construction of the Messrs. Repsold, of Hamburg, though this instrument, through accidents and unavoidable delays in its construction, did not come into use till the year 1850.

Up to this time Mr. Johnson, with one assistant (the present first assistant, Mr. John Lucas), was engaged in the re-observation of the stars in Groombridge's Catalogue of Circumpolar Stars.

This catalogue, which may be called Mr. Johnson's *Opus Magnus*, and contains 6,317 stars, was compiled and printed

during the lifetime of Mr. Johnson, but he did not live long enough to see its publication. The introduction was written and the work published by the present Radcliffe Observer, the Rev Robert Main, who succeeded Mr. Johnson in the year 1860. Commencing with the year 1850, Mr. Johnson was engaged for two or three years with the heliometer, the most noteworthy results of his observations being the redetermination of the parallax of 61 Cygni; and his researches on photometry or the relative magnitude of stars. In the year 1854 he began that system of photographic meteorology which has been continued to the present time with considerable advantage to science. In the small volume of meteorological results attached to the astronomical volume every year, there are not only given the journal of daily observations and ordinary weather phenomena, but the results of every kind (pressure, temperature, and hygrometry of the air, velocity and direction of the wind, elastic force of vapour, &c, &c) are extracted from the photographic sheets for every two hours, and the monthly and yearly means taken. The monthly results are then formulated in terms of the sun's hour angle, so as to give for any hour of the day the function required (whether pressure, temperature, or moisture) in terms of the mean for the day and the hour. The velocity and direction of the wind at any hour is considered as a mechanical force, and the resultant is obtained for every two hours, in monthly results, and the final mean for the year is also computed. These investigations have led already to some interesting discoveries.

Mr. Johnson died in March 1859, and was succeeded at Midsummer 1860 by the present Radcliffe Observer, the Reverend Robert Main. Mr. Main has continued the general system adopted by his predecessor as much as possible, his chief object being to provide (as far as the limited force at his disposal allows him), 1st, for the vigorous prosecution of meridional observations of stars and certain planets, including the sun and moon, 2ndly, for the tolerably constant use of the heliometer by himself almost exclusively, 3rd, for the prosecution of the system of meteorology previously established, \* and 4thly, for the regular reduction, printing, and publication of the observations.

The results already arrived at under Mr. Main's directorship may be briefly summed up as follows:—

1 The compilation and publication of a second Radcliffe Catalogue of 2,386 stars from the observations, 1854 to 1861, both years inclusive.

2 The re-observation (essentially completed) of the stars of the British Association Catalogue, which require to be re-observed, and which are visible in this latitude, together with the re-observation still in progress of Struve's double stars, and of other lists of stars.

3 The establishment in 1862 of the Carrington transit circle, which superseded the use of the transit instrument and meridian circle.

4 The observation of about 600 double stars with the heliometer, and the remeasurement of the disks of the large planets.

5 Several remarkable results deducible from the meteorological observations by their mode of treatment at this Observatory.

It may be finally mentioned that the present establishment of the Observatory (which has never been exceeded) consists of the Observer, two assistants, and one computer.

\* The meteorological observations will from the date, May 20, 1872, be more useful to the public by the Observatory being included amongst the inland stations, which are to be added to those which already send results to the Meteorological Office in London.

The astronomical instruments of the Radcliffe Observatory are at present (1873),—

First, those in actual use —

1. A transit circle by Summs, formerly belonging to Mr. Carrington, with telescope of 66 inches focal length and 5 inches aperture, and two circles of 42 inches in diameter.
2. The heliometer, of which the telescope is of 10½ feet focal length and 7½ inches aperture.
3. An equatorially-mounted telescope of 10 feet focal length and 7 inches aperture.
4. A 42-inch achromatic telescope by Dollond, and another smaller unmounted telescope.
5. Four sidereal clocks, of which two are by Dent and of first-rate excellence, and a sidereal box chronometer by Dent.

Secondly, those not in actual use —

- 1 The two 8-feet mural quadrants by Burd, with the corresponding 12-feet zenith sectors, which were established in 1774.
- 2 The transit-instrument and meridian circle used during the whole of Mr. Johnson's directorship, but now superseded by the transit-circle.

There are besides a large unmounted reflecting telescope, of which the mirror (by Short) is of 18 inches diameter, and a smaller 10-foot Newtonian telescope by Herschel. The latter instrument is available for occasional use.

The meteorological instruments consist of a barograph, thermograph, and hygrograph, and an anemograph for automatic registration of the corresponding elements; and of the ordinary standard instruments (barometer, dry and wet thermometers, and maximum and minimum thermometers) for eye observations taken three times a day.

RADCLIFFE OBSERVATORY, OXFORD

Expenditure for one year, viz., from Midsummer 1870 to Midsummer 1871.

	£	s	d.
Observer's salary - - - - -	600	0	0
Mr. Lucas, first assistant (additional) - - - - -	40	0	0
(Note.—There is a bequest under the will of Burd of 120 <i>l</i> per annum, for payment of the salary of an assistant at the Observatory.)			
Mr. Keating, second assistant - - - - -	100	0	0
Mr. Luff, additional computer - - - - -	40	0	0
Quarterman, gardener - - - - -	60	0	0
Charwoman, for cleaning Observatory - - - - -	20	0	0
Rates, taxes, gas - - - - -	18	16	7
	21	18	4
	19	15	11
	60	10	10
Tradesmen's bills and general expenses, including printing the annual volume of observations - - - - -	49	7	10
	132	2	8
	52	7	9
	110	19	4
	344	17	7
	£1,265	8	5

ROBERT MAIN,  
Radcliffe Observer.

APPENDIX III.

STATEMENT of the REV. C. PRITCHARD, M.A., F.R.S., Savilian Professor of Astronomy in the University of Oxford.

The Savilian Professor of Astronomy aims at the establishment in Oxford of an efficient school of Astronomical Physics.

To enable the Professor to carry out this view, the University has recently voted the large sum of 2,500*l* for the purchase of a first-class refracting telescope of 12½ inches aperture, and for a suitable building to contain it. This instrument will be provided with its proper spectroscopes, and all the other modern appliances for researches connected with Astronomical Physics.

In addition to this, and in furtherance of the same objects, Mr. Warren De La Rue, F.R.S., D.C.L., &c., has very recently offered for the acceptance of the University his well-known reflecting telescope, together with all its valuable appurtenances, including among them no less than four mirrors, each excellent of its kind, besides all the mechanical means necessary for the most accurate grinding, polishing, and testing, after Foucault's method, of large

mirrors and object glasses. The Heliomadal Council have already advised the acceptance of this noble gift, and there can be no reasonable doubt but that it will be provided with a proper location, and with the means of applying it to the purposes for which it was constructed.

Independently of these larger and more valuable instruments, Oxford already possesses, for the use of students, a very serviceable transit, and an excellent altazimuth by Troughton and Summs. There are also clocks and chronometers and smaller telescopes available for instruction, or for independent research. It is expected that the buildings will be completed and the instruments in adjustment before the end of April 1874; this being effected, the University will be in possession of almost all the means necessary for the prosecution of researches in the Physics of Astronomy on a very efficient scale.

C PRITCHARD,  
Savilian Professor of Astronomy.

APPENDIX IV.

UNIVERSITY REFORM.

To the Rt. Hon. W. E. Gladstone, M P., &c. &c.  
Trinity College, Cambridge,

April 25, 1873.

Sir, We have the honour to submit to you the accompanying document, and beg leave to draw your attention to the explanation we would desire to offer respecting its origin and purport.

In accordance with a feeling generally current in the University regarding the necessity of the reforms here indicated, a meeting was held at Cambridge in the month of December last, consisting of persons engaged in University Education, on which occasion the resolutions embodied in the document were drawn up as expressing the changes considered to be of the greatest urgency.

This document has since received the signatures which are now attached. The fact that so many residents, including so very large a majority of the most influential and eminent members of the University, of all political opinions, should support the proposed resolutions, is, we trust, a sufficient proof that they are, in their estimation, necessary and important.

The whole question respecting the Tenure of Fellowships has lately been much discussed. We do not therefore consider it requisite to lay before you reasons in detail for the expediency of the reforms here advocated. We may, however, observe that reform on this point has become an imperative necessity, owing to the great increase in the number of laymen who now occupy educational posts at Cambridge.

It is universally admitted that the present regulations connected with the Tenure of Fellowships are highly unsatisfactory. They seriously diminish the number of learned residents in Cambridge. They are detrimental to the efficiency of teaching in the University, and calculated to deprive her of the educational services of many of her ablest members.

Reforms analogous to those proposed in the first two resolutions have already been carried out in several of the Colleges. It has been the desire of other Foundations to reorganise their Statutes in a similar manner, but the late refusal of Her Majesty in Council to accede to the alterations in the College Statutes proposed by the Master and Fellows of Trinity College has left no alternative but to lay the subject before you, Sir, as the Head of the Government, in the confident assurance that you have truly at heart the interests of learning, and are most anxious to render the Universities efficient schools for the promotion of science and culture.

We beg to remain

Faithfully yours

ROBERT BURN, Fellow, Senior  
Classical Lecturer and late  
Tutor of Trinity College  
H A. MORGAN, Fellow and Tutor  
of Jesus College.

[Document referred to in the foregoing letter.]

We, the undersigned, being resident Fellows of Colleges and other resident Members of the University of Cambridge engaged in educational work or holding office in the University or the Colleges, thinking it of the greatest importance that the Universities should retain the position which they occupy as the centres of the highest education, are of opinion, that the following reforms would increase the educational efficiency of the University, and at the same time promote the advancement of science and learning.

I. No Fellowship should be tenable for life, except only when the original tenure is extended in consideration of services rendered to education, learning, or science, actively and directly, in connexion with the University or the Colleges.

II. A permanent professional career should be as far as possible secured to resident educators and students, whether married or no.

III. Provision should be made for the association of the Colleges, or of some of them, for educational purposes, so as to secure more efficient teaching and to allow to the teachers more leisure for private study.

IV. The pecuniary and other relations subsisting between the University and the Colleges should be revised, and, if

necessary, a representative Board of University Finance should be organised.

We are of opinion that a scheme may be framed which shall deal with these questions in such a manner as to promote simultaneously the interests of education and of learning, and that any scheme by which those interests should be dissociated would be injurious to both.

PROFESSORS.

J. G. Adams, Lowndean Professor of Astronomy.  
Churchill Babington, Disney Professor of Archaeology.  
C. C. Babington, Professor of Botany.  
A. Cayley, Sadlerian Professor of Mathematics.  
J. Challin, Plumian Professor of Astronomy.  
E. C. Clark, Regius Professor of Laws.  
S. Colvin, Slade Professor of Fine Arts.  
H. Fawcett, Professor of Political Economy.  
W. W. Fisher, Downing Professor of Medicine.  
G. V. Harcourt, Professor of International Law.  
G. M. Humphry, Professor of Anatomy and Physiology.  
B. H. Kennedy, Regius Professor of Greek.  
J. B. Lightfoot, Hulsean Professor of Divinity.  
G. D. Living, Professor of Chemistry.  
J. C. Maxwell, Professor of Experimental Physics.  
W. H. Miller, Professor of Mineralogy.  
Alfred Newton, Professor of Zoology.  
G. E. Paget, Regius Professor of Physics.  
E. H. Palmer, Lord Almoner's Reader in Arabic.  
J. R. Seeley, Professor of Modern History.  
C. Swainson, Norman Professor of Divinity.  
B. F. Westcott, Regius Professor of Divinity.  
R. Willis, Jacksonian Professor of Natural and Experimental Philosophy.  
W. Wright, Professor of Arabic.

ST. PETER'S COLLEGE.

A. Dey, Fellow and Librarian.  
J. Porter, Fellow and Tutor.  
C. Wordsworth, Fellow, Assistant Tutor, and Dean.

CLARE COLLEGE.

T. O. Bonser, Fellow and Librarian.  
L. Ewbank, Fellow and Lecturer.  
H. E. Maddock, Fellow.

GONVILLE AND CAIUS COLLEGE.

R. L. Bently, Lecturer.  
N. M. Ferrers, Fellow and Tutor.  
E. J. Gross, Fellow and Librarian.  
J. Lamb, Fellow and Bursar.  
E. S. Roberts, Fellow and Lecturer.  
J. Venn, Fellow and Lecturer.

TRINITY HALL.

E. A. Beck, Fellow and Lecturer.  
E. Carpenter, Fellow and Assistant Tutor.  
A. R. Hayes, Lecturer.  
W. Walton, Lecturer of Magdalene College, and Fellow.

CORPUS CHRISTI COLLEGE.

S. S. Lewis, Fellow and Librarian.  
C. W. Moule, Fellow and Lecturer.  
B. Walker, Lecturer of St. John's College, and late Fellow.

KING'S COLLEGE.

A. Austen Leigh, Fellow and Tutor.  
Arthur Beard, Precentor and Lecturer.  
J. E. Nixon, Fellow.

QUEEN'S COLLEGE.

J. R. Lumby, Lecturer.  
G. Frie, Fellow and Lecturer.  
A. Wright, Fellow and Dean.

ST. CATHERINE'S COLLEGE.

E. T. S. Carr, Fellow and Tutor.  
G. B. Morley, Fellow.  
A. Pretor, Fellow and Assistant Tutor.  
A. W. Spratt, Fellow, Assistant Tutor, and Dean.



**JESUS COLLEGE.**

C. A. M. Fennell, Fellow and Librarian.  
H. M. Luckcock, Lecturer of King's College, Lecturer and late Fellow.  
E. H. Morgan, Fellow, Lecturer, and Dean.  
H. A. Morgan, Fellow and Tutor.  
\* A. Westmorland, Fellow and Prælector.

**CHRIST'S COLLEGE.**

J. W. Cartmell, Fellow and Senior Dean.  
J. F. Moulton, Lecturer of Jesus College, Fellow and Assistant Tutor.  
J. Peile, Fellow and Tutor.  
J. S. Read, Assistant Tutor.  
J. Sharpe, Fellow and Junior Dean.  
W. W. Skeat, Lecturer and late Fellow.  
R. T. Wright, Fellow and Assistant Tutor.

**ST. JOHN'S COLLEGE.**

W. H. Besant, Lecturer and late Fellow.  
T. G. Bonney, Fellow and Tutor.  
E. Carver, Lecturer on Clinical Surgery.  
A. Freeman, Fellow.  
P. Frost, Lecturer of King's College, and late Fellow.  
C. E. Graves, Lecturer of Sidney College, and Lecturer and late Fellow.  
H. M. Gwatkin, Fellow and Examiner.  
C. E. Haskins, Fellow.  
W. E. Heitland, Fellow and Lecturer.  
W. H. H. Hudson, Fellow and Lecturer.  
P. T. Main, Fellow and Lecturer.  
A. Marshall, Fellow and Lecturer.  
F. A. Paley, Examiner for the Classical Tripos.  
R. Pendlebury, Fellow and Lecturer.  
J. E. Sandys, Lecturer of Jesus College, Fellow and Tutor.  
C. Taylor, Fellow.  
I. Todhunter, Lecturer and late Fellow.  
R. R. Webb, Lecturer of Emmanuel College, Fellow.

**MAGDALENE COLLEGE.**

F. Gunton, Fellow, Assistant Tutor, and Dean.  
F. Patnick, Fellow and Tutor.

**TRINITY COLLEGE.**

W. H. Thompson, Master.  
E. W. Blore, Fellow and Tutor.  
Robert Burn, Fellow, Senior Classical Lecturer, and late Tutor.  
J. W. Clark, Superintendent of the Museums, and late Fellow.  
W. G. Clark, Fellow and late Tutor.  
G. F. Cobb, Fellow and Junior Bursar.  
M. Foster, Fellow and Prælector in Physiology.  
J. W. L. Glaisher, Fellow and Assistant Tutor.  
B. E. Hammond, Fellow and Assistant Tutor.  
A. E. Humphreys, Fellow and Assistant Tutor.  
H. Jackson, Fellow and Assistant Tutor.  
R. C. Jebb, Fellow and Tutor, and Public Orator.  
J. M. Image, Fellow and Assistant Tutor.  
C. W. King, Fellow.  
A. F. Kirkpatrick, Fellow and Assistant Tutor.  
H. Lamb, Fellow and Lecturer.  
E. T. Leeks, Fellow and late Assistant Tutor.  
C. Lestourgeon, Lecturer on Clinical Surgery.  
H. C. G. Moule, Fellow and Junior Dean.  
W. D. Niven, Fellow and Assistant Tutor.  
J. J. S. Perowne, Prælector in Theology, late Fellow of Corpus Christi College.  
J. Prior, Fellow and Tutor.  
H. Sidgwick, Lecturer and late Fellow.  
R. B. Somerset, Censor of Non-Collegiate Students, and late Fellow.  
V. H. Stanton, Fellow.  
J. Stuart, Fellow and Assistant Tutor.  
H. M. Taylor, Fellow and Assistant Tutor.  
C. Trotter, Fellow, Senior Dean, and Tutor.  
W. A. Wright, Bursar.

**EMMANUEL COLLEGE.**

S. G. Phear, Master.  
A. T. Chapman, Fellow and Tutor.  
W. Chawner, Fellow and Assistant Tutor.  
F. J. A. Hort, Fellow and Lecturer.  
J. B. Pearson, Fellow and Tutor.

W. Reith, Fellow.

A. Rose, Fellow, Assistant Tutor, and Bursar.  
E. S. Shuckburgh, Fellow and Assistant Tutor.

**SIDNEY SUSSEX COLLEGE.**

J. C. W. Ellis, Fellow and Tutor.  
G. Hale, Lecturer.  
J. W. Hicks, Lecturer.  
E. G. King, Lecturer.  
C. Smith, Fellow, Lecturer, and Dean.

**DOWNING COLLEGE.**

J. B. Bradbury, Lecturer.  
R. M. Lewis, Lecturer.

The following have signed those parts only which are specified.—

T. R. Burks, Professor of Moral Theology, I. in substance, and III.  
G. F. Browne, Assistant Tutor and late Fellow of St Catharine's College, I, II, III.  
H. Godfray, Senior Esquire Bedell and late Lecturer of Pembroke College, I, II, III.  
F. L. Hopkins, Fellow and Tutor of Trinity Hall, II, III, IV.  
P. W. Latham, Lecturer on Medicine, late Fellow of Downing College. Subject to the omission of "in connexion with the University and Colleges" in I, and of "students" in II.  
H. E. Malden, Lecturer of Trinity Hall, I, II, III.  
J. E. B. Mayor, St. John's College, Professor of Latin, I, III.  
R. Kalley Miller, Fellow and Lecturer of St. Peter's College, I, II.  
J. H. H. Moxon, Law Lecturer of Trinity College, except last clauses of I.  
J. Perkins, Fellow and Tutor of Downing College, I, II, IV.  
J. C. Rust, Fellow and Lecturer of Pembroke College, I, II.  
C. E. Searle, Fellow and Tutor of Pembroke College, I, II, III.  
H. B. Swete, Fellow and Tutor of Gonville and Caius College, I, III.

**ANALYSIS OF SIGNATURES.**

Total number of signatures, 142.

127 have signed all the resolutions.

141 " " No. I.

139 " " No. II.

138 " " No. III.

131 " " No. IV.

Of 17 Heads of Colleges 2 have signed.

Of 33 Professors 26 have signed.

Of 26 Tutors 20 have signed.

Of 84 Lecturers and Assistant Tutors 66 have signed.

Of 57 Resident Fellows, University and College Officers, exclusive of the above, 28 have signed.

[Mr. Gladstone's Reply.]

10, Downing Street, Whitehall,  
April 28, 1873.

GENTLEMEN,

I HAVE to acknowledge the receipt of your letter of the 25th, with the important document which sets forth the views of so large and weighty a part of the Residents of Cambridge with respect to some subjects of very great moment to the University.

It gives me great pleasure to find supported by this authoritative judgment a proposal with respect to the tenure of Fellowships, the principle of which was included in the Oxford University Bill of 1854, but from which the state of Parliamentary and Academic opinion at the time compelled the Government of Lord Aberdeen to withdraw.

The time has hardly arrived for bringing into a working shape proposals for extending and invigorating the action of the Universities and Colleges in connexion with the more effective application of their great endowments; but I may venture respectfully to assure you that the subject is one which, in whatever position I may be placed, will always command my warm and friendly interest.

I have the honour to remain, Gentlemen,

Your very faithful servant,

Rev. R. Burn.  
Rev. H. A. Morgan.

W. E. GLADSTONE.

LONDON.

Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,  
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For Her Majesty's Stationery Office.

V121

# FOURTH REPORT

OF THE

ROYAL COMMISSION .

ON



SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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Presented to both Houses of Parliament by Command of Her Majesty.

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LONDON:

PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,  
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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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VICTORIA R.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

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## FOURTH REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty the following Report respecting the National Scientific Museums and Collections and the Scientific Portions of the National Museums of a General Character.

For the sake of convenience we have classified the subjects referred to in the Evidence under the following heads:—

- I. The British Museum.
- II. The Museum of the Royal College of Surgeons of England.
- III. The National Botanical Collections and Gardens.
- IV. The Museum of Practical Geology.
- V. The South Kensington Museum, and its Branch Museum at Bethnal Green.
- VI. Other Scientific Collections.
- VII. Public Lectures in connection with Museums.

### I. THE BRITISH MUSEUM.

1. Our Inquiries concerning the British Museum have had reference mainly to the Natural History Collections (including the Mineralogical Collection), which, it has been determined, are to be transferred to a new Building now being erected for their reception at South Kensington.

#### *Government and Administration.*

2. The British Museum is Governed by a Board of Trustees. These are 50 in number: 25 are Trustees *ex officio*, one is nominated by the Crown, nine are Representatives of the Families of Benefactors, and the remaining 15 are elected by those otherwise appointed.\* Among the *ex-officio* Trustees are the Archbishop of Canterbury, the Lord

\* The following is the Official List of the Trustees for 1873:—

#### *Official Trustees:*

Archbp. of Canterbury; Lord Chancellor; Speaker of the House of Commons; Lord President of the Council; First Lord of the Treasury, Lord Privy Seal; First Lord of the Admiralty; Lord Steward; Lord Chamberlain; Principal Secretaries of State; Bishop of London, Chancellor of the Exchequer; Lord Chief Justice, Queen's Bench; Master of the Rolls; Lord Chief Justice, Common Pleas; Attorney-General; Solicitor-General; President of the Royal Society; President of the Royal College of Physicians; President of the Society of Antiquaries; and President of the Royal Academy.  
*Trustees appointed by Her Majesty:* The Hon. and Very Rev. Gerald Wellesley, Dean of Windsor.

#### *Family Trustees.*

Earl Cadogan; Earl of Derby.—*Sloane Family.*  
Rev. Fr. Annesley; Rev. Francis Hanbury Annesley.—*Cotton Family.*  
Lord Henry Charles George Gordon-Lennox, M.P.; George Ang. Fred. Cavendish Bentinck, M.P.—*Harley Family.*  
Charles Towneley, Esq.—*Townley Family.*  
Earl of Elgin.—*Elgin Family.*  
Frederick Winn Knight, Esq., M.P.—*Knight Family.*

#### *Elected Trustees.*

Right Hon. Sir David Dundas; Sir Philip de Malpas G. Egerton, Bart., M.P.; Duke of Somerset, K.G.; Right Hon. Earl Russell, K.G.; Right Hon. W. E. Gladstone, M.P.; Right Hon. Spencer Horatio Walpole, M.P.; Viscount Eversley; Right Hon. Benjamin Disraeli, M.P.; Right Hon. Robert Lowe, M.P.; Duke of Argyll, K.T.; Bishop of Winchester; Duke of Devonshire, K.G.; Lord Acton; Viscount Ossington; and Sir William Stirling-Maxwell, Bart.



Chancellor, and the Speaker of the House of Commons, who are named Principal Trustees, and with whom rests the appointment to all Offices in the Museum except the Office of Principal Librarian, to which the Crown appoints. The remaining Official Trustees are certain Chief Officers of State, with the Presidents of the Royal Society, the Society of Antiquaries, the College of Physicians, and the Royal Academy. The General Body annually appoint 15 of their number, who, with the three Principal Trustees, form a Standing Committee for carrying on the Ordinary Government of the Museum. The Standing Committee appoint, from among themselves or from the General Body, Sub-Committees for special Superintendence of the several branches of the Establishment, one being for Natural History. The Sub-Committees report their opinions and recommendations to the Standing Committee.

Qu. 6491.

3. The Natural History Collections form four Departments: Zoology, Botany, Geology, and Mineralogy. Each is under the charge of a Keeper or Head, under whom are Assistants and subordinate officers. The whole are placed under a Superintendent, who at present is Professor Owen. His duties are—

Qu. 6492,  
6494.

(1.) "To exercise a general Superintendence over the Departments of Natural History; to transmit to the Principal Librarian the Reports of the Keepers of each Department, accompanied by such remarks as he may think proper for the information of the Standing Committee; to suggest such improvements as, in his judgment, may increase the Scientific value and general utility of the collections; and, within the first fortnight after Christmas of every year, to lay before the Standing Committee an Annual Report on the condition of the Collections under his Superintendence.

(2.) "To be the Editor of such Catalogues and other Scientific Publications as shall be entrusted to him by the Standing Committee; and to see that they are prepared and printed in a proper manner, and in accordance with such directions as may, from time to time, be given to him by the Standing Committee.

(3.) "To take care that the officers, assistants, attendants, and servants of each Department be regular in their attendance and perform their proper duties; and to report every omission in this respect to the Principal Librarian."

Qu. 6498,  
6494, 6592.

(4.) The Reports and Recommendations of the Keepers of the Natural History Collections are transmitted, through the Superintendent, to the Principal Librarian, and by him brought before the Standing Committee. It is the duty of the Superintendent to append to these Reports an expression of approval or disapproval, with such remarks as he may think proper, after communication, if he see fit, with the Keeper making the Report.

Qu. 6519.

Qu. 6507.

5. The Sub-Committee on Natural History, as constituted in 1871, consisted of the Duke of Argyll, Earl Cadogan, Viscount Eversley, the Bishop of Winchester, Sir Philip Egerton, Sir Roderick Murchison, Sir Edward Sabine, Sir James Alderson, and George Annesley, Esq. The Sub-Committee may communicate directly with the Superintendent, the Keepers and other officers, and may make Recommendations to the Standing Committee; which Recommendations, if adopted by that Committee, are embodied in Minutes. These Minutes, as well as other orders and directions of the Standing Committee, are transmitted by the Principal Librarian to the respective Keepers, a copy being also communicated by him to the Superintendent.

Qu. 6512.

6. As we have already stated, all appointments of officers, except that of Principal Librarian, are made by the three Principal Trustees; these, however, have the advantage of learning the opinion of the Standing Committee as to the eligibility of candidates, after that Committee has consulted the Heads of the respective Departments, and deliberated on the matter.

Qu. 6564,  
6568, 7555.

7. The funds applied to the maintenance of the Museum, whether derived from property belonging to the Institution, or voted by Parliament, are entirely under the management of the Trustees. The estimates to be submitted to the Treasury are framed under their direction, and the vote is moved by some one of their number who is a Member of the House of Commons.

See  
Appendix L.

8. The opinions expressed in the Evidence laid before us concerning the Constitution and Functions of the Governing Body have been widely different. Sir Philip Grey Egerton, who has had long experience as a Trustee, considers that the general or routine business of the Museum is thoroughly well conducted through the Standing Committee, and he would recommend no fundamental change in the Constitution of the Board of Trustees; but he would confine the duty of the General Body of Trustees to an annual inspection of the Museum, and the appointment of the Standing Committee, to whom the whole management of the Museum should be entrusted for the ensuing year. At the same

time, he thinks that Natural History is not sufficiently represented on the Board of Trustees, and that the defect should be remedied by appointing more men of scientific eminence as Trustees when vacancies occur, so as to keep up a due representation of Natural Science in the Standing Committee; by which, or by a Board similarly constituted, including both men of science and men of experience in business, a Natural History Museum could, in his opinion, be best administered; there being under them a Scientific Head or Director over the whole Natural History Establishment, with a seat at the Board.

Qu. 7523 and seq.

9. Other witnesses whom we have examined have generally expressed unfavourable opinions respecting the Constitution of the Governing Body, and especially consider that Science is not adequately represented. In their view it is unsatisfactory that the National Collections should be managed by a body of gentlemen whose time is in most cases fully occupied by other important duties, and the majority of whom are not selected with reference to any special qualifications for such a post. These objections are, in their opinion, but partially obviated by the appointment of a Standing Committee and Sub-Committees. Moreover, it is held to be singularly inappropriate that the three important Personages who are the Principal Trustees, occupied as they are in the discharge of the highest functions in Church and State, should be burdened with the duty of making appointments to offices of every grade in the British Museum.

Qu. 6707, 6771 and seq. Qu. 7221.

Qu. 6696, 7546.

10. It has accordingly been recommended by various witnesses that the British Museum should be placed under the direct control of some responsible Government Authority—a Minister of Public Instruction, if such an office be created, or, in existing circumstances, the Lord President of the Council; that the administration of the Natural History Department should be confided to a Director appointed by the Crown and immediately accountable to the Minister; that the Director should be an accomplished Naturalist; that the Keepers of Collections and the other officers of the establishment should be subject to his control and direction; that the different officers, at least those holding the higher appointments, should be appointed by the Minister, on the recommendation of the Director, or after receiving a report from him; and that the Director, with suitable aid, should regulate and control the expenditure and prepare the estimates for the approval of the Minister, to be by him submitted to the Treasury and brought before Parliament.

Qu. 6708 and seq. Qu. 6770-6773, 6755, 7221.

Qu. 6755.

11. It has been further suggested that in addition to the arrangements above indicated it would be advantageous to appoint a Board of Visitors, who should inspect the Collections at stated times, and, in communication with the Director, acquaint themselves with the working of the Establishment, recording the result in Minutes to be transmitted by the Director to the Minister. The Board of Visitors need not be a large Body, and it has been recommended that, besides men of general accomplishment and knowledge of affairs, it should include Members specially acquainted with Natural History, and that to secure this end, a certain number might, from time to time, be nominated by the Royal Society and the several Natural History Societies of the Metropolis.

Qu. 6774.

12. After due consideration of the question, Your Commissioners are of opinion that the objections to the present System of Government of the British Museum by a Board of Trustees, as at present constituted, so far as relates to the Natural History Collections, are well founded; and we have been unable to discover that the system is attended by any compensating advantages.

13. We accordingly recommend that the occasion of the removal of those Collections to a separate building in a different locality should be taken advantage of to effect a change in the Governing Authority and Official Administration of the Natural History Division of the Museum, in the sense indicated by several of the witnesses.

We further recommend—

14. That a Director of the National Collections of the Natural History Department should be appointed by the Crown, and should have the entire Administration of the Establishment, under the control of a Minister of State, to whom he should be immediately responsible; that the Keepers of Collections should be responsible to the Director; that the appointments of Keepers and other Scientific Officers should be made by the Minister, after communication with the Director and with the Board of Visitors (herein-after referred to); and that the Director should prepare the Estimates

to be submitted, after consultation with the Board of Visitors, for the approval of the Minister.

15. That the present Superintendent be the first Director.

16. That a Board of Visitors be constituted. That this Board be nominated in part by the Crown, in part by the Royal and certain other Scientific Societies of the Metropolis, and, in the first instance, in part also by the Board of Trustees; that the Members be appointed for a limited period, but be re-eligible; that the Board of Visitors should make Annual Reports to the Minister, to be laid before Parliament, on the Condition, Management, and Requirements of the Museum; and that they should be empowered to give Advice on any points affecting its Administration to the Minister.

17. It is no part of the duty of the Commission to attempt to define the boundary between the Scientific and the Art Collections of the Museum; but we conclude that the Collections to be left in Bloomsbury will have reference, in the main, rather to Literature and Art than to Science, and that the Collections at South Kensington will be exclusively Scientific; we have, therefore, confined ourselves to the question of the Government of the latter Collections.

18. The evidence which we have received, however, leaves no doubt upon our minds that the Banksian Library ought to follow the Botanical Collections to South Kensington. On this point Mr. Carruthers says:

Qu. 7759.

"It would be absolutely necessary [to have a subsidiary library, if the Botanical and other Natural History Collections are removed to South Kensington]; and I believe that unless the value of the herbarium were to be greatly destroyed, the Banksian Library will be required to form a portion of that subsidiary library, inasmuch as the Banksian Collection was in continual use while the Banksian Herbarium was being formed, and the volumes that form that library were annotated by the workers in the herbarium, so that if the books were left behind and the plants separated anywhere from the annotations on the books, the value of the plants in their cross references to books would be completely destroyed."

*Employment for Purposes of Special Scientific Study and Instruction.*

19. The Natural History Collections of the British Museum are not only open to the general public on certain days of the week, but, being intended to supply materials for study and research, are accessible, at certain other times, to Students of Science, specially qualified, for the more minute and elaborate examination of specimens. We consider it of importance that this purpose of the National Establishment should be steadily kept in view, and carried out in the most effectual manner. To this end it is essential that ample accommodation should be provided in the New Building for properly qualified persons desirous of using the Collections for a Scientific Object. With a view to affording increased facilities for this purpose, it has been pointed out by some of the witnesses conversant with the management of Museums, that the admission of students need not, as at present, be restricted to private days; and that, by adopting a certain mode of constructing the cases in which specimens are exhibited, it would be quite practicable to enable Students to carry on their scientific work at the same time that the Galleries are frequented by the Public. The method they propose is described in their Evidence: it consists in making the glazed cases to open at the back, so as to be accessible from the working rooms, whilst they are effectually and permanently closed towards the public Galleries. Without pronouncing an opinion as to the general applicability of this proposal, we think that it should receive careful consideration when the fittings of the new Natural History Galleries are planned.

Qu 6717-  
6720, 6780,  
6845, 6846,  
7467.

20. Under the present head we call attention to an opinion expressed by several witnesses as to the distribution of the contents of the Museum best calculated to meet the wants of Students and General Visitors respectively. It is held that the object should not be the display of the Natural History treasures in detail, but rather the exhibition of a Selection of Typical Specimens, adequately representing the several departments, for general study; the rest being reserved, and accessible under appropriate arrangements, for the purposes of special Scientific Investigation. In this view we entirely concur, and we would especially direct attention to the very decided opinion on this question given by Professor Phillips.

Qu. 6798.

Qu. 8107.

21. The Special Collections of Botany and Mineralogy are further referred to in a subsequent part of this Report.

II. THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

22. This Collection of Human, Comparative, and Morbid Anatomy was founded in the last century by the celebrated John Hunter. After his decease the Hunterian Collection

was purchased by the Government, and placed in the keeping of the Royal College of Surgeons, subject to periodical inspection by a Board of Trustees, which is kept up by co-optation of new members as vacancies occur. Since the Collection came into the possession of the College, it has been vastly extended and enriched, and is now probably the most complete and best arranged museum of its kind in existence. It is freely accessible to Students; and Lectures to Members of the College, to which any person interested readily obtains admission, are delivered, on Comparative Anatomy, by the Conservator, Professor Flower, and, on surgical subjects, by Fellows of the College appointed to that duty, from time to time, by the Council.

23. For the purchase of the original or Hunterian Collection, and in grants for buildings, the Nation has contributed 57,500*l.* towards the expense of this Museum; but the entire expense of its maintenance and continued extension, amounting to about 2,500*l.* a year, is discharged by the College out of the fees payable by candidates who pass the Examination for the College Diploma; and the aggregate sum which has been thus expended far exceeds that supplied by the State. Qu. 6874. Qu. 6869.

24. The Comparative Anatomy Division of this Museum, besides a great Osteological Collection, contains an extensive series of preparations of the internal organs and other dissected parts of animals, preserved in spirits. Preparations of this description are requisite for a well grounded study of Zoology; and as no such series exists in the British Museum, this part of the College of Surgeons' Museum may be regarded as supplemental to it. But although it might seem, on this account, desirable to incorporate the Comparative Anatomy Division of the College of Surgeons' Museum, in whole or in part, with the Zoological Collections of the British Museum, there appear to be serious objections to such a measure. For, in the first place, by far the greater part of the collection in question being the property of the College of Surgeons, a very large outlay of public money would be required for the purchase of it, were the College willing to part with it, which we have no reason to think probable. Again, so large an increase of spirit-preparations in the British Museum would increase the risk of destruction in case of fire; and, lastly, the transference of the Comparative Anatomy Collection to South Kensington would render it much less conveniently accessible than it is at present to Students attending the Medical Schools, who now make use of it. Qu. 6864.

25. Should the fund at the disposal of the College, owing to changes in Medical Legislation, or from any other cause, prove inadequate for the efficient Maintenance and continued extension of the Museum, we are of opinion that it should receive support from the State as an Institution intimately connected with the progress of Biological Science in this country. At the same time, there seems to be no sufficient reason why it should, in such a case, pass from the custody and management of the College, under which it has so long and so greatly prospered. Qu. 6855.

### III. THE NATIONAL BOTANICAL COLLECTIONS AND GARDENS.

26. Two Institutions for the promotion of Botanical Science are at present supported by the State in or near the Metropolis. Of these, one is lodged in the British Museum, under the charge of the Keeper of Botany; the other at the Royal Gardens, Kew, under the Director of the Gardens.

27. From the date of its Foundation in the year 1755, the British Museum has contained a collection of dried plants, the most valuable part of which, at that time, was the Sloaniar Herbarium; but Botany is said by the celebrated botanist, the late Mr. Robert Brown, to have been almost entirely neglected in the British Museum, from the death of Dr. Solander, in 1782, until the year 1827. In the latter year, however, the Botanical Collection was made into an Independent Department, of which Mr. Brown was appointed Keeper; and the Banksian Herbarium, devised to Mr. Brown during his life by Sir Joseph Banks, was provided with accommodation in the Museum. The Collections were at the same time opened to general scientific visitors two days a week, and to foreign botanists visiting England five days a week.

28. The collection, as it now exists, consists of—

#### 1. *The Herbarium, comprising,*

- a. The general herbarium.
- b. The British herbarium.
- c. Various separate herbaria of historical interest.

Report,  
1850  
8317.  
Report,  
1850.  
8317.  
Mr.  
Carruthers,  
Appendix  
XV. vol. 1.,  
pp. 44-47.  
Report,  
1850.  
8303.

2. *The Structural series, comprising,*

- a. The fruit collection.
- b. The collection of gums, resins, and other natural products.
- c. The general collection, consisting of the larger specimens chiefly exhibited to the public; and
- d. The microscopical preparations, illustrating the minute structure of recent and fossil plants.

29. It may be remarked that the General Collection of Fossil Plants is under the charge of the Keeper of Geology.

30. Additions are made to the Collection, by purchase, at the discretion of the Keeper, subject to the approval of the Trustees, and by donation.

31. At present the full staff of the Botanical Department is a Keeper and two Assistants, and its cost, during the financial year 1870-71, was 1,767*l.*

32. With respect to the magnitude and scientific importance of the Herbarium, the Keeper of Botany has expressed the following opinion:—

"I believe that our British Museum herbarium is unequalled in the world; and that is not only the opinion which I myself have formed, for I am not very extensively acquainted with herbaria abroad, but it is the universal testimony of men who have become sufficiently acquainted with the British Museum herbarium to form an opinion worth considering."

"I believe that the British Museum is visited by all the foreign botanists that come to this country. I find amongst the foreign botanists, who have been in the habit of visiting the museum, the names of Cosson, Bailon, Triana, and Welwitsch, who have been here during the year 1871."

33. The Royal Gardens at Kew were the private property of the Crown until the year 1840.

34. In the year 1838, a Committee was appointed by the Treasury to Inquire into the Management of the Royal Gardens, and that Committee desired the late Dr. Lindley, aided by Messrs. Paxton and Wilson, to Report upon the Condition of the Gardens, and make Recommendations for their future Administration. In consequence, a "Report upon the present condition of the Botanical Gardens at Kew, with Recommendations for their future Administration" was drawn up by Dr. Lindley, and was published as a Parliamentary paper in 1840.

35. According to this Report, the Garden (including the Arboretum) occupied 15 acres, and the collection of herbaceous plants was stated to be then "inconsiderable." The Reporter states that "no attempt has been made till lately to name the multitudes of rare plants it comprehends, and thus to render it a place of public utility;" and, further, "What names are to be found in the Garden have been furnished by Mr. Smith, the Foreman, and the Director [Mr. Aiton] does not hold himself answerable for them. This was most particularly inquired into, and most distinctly avowed; so that by far the most difficult part of the duty of the principal officer—a duty on the perfect execution of which the credit and utility of the Garden essentially depend—a duty which can be only executed properly by a man of high scientific attainments, aided by an extensive herbarium and a considerable library; this most important duty is thrust upon a foreman, paid small weekly wages for cultivating plants, who, whatever his zeal and assiduity may be (and in this case they have been such as to deserve the greatest praise), has no sufficient means of executing such an office."

36. Dr. Lindley recommended that the Royal Gardens at Kew should become public property, and be converted into a National Botanical Garden, and brought into close official relations with the Botanical Gardens of the Colonies; that at least 30 acres should be added to the gardens, and considerable additions be made to the houses; that everything should be systematically arranged and named; that there should be nurseries for the propagation of plants for Government exportation or for public purposes; that gratuitous Lectures should be given upon Botany in a popular form, but not as a regular academical course; and that the most beautiful specimens of the Vegetable Kingdom should be carefully preserved for exhibition. He further urged the necessity of providing an extensive herbarium and a considerable library.

37. The Royal Gardens became public property in the year 1840, and most of Dr. Lindley's other recommendations were carried into effect by Sir William Hooker, who was appointed Director of the Gardens in that year.

38. The Gardens at Kew were unprovided with any public herbarium or scientific library when Sir William Hooker took charge of them. As Dr. Lindley's "Report"

Ev. qu.  
7725; and  
Appendix  
XV., vol. i.,  
p. 46, and  
Appendix I.  
to this  
Report.  
Qu. 7734.  
Qu. 7735.

Report, p. 2.

Dr. Hooker's  
Memo-  
randum,  
Appendix II.

shows, the naming of the plants was insufficiently attended to by his predecessors. The new and rare plants in the gardens, before Sir William Hooker's time, were named partly by the use of a herbarium, in the gardens, which was broken up before their transference to the Nation, and partly by the aid of the Banksian Herbarium.

39. Sir William Hooker brought a large private herbarium (which Mr. Bentham terms the richest in Britain) and library to Kew, and these were increased, at his own expense, until his death in 1865. After his death, the herbarium and library were purchased by the Government at a valuation, and have been added to the public herbarium at Kew, which was founded in 1854, when Mr. Bentham presented his large private collection of plants and botanical library to the Nation.

Dr. Hooker's "Reply," Mr. Bentham's Statement, Appendix II. Dr. Hooker's Statement, Appendix II.

40. In regard to the work done at Kew at the present time, the latter gentleman, who is one of our most eminent botanists, and who has been for many years well acquainted with Foreign Botanical Establishments, observes:—

"1. For the close study of plants—the only sound foundation upon which the science of botany can be usefully established—for their accurate determination and practical classification, the requisites are: that the herbarium should be as rich as possible, not only as to the genera and species, but as to the variations of all sorts and repetitions of the same form from different localities and stations; that the herbarium should be a single one, the geographical arrangement being kept in subservience to the scientific classification, and without any detached smaller herbaria, except such definite historical ones as only require occasional reference like the books of a library; that there should be good accommodation for the sorting of unnamed collections and fresh arrivals, ample means for the dissection and examination of specimens not only by the staff of the establishment, but also by scientific botanists in general, who, under special regulations, are allowed to work in the herbarium, and store rooms for duplicates required for exchanges, &c.; that there should be in the same suite of rooms as the herbarium a botanical library, as complete as possible, and a series of drawings of plants, also as complete as possible; that the herbarium should be in close connexion with the National Collection of living plants; and that it should be under the keepership of a resident scientific botanist, with the requisite staff of scientific assistants. All these essentials are at present afforded by the herbarium at Kew, in a degree far beyond what can be met with in any other establishment at home or abroad."

Qu. 7205.

41. For 40 years the herbarium has received almost all Collections made by Government Expeditions; and it has been the chief recipient of contributions from both British and Foreign Travellers; as well as from Continental Museums.

Qu. 6658.

42. At present the Gardens occupy 300 acres, and are estimated to contain 20,000 species of plants; and the following Statement of the operations carried on at Kew is taken from a Memorial (signed by many eminent scientific men) presented to the First Lord of the Treasury in 1872.

Papers relating to Kew Gardens, p. 43, ordered by the House of Commons to be printed 25th of July 1872. See, also, a Second Memorial, Appendix II.

"In no particular does England stand more conspicuously superior to all other countries than in the possession of Kew. The establishment is not only without a rival, but there is no approach to rivalry as regards the extent, importance, or scientific results of its operations. Upwards of 130 volumes on all branches of botany, including a most important series of Colonial Floras, but excluding many weighty contributions to scientific societies and journals, have issued from Kew. To these are to be added guide books and official papers. This vast literature has been produced and published through the efforts of the Directors of Kew, for the most part at no expense whatever to the Nation.

"To these labours is to be added the correspondence of the Directors with all parts of the world, a mere selection from which, now bound together at Kew, embraces some 40,000 letters addressed to the Directors, and for the most part answered with their own hands.

"During the 10 years from 1863 to 1872 inclusive, the number of living plants sent from Kew to various parts of the world has been doubled, amounting on an average to 8,000 or 9,000 annually. Of seeds ripened at Kew, or obtained by the Director from various parts of the world, the annual average distributed amounts to about 7,000.

"Of the practical value of these labours, the introduction of the Cinchona plant into India, Ceylon, and Jamaica, the commercial success of which is established, constitutes one of many illustrations. The introduction of *pecaanaha* is another.

"In India upwards of 30 gardeners, trained at Kew, are now employed in forestry, cotton, tea, and cinchona plantations, Government gardens, &c, and a far greater number are usefully employed in other parts of the world.

"By the joint efforts of the Directors, a series of complete Floras of India and the Colonies was set on foot at Kew, of which those of the West Indies, all the Australian Colonies, New Zealand, Tropical Africa, the Cape Colonies, and British India, are completed or in progress. These are standard works of estimable value to the countries whose plants they describe, as well as to scientific travellers and institutions in Europe."

43. In addition, there is the work of the Economic Museums, which are thus described by Dr. Hooker:

Qu. 6662.

"Of museums proper, apart from the herbarium, there are three; they were designed primarily to illustrate to the public the uses to which plants are put, by exhibiting specimens that illustrate useful plants; maps showing their distribution, diagrams showing their structure, and specimens of the products which they afford. They are arranged scientifically, according to the natural system, and, as far as we have procured them, all the products of the plants are shown. At the same time it is the receptacle for all specimens that are not fitted to be kept in a herbarium; for instance, there are certain fruits of no known economic value which are interesting from their structure or from their appearance, but which, though they are not of economic value, are placed in the museum, because they could not be put into the herbarium. The arrangement of the herbarium is similar to that of a library. Thus the museums serve a double object. They are ancillary to the herbarium in containing specimens not fit to be placed in the herbarium, and they are instructive to the public, inasmuch as they show the uses to which the plants of all Natural Orders are put."

44. There is no competition between the Kew and South Kensington Museums; for the Museum at South Kensington consists chiefly of manufactured articles arranged according to their uses. At Kew the fibres used for textile fabrics are arranged under the Natural Order to which each belongs; the European flax going into the case illustrating the Natural Order to which the flax plant belongs, the New Zealand flax under another order, and the hemp under a third; but at South Kensington all the flaxes would be brought together. At Kew little is shown beyond the raw product and one or two manufactured articles to attract public attention immediately to its uses. South Kensington, on the other hand, affords a complete illustration of the uses of Vegetables as applied to Arts and Manufactures, arranged under their applications.

45. The collection of numerous Vegetable Products in the Food Museum at South Kensington is totally different in object from the Kew Economic Museum, and cannot be said to be intended for the promotion of Botanical Science.

Qu. 6664.  
Dr. Hooker's  
Memorandum,  
Appendix II.

46. Besides the Director, who has charge of the whole Establishment at Kew, the Staff consists of a Keeper of the herbaria and library, two Assistants, a Clerk, a Curator of the Museums, and two Attendants, whose pay altogether amounts to 1,792*l.* a year.

47. Three distinct methods of dealing with the two Botanical Establishments now maintained at the expense of the State—the one in the British Museum, and the other in the Royal Gardens at Kew—have been put before us by the witnesses who have given evidence.

Appendix  
XV., vol. i.,  
p. 40.  
Qu. 7745.

1. The first proposal is that of the Keeper of Botany in the British Museum, Mr. Carruthers, who thinks that the best way would be to keep both collections at their full efficiency; but that, if only one great National Herbarium is to exist, it should be lodged in the British Museum, and that Mr. Bentham's collection should be transferred to the British Museum, a second Herbarium of a subordinate character, for use in the Garden and Museum, being provided at Kew. Mr. Carruthers is of opinion that all Collections purchased by the Government, or made at Government expense, should be sent to the British Museum and worked out there, and that the Kew Botanical Library should be transferred to the British Museum.

2. The second proposal is that of the Director of the Royal Gardens at Kew, Dr. Hooker, who agrees with Mr. Carruthers, that the Herbarium at the British Museum and that at Kew should both be maintained in a state of efficiency.

But, in disagreement with the Keeper of Botany in the British Museum, the Director of Kew Gardens recommends that Kew should be the site of the principal National Herbarium; and that it should remain, as heretofore, the centre to which the collections made at the expense of the Government are sent, worked out, and published.

Dr. Hooker further recommends that the Collection in the British Museum should be of a subordinate character to that at Kew, and should be arranged chiefly with a view to Geographical Distribution and to the needs of Botanical Palæontology.

Dr. Hooker does not suggest the transference of any of the Collections now in the British Museum to Kew; on the contrary, he proposes to recruit the British Museum Collection from that at Kew; nor does he think it necessary that any part of the Library of the British Museum should be transferred to Kew.

3. The third proposal is that made by the Superintendent of the Natural History Collections in the British Museum, Professor Owen, to the effect that the Herbarium at Kew should be altogether transferred to the British Museum; and that it should be the duty of the Director of the Royal Gardens to occupy himself exclusively with Physiological and Horticultural Botany.

48. As respects this last proposal, we have already shown that, in the opinion of Dr. Lindley, Mr. Bentham, Mr. Carruthers (the Keeper of Botany in the British Museum), and other eminent Botanists, the possession of an extensive Herbarium is indispensable for the efficiency of the Kew Establishment. In this opinion we concur, and we cannot, therefore, recommend, as proposed by Professor Owen, that the Kew Herbarium or any portion of it should be transferred to the British Museum.

49. With respect to the first and second propositions, we have now not to consider what arrangement might be theoretically best if the Botanical Establishments supported by the Government were to be organized *de novo*; but to recognize the fact that two such Establishments have grown up, each of which is doing its own special work efficiently.

We do not think it advisable to interfere with existing arrangements, which are working satisfactorily, for the mere sake of administrative symmetry.

50. The two proposals under discussion, much as they diverge in some respects, agree in advocating the continued existence of two Herbaria, one at the British Museum, and the other at Kew. All Botanists are of opinion that Kew needs a Herbarium. Dr. Lindley, whose opinion we have already quoted, and than whom there could be no more competent judge, 35 years ago urged the necessity of an "extensive herbarium and a considerable library" for Kew; and the Keeper of Botany in the British Museum expressly speaks of "the great waste of time which would be incurred in consulting a herbarium at a distance." On the other hand, no one has suggested that the British Museum should be deprived of its Herbarium, and the Director of Kew Gardens, as we have seen, proposes to increase that Herbarium.

Mr. Car-  
ruthers'  
Paper,  
Appendix  
XV., vol. i.,  
p. 45.

51. The Keeper of Botany in the British Museum has made suggestions as to the best mode of uniting the two Herbaria, if such a course should be deemed desirable; but he has also stated reasons for the separate maintenance of these two Herbaria, which appear to be so conclusive in favour of that course that we recapitulate them here.

1. "The two herbaria already exist, and are to a considerable extent parallel collections." In other words, the collections are to a considerable extent in duplicate, and, so far, nothing could be gained by bringing them together in one place.

Mr. Car-  
ruthers'  
Paper,  
Appendix  
XV., vol. i.,  
p. 45.

2. "The two herbaria have been under different management, and, to some extent, express different results of the 'close study of plants.' The important bearing of this consideration on Botanical Science in Britain can scarcely be overrated."

3. "The objects of the herbaria are fundamentally different, and in as far as they fulfil their objects they are employed for totally different purposes."

4. "The practical difficulties in the administration of two separate, and, to some extent, independent herbaria would be numerous and serious; and, in the course of time, a condition of things similar to what at present exists would result."

5. "It is not an unimportant consideration that the continued separate existence of these two great herbaria is a great security against their destruction by fire."

6. "The expense of the two herbaria is very small. I am unacquainted with the amount granted for Kew Herbarium, but it cannot greatly differ from that required by the National Herbarium, which amounted for the financial year lately completed to 1,767*l.* I know of no way in which the country can at once advance the interests of Science and encourage its students at a smaller cost and with more important results, than by maintaining in their full efficiency the two Botanical Collections at present existing."

Appendix  
XV., Vol. i.,  
p. 46.

52. In this, as in other cases, we conceive that the State may be asked to aid Science with those Appliances which are out of the reach of private enterprise, and as such we regard the Herbaria at the British Museum and at Kew, each of which, being supported by the State, is as much entitled as the other to the name of a "National Collection." And the evidence which has been laid before us leaves us no alternative but to recommend that these two Botanical Collections, the maintenance of neither of which involves any considerable cost, should not be merged into one, but that both be kept in a state of efficiency, and that the special scientific direction which each has spontaneously taken should be retained.

53. As a matter of fact, the Botanical Department of the British Museum, under its present able Keeper, has inclined in the direction of Botanical Palæontology—a direction rendered particularly convenient and appropriate by the existence of a large and valuable collection of Fossil Plants in the Museum; no less, as a matter of fact, under the late and present Directors of the Royal Gardens, has the Herbarium at Kew become the most complete apparatus for the cultivation of Systematic Botany in existence. It is the centre to which Botanists flock from all parts of the world, and with which Botanists of all parts of the world are kept in communication by a system of Correspondence, of vast extent, which could only have been organized by means of the exceptional physical strength and mental capacity of successive Directors.

54. It may be said that if the Kew Herbarium is to remain a great National Scientific Herbarium, the accommodation to be given to Botany in the new building at South Kensington is excessive. But we do not think that such will prove to be the case. In the first place, we should not be disposed unduly to limit the power of the Keeper of Botany in the British Museum to purchase systematic collections for purposes of palæontological comparison; and, in the second place, it would be highly useful to have a geographically arranged collection in the British Museum as the complement of the purely systematically arranged collection at Kew.



55. We think it desirable, then, that the collection at the British Museum should be maintained and arranged with special reference to the Geographical Distribution of Plants and to Palæontology; and that the collection at Kew should be maintained and arranged with especial reference to Systematic Botany. And we are of opinion that all collections of recent plants made by Government Expeditions should, in the first instance, be sent to Kew, to be there worked out and distributed, a set being reserved for the British Museum; and that all collections of fossil plants made by Government Expeditions should be sent to the British Museum.

Qu. 11,537.  
Qu. 12,190.  
Qu. 12,192.

56. It has been suggested to us that some part of the resources of Kew might be advantageously directed towards the advancement of the science of Botanical Physiology, and the Director of the Gardens states that he has "repeatedly urged young experimenters to commence, offering them facilities; but the difficulty with them, has always been to give the time and get funds to support themselves."

57. We agree with the Director in thinking that it is highly desirable that opportunities for the pursuit of investigations in Physiological Botany should be afforded at Kew to those persons who may be inclined to follow that branch of science.

#### IV. THE MUSEUM OF PRACTICAL GEOLOGY.

58. The Museum of Practical Geology is administered by a Director, who is responsible to the Lords of the Committee of Privy Council on Education.

The primary object of this Museum is to exhibit the industrial applications of Geology and the kindred sciences, with special reference to the mineral resources of this Country and its Dependencies; and the Collection of British fossil and rock specimens, illustrating the Geological Survey of Great Britain. The following collections are comprised in the Museum:—

(a.) Specimens of British building stones, polished marbles and other ornamental stones, used for constructive and decorative purposes.

(b.) A collection of British, Colonial, and Foreign Minerals, specially selected for their economic value, or for their importance to the Student of Mineralogy, Geology, and Mining.

(c.) A Metallurgical Series, comprising specimens illustrating the smelting of ores and the industrial applications of metals and metallurgical products.

(d.) Models of mines and mining machinery, with examples of mining tools; models of ore-dressing apparatus, furnaces, and metallurgical appliances, with geological and topographical models of special localities.

(e.) A collection of specimens showing the technological applications of clays, and fully representing the history and present position of British Ceramic Art; with illustrations of manufactures in glass and enamels.

(f.) The Palæontological Collections, embracing a large series of British fossils, stratigraphically arranged.

(g.) A Petrological Collection, comprising specimens of the Igneous, Metamorphic, and Stratified Rocks of Great Britain.

(h.) A Library of upwards of 20,000 volumes, including works on all those branches of Science which find illustration in the Collections exhibited in the Museum.

Appendix I.

59. The Museum is open gratuitously to the public, on Mondays and Saturdays from 10 a.m. till 10 p.m., and on the other days of the week (Friday excepted) from 10 a.m. till 4 p.m. during the months of November, December, January, and February; and until 5 p.m. during the remainder of the year, with the exception of one month's vacation from the 10th of August to the 10th of September. It is in evidence before us that the evening opening of this Museum is attended with considerable expense without corresponding advantage.

Qu. 13,819-  
13,831.

60. It is evident that the Collections of Minerals in this Museum are closely allied to the Mineralogical Collections of the British Museum, which it is proposed shall hereafter find a place in the New Natural History Museum.

61. In a Paper printed as an Appendix to our first volume of Evidence, Professor N. Story-Maskelyne, the present Keeper of the Mineralogical Department of the British Museum, expresses the opinion that the juxtaposition of Mineralogical and Biological Collections is not now considered so important as formerly.

"So long as the British Museum might be retained in its integrity, or its collections might be re-grouped into distinct divisions at the present locality, the mineral collection would seem to be in its place among them. But when once a separation of a part of these collections from the rest is determined on, the logical position of a collection of minerals in the midst of a series of biological collections assumes a new and very questionable phase."

Vol. I. App. XIV.; p. 43.

"The division of created things into animal, vegetable, and mineral is no longer exhaustive; it no longer represents the whole world known to science. Organic chemistry and the sciences that deal in organisms treat of certain forms of matter that are organic from one point of view and yet are not organic from another, and even inorganic chemistry deals in substances that can only be called mineral by using the word in what must, even in the present age, be termed an ambiguous sense. The place of a collection of minerals is certainly either by the side of the crystallised products of the laboratory, that is to say, it should aid in illustrating the science of chemistry; or that place is to be found where minerals are most completely studied, technically as well as scientifically, that is to say, where mining is especially taught."

62. Professor Story-Maskelyne then expresses his opinion, that the Museum of Practical Geology in Jermyn Street is:—

"The best and most practical destination for the Mineral Department of the British Museum under the supposed change in the distribution of the collections, and I think this is equally so, whether the objects embraced in my collection be confined, as at present, to natural minerals, or whether the limits of that collection be enlarged in the manner I have proposed, so as to embrace artificially formed 'mineral' or chemical products."

Vol. I. App. XIV.; p. 44.

"Under any circumstances, a gallery must be built to contain the mineralogical collection, and the cost of building it will not be very different, whether it be associated with the 'Biological' Museum or with the School of Mines. But I beg to place on record, and in the hands of Her Majesty's Commissioners, my strong opinion that the least appropriate destination of this collection would be in association with a Biological Museum."

63. We have felt it our duty to call attention to this opinion; but, considering that arrangements have been made for the lodgment of the Mineralogical Collections of the British Museum in the New Buildings which have been begun at South Kensington, and that these Collections could not be accommodated in the Museum of Practical Geology, which needs all the space disposable for the display of the British Palæontological, Rock and Mineral Specimens—which is its primary object—we do not base any recommendation upon it. In connexion with this subject, we may again refer to the insufficiency of accommodation in the Museum in Jermyn Street for the staff of the Geological Survey of Great Britain, upon which Professor Ramsay, the Director-General of the Survey, has so strongly insisted in his evidence.

Qu. 669-674.

#### V. THE SOUTH KENSINGTON MUSEUM, AND ITS BRANCH MUSEUM AT BETHNAL GREEN.

64. The South Kensington Museum is administered by a Director who is responsible to the Lords of the Committee of Privy Council on Education.

65. Though, from special circumstances, the Art Collections of this Museum have been, up to the present time, most developed, it has contained, from its earliest days, several Collections of a Scientific Nature. Those at present existing are:

1. The Food Collection.
2. The Animal Products Collection.
3. The Structure and Building Materials Collection.
4. Models of Machinery, Ships, and Military and Naval Appliances.
5. Collections illustrating Economic Entomology and Forestry.
6. Collections illustrating Fish Culture.
7. The Educational Collections.
8. The Patent Museum.

##### *The Food Collection.*

66. This Collection, which was commenced in 1858, has been formed with a view to showing first, the chemical composition of the various substances used as food; secondly, the sources from which all varieties of food are obtained; and, thirdly, the various substances used for adulteration, and the best methods of detecting them.

A duplicate Collection of the chemical analyses of food is used for circulation among country Schools, and large descriptive labels are supplied to the Managers of country Museums who may apply for them.

##### *The Animal Products Collection.*

67. This Collection was established by the Commissioners for the Exhibition of 1851, who observed that, whilst the public possessed in the Museums of Kew and Jermyn Street Collections illustrative of the Economic Applications of Mineral and Vegetable Sub-

stances, there was no representation of the uses of the Animal Kingdom. The Collection consists of Animal Substances employed in Textile Manufactures and Clothing; substances used for domestic and ornamental purposes; Pigments and Dyes yielded by animals; Animal substances used in Pharmacy and in Perfumery; and the application of waste matters, together with Illustrations of the Processes of Manufacture.

We have been informed that for want of space this Collection has been but little developed of late years.

*Construction and Building Materials Collection.*

68. This Collection had its origin in a large number of models and specimens which were presented to the Commissioners for the Exhibition of 1851 at its close. In 1859 the Collection had become so extensive from gifts, especially from the Exhibitions in London and Paris, that the Classified Catalogue formed a most useful book of reference on the subject, and was largely sold as such.

The Collection consists of the following objects:—Building Stones; Marbles and Slates; Cements and Plasters; Bricks of every description; Tiles for roofing, flooring, and wall decoration; Terra Cottas; Drain-pipes; Asphalte and Bitumen; Iron and Metal Work; Woods applicable to building purposes; Glass, and its application; Models of Buildings and Construction; Paperhangings; Papier-mâché Work; Architectural Drawings and Plans.

69. In connexion with this Museum, numerous experiments on the strength of materials have been carried on, the results of which have been published in the Catalogues.

*Models of Machinery, Ships, and Military and Naval Appliances.*

70. This Collection consists principally of Models of Marine Engines, Ships, and Guns. But there are also specimens and models of machinery of a different character, such as the Jacquard Loom, the Whitworth Measuring Machine, and the Babbage Calculating Machine.

*Collections illustrating Economic Entomology and Forestry.*

71. A Collection of Economic Entomology is now in course of formation. It is intended to enable the public to distinguish insects injurious to man from those that work to his advantage, and to illustrate the best means of destroying those which are injurious, or of mitigating the ravages committed by them.

This Collection, in its relation to Forestry, contains specimens of the various kinds of timber attacked by insects, the insects themselves in various stages of growth, and the appearance of the foliage and bark when attacked. The best known means of destroying the insects are also indicated.

*Collection illustrating Fish Culture.*

72. This Collection illustrates the artificial breeding of fish, the protection of rivers, methods of capture of fish, &c. All or nearly all the Collection belongs to Mr. Buckland (Inspector of Salmon Fisheries). It is on loan to the Museum.

*The Educational Collections.*

73. These Collections comprise: 1. A Library of Books bearing on Education in which Education in Science is largely represented, and 2. A Collection of School Furniture and Fittings, Philosophical Instruments, Apparatus for Scientific and other Instruction, specimens and diagrams of Natural History, including Mineralogy and Geology, and other Educational Appliances, such as drawing materials, &c.

74. The origin of the Library and Collections is due to an Educational Exhibition formed by the Society of Arts, and held in St. Martin's Hall in the summer of 1854. When this Exhibition closed, many of the contents, English and Foreign, were placed by the Exhibitors at the disposal of the Society, and a strong desire was expressed that it should become a Permanent Institution. The Collection thus formed was offered to and accepted by the Government.

75. The chief Manufacturers of Educational Appliances and Publishers of School Books have largely contributed, and numerous gifts have been received from Foreign Governments, especially at the close of the Exhibitions of 1862 and 1871. In consequence of

the great demand for Educational Works on Scientific Subjects, the vote for purchases has of late years been largely expended in strengthening the Library and Collections in this direction.

76. Special Collections of Apparatus for Teaching the various branches of Science have lately been formed. Duplicate sets of these are circulated in the country.

77. The total number of books and pamphlets in the Library exceeds 30,000.

78. A Reading Room, ill-adapted and much too small for the purpose, as it has been stated in evidence, is attached to the Library. It is open during the same hours as the Museum, and is chiefly frequented by students, teachers, clergymen, school managers, and others who wish to consult special books, or to become acquainted with the best Educational Works on the various subjects. Qu. 13,833.

#### *The Patent Museum.*

79. In connexion with the South Kensington Museum, but under the Control of the Commissioners of Patents, there is also a Patent Museum, consisting of a Collection of patented and other inventions, ill-accommodated in a building which is much too small for the proper display of the Objects. The Collection belongs partly to the Commissioners of Patents, partly to the Commissioners for the Exhibition of 1851, and partly to private persons: it contains many most interesting specimens, especially a series illustrating the History of the Steam Engine from its earliest days. Appendix I.

#### *Proposed Additions to the Scientific Collections of the South Kensington Museum.*

80. We consider it our duty to point out the striking contrast afforded by the British Museum Collections, dealing with Biology, Geology, and Mineralogy; the Jermyn Street Collections, dealing with Geology (Scientific and Economic), Mineralogy, Mining, and Metallurgy; the Kew Collections, dealing with Botany, on the one hand, and, on the other hand, the Collections in the Scientific Department of the South Kensington Museum (including the Patent Museum), where alone has any attempt been made to collect together, in a Museum, Objects Illustrating the Experimental Sciences.

81. While it is a matter of congratulation that the British Museum contains one of the finest and largest Collections in existence illustrative of Biological Science, it is to be regretted that there is at present no National Collection of the Instruments used in the Investigation of Mechanical, Chemical, or Physical Laws; although such Collections are of great importance to persons interested in the Experimental Sciences.

82. We consider that the recent progress in these Sciences, and the daily increasing demand for knowledge concerning them, make it desirable that the National Collections should be extended in this direction, so as to meet a great Scientific Requirement which cannot be provided for in any other way.

83. The defect in our Collections to which we have referred is, indeed, already keenly felt by Teachers of Science. If a Teacher of any branch of Experimental Science wishes to inspect any Physical Instrument not in his possession, as a Teacher of Literature would a book, or a Teacher of Biology would a specimen, there is no place in the country where he can do it.

84. We are assured by high authorities that, on the Continent, Collections of Scientific Apparatus, when combined with Lectures accessible to workmen, have exerted a very beneficial influence on the development of the skill of artizans employed in making such instruments.

85. Lord Salisbury, in Evidence before us, has stated:

"There is another point in which I think that the Government might give an advantage of an educational kind to Scientific Research. It would be desirable, if it were possible, to provide the means of giving Scientific Instruction to Instrument Makers. My impression is that their importance to the conduct of scientific research is scarcely sufficiently recognised by the public, and that it is, I will not say quite, but almost of equal importance, to have highly educated and cultivated scientific instrument makers, as to have highly educated scientific thinkers." Qu. 13,575.

86. A valuable part of the instruction to which Lord Salisbury refers would be derived from the examination of Collections in which the history and latest developments of each instrument could be studied with a view to its improvement or modification in any particular direction.

87. On this point we have received interesting Evidence from Colonel Strange :

Qu. 10,434.

"What is your opinion as to the head of a museum of scientific instruments, and apparatus, and machines, and tools used in the arts?—I think that that is a very important branch of the subject indeed. I need scarcely allude to the great importance that is attached to that on the Continent. The name of the Conservatoire des Arts et Métiers will suggest it at once, which is the very best evidence indeed that I could produce. I have often visited it with great interest and profit. Moreover, I believe there are several others in Paris, some of more recent establishment, of the same kind; I look upon that as a most necessary part of any scientific system. No Scientific System can be complete without examples of the apparatus that are being used in all branches of Science, both in England and abroad, and on that point I speak from experience of the great use that such a museum would be. \* \* \* \* \* If there were a great Museum, such as I suggest, containing all the new developments in instruments, and in machines and tools, to which I could resort, I should be able to introduce modifications with far greater confidence, and it would be an enormous assistance to me individually. I find very few persons who have really studied what I will venture to call the physiology of instruments and apparatus, and such persons would derive very great advantage, I think, from being able to go to an establishment where large collections of apparatus of different dates and the products of different minds were collected together in one view, some of which would contain some desideratum of which they were in search. I think, if they had such a collection to go to, it would materially aid them in the choice of the apparatus that they required, and would tend enormously to advance exact experiments. There is no doubt that some years ago there was no nation that could compete at all with England in such matters, but we have taught the rest of the world, and the pupil has now become somewhat in advance, in many directions, of his master. Also the spread of scientific education on the Continent has tended to the application of more sound principles of construction in such things than with us.

88. Although the question of the Establishment of a Museum of Scientific Apparatus is more closely allied to the objects of our Commission than that of a Museum of Mechanical Inventions, we think it right to call attention to the proposals made by a Committee of the House of Commons appointed to Report on the Patent Office Library and Museum.

89. That Committee gave, in the following terms, their conception of the nature of the "General Museum of Mechanical Inventions," the establishment of which they contemplated :

"It appears to your Committee that the chief purpose of a General Museum is to illustrate and explain the commencement, progress, and present position of the most important branches of mechanical invention; to show the chief steps by which the most remarkable machines have reached their present degree of excellence, to convey interesting and useful information, and to stimulate invention."

90. With regard to the Funds which would be necessary for the Establishment of such a Museum on an adequate scale, the Committee, referring to a large sum which had accumulated from the fees paid by inventors (which Fund at the end of the year 1871 amounted to 923,741*l.* 8*s.* 11*d.*), stated that—

"Your Committee consider that the principal object of the fees payable under the provisions of the Patent Law Amendment Act, was to provide for the proper working of that Measure, and not for the purpose of increasing the general revenue of the country. Without entering upon the question whether or not a claim exists to have the surplus exclusively devoted to the purposes of the Act of 1852, your Committee are of opinion, that for the future the annual surplus revenue accruing from the operation of that Act, should be so applied to the extent which may be necessary."

91. We agree with the Committee as to the general character of the objects to which the Fund in question should be appropriated.

92. We consider that this Fund, which is derived in great part from the Applications of Scientific Principles to various uses in the Arts and Industries of the Country, would be very properly spent in bettering some of the conditions on which invention and discovery depend; and we are of opinion that, among the uses to which such a Fund could be most advantageously applied, the Establishment of such a Museum of Scientific Apparatus as that which we contemplate, would rank among the most important; and we are convinced that such a Museum would have a material influence upon the spread of Scientific Instruction throughout the country, and would, therefore, largely foster Invention and Discovery.

93. We accordingly recommend the formation of a Collection of Physical and Mechanical Instruments; and we submit for consideration whether it may not be expedient that this Collection, the Collection of the Patent Museum, and of the Scientific and Educational Department of the South Kensington Museum should be united and placed under the authority of a Minister of State.

94. Whether this union be effected or not, we are of opinion that it is desirable that the Scientific Collections now placed at South Kensington should be subjected to a critical revision with a view to restricting them to such objects as are of National Interest or Utility.

## VI. OTHER SCIENTIFIC COLLECTIONS.

95. The only Public Scientific Museums and Botanic Gardens besides those already referred to which receive direct aid for their maintenance from the Government are the Edinburgh and the Dublin Museums, and the Botanic Gardens of those cities. The Edinburgh Museum consists of a Scientific and also of an Industrial Collection. The Natural History Collection, formed by the University of Edinburgh, was some years ago handed over to the Government, and was lodged in the same building with the Industrial Museum, adjoining the University, and placed under the general charge of the Professor of Natural History, as Regius Keeper, and of the Director of the Industrial Museum, an officer appointed by and responsible to the Science and Art Department of the Privy Council. Appendix I.

96. Evidence has been brought before us on the Condition and Management of the Natural History Collection so transferred; but as we have been informed that the Education Department had appointed a Commission to which it had committed the prosecution of the Inquiry into the Management of the Industrial Museum in Edinburgh, and that the Commission so appointed had Reported; and, further, that the Department had taken administrative action on their Report; we are of opinion that the further investigation of questions concerning the Management of this Museum has been removed from our hands. We have, therefore, felt it to be our duty to omit whatever passages in the Evidence relating to matters of fact respecting this Museum have been controverted before that Special Commission.

97. The arrangement recommended by the Special Commissioners and adopted by the Government is the appointment of a fully qualified Naturalist, under the administrative control of the Director of the Museum, as Curator of the Scientific Collections; the Regius Professor in the University being relieved of his responsibility as Regius Keeper.

98. The Royal Dublin Society act as Trustees of the Museum of Natural History (including Mineralogy and Geology), of the Botanic Gardens and Botanical Museum, Glasnevin, and of the Library, and are responsible for their Administration. These establishments are wholly supported by public funds, provided for annually in the Estimates of the Science and Art Department. The Agricultural Museum is supported by the Royal Dublin Society out of its own funds. Appendix I.

The Institution in St. Stephen's Green, formerly known as the Museum of Irish Industry, has ceased to exist under that name; and the School of Science applied to Mining and the Arts, which was attached to it, has been converted into a Royal College of Science. All the Collections of the Industrial Museum (with the exception of the Portlock Collections of Irish Flora and Fauna, which have been transferred to the Royal Dublin Society) are still retained, and, with the Collections of the Geological Survey, are exhibited in the building in St. Stephen's Green. The Collections comprise objects illustrative of building materials, mining, metallurgy, and fuel; of ceramic and glass manufactures; and of vegetable and chemical products. These Collections are in charge of the Curator of the Museum. The Director of the Geological Survey of Ireland has charge of the Palæontological and Rock Collections the former has been made by the Geological Survey; the latter purchased; out of the funds of the Museum, to illustrate Lectures and for the use of the Officers of the Survey.

100. Besides the Museums and Collections which receive aid from the Government, there exist in various parts of the United Kingdom Local Museums, supported from independent sources. Most, if not all, of these include Natural History Collections, often associated with other objects, especially with specimens illustrative of Archæology and Ethnology, and sometimes of the Industrial Arts.

101. Some of these are under the government of Municipal Bodies; some are maintained by the inhabitants of the locality, and are managed by Committees or Governors elected by the Contributors; while others are connected with Scientific Societies or Naturalists' Clubs.

102. Certain of the great Towns possess Museums of considerable extent, and arranged with skill and care. We may refer to those of the Manchester Natural History and Geological Societies, which, associated as they now are, with a College possessing an efficient Staff of Scientific Professors, are able to afford important assistance, not only in illustration of their lectures, but also to the independent studies of advanced Students.

However, even in the case of many of the larger and more important Museums, many specimens are often required for the completion of their series.

103. The Museums of less important Towns are generally very incomplete. They too often consist of specimens unconnected with each other, the gifts of travellers possessing little or no knowledge of Natural History. When they are the result of the labours of some local Naturalist, or of some Provincial Society, they are of exceptional, and sometimes of great, value; but such Collections are rare.

104. It cannot be doubted that Local Museums greatly tend to create and diffuse a taste for Natural History Studies; but if they are to become useful in promoting such studies, and for the purposes of instruction, it is essential that they should contain typical specimens illustrative of Geology, Botany, and Zoology; and, also, as far as possible, a Collection illustrating the recent and fossil Zoology, Botany, and Geology of the district.

105. Museums of this character might be used most advantageously for purposes of class instruction, and for demonstrations by competent scientific persons.

106. In our Second Report, on Elementary Scientific Instruction, we insisted on the importance of more practical Scientific Teaching in Laboratories, and on the illustration by specimens of all instruction in the Natural Sciences depending on Observation. Consequently, we recommended that greater facilities should be given to obtain grants for buildings and for museum fittings [p. xxix. vol. 1.]. We suggested that whenever a Provincial Science School had attained such a degree of efficiency as to be capable of being organised as the centre of a group of Elementary Science Classes, it should be enabled, among other things, to provide a supply of specimens for the illustration or instruction in those classes.

107. In many towns of considerable population, there are no Museums, or only such as are worthless for purposes of even popular instruction. Yet some of these towns are, as is shown by the Evidence submitted to Your Commissioners, well fitted by situation to become centres of Scientific Instruction to considerable groups of population. On the Coalfields a town containing 30,000 or 40,000 inhabitants is, not unfrequently, the centre of a group of smaller towns existing within a radius of from five to ten miles, and, to a great extent, connected by railways. Within this area, the population is often as numerous as from 100,000 to 150,000. If a Science School, provided with Laboratories and a Typical Museum, existed in such a centre, it would exercise a most important influence on the Scientific Education of the District. The Museum would also be eminently attractive and humanizing as a place of popular resort.

108. We, therefore, consider that the Establishment of such Museums, where they do not exist, as well as their maintenance and improvement where they have already been formed, should be promoted by Aid from the State.

109. The aid here recommended might either take the form of grants of money (as has been already suggested in our Second Report), or of contributions of specimens coming into the possession of the Government which may not be required by the British Museum or other Public Collections.

110. We would point out that the latter proposal is in accordance with one of a series of Recommendations made in 1857 by the Committee which assists the Council of the Royal Society in the administration of the Fund for the Promotion of Science known as the "Government Grant." These recommendations were approved by the Council and communicated to the Prime Minister of the day, in answer to an inquiry as to the measures which could be adopted by the Government or by Parliament with a view to improve the position of Science, or its Cultivators, in this country.

The Recommendation in question was as follows:—"That duplicate specimens from the British Museum, and other Institutions supported at the public expense, be distributed to Provincial Museums." This was in pursuance of a previous Recommendation to encourage the formation of Provincial Museums and Libraries.

Qu. 6567,  
6568.

111. A difference of opinion prevails among the witnesses as to the possibility of carrying out this Recommendation. Mr. Winter Jones and others connected with the British

Museum have pointed out that the number of duplicates or redundant specimens is insignificant, and it appears not to be the usual practice to acquire duplicates, or to accept them when offered as a gift, as such duplicates are looked upon as an incumbrance; whilst the few which are preserved, as being especially valuable, are utilized for exchanges, and are thus to be reckoned as part of the resources of the establishment. It is further urged that the determination of duplicates is a work of difficulty, consuming time and labour, and that were they to be habitually received in large numbers, and were the task of assorting them and distributing them to Local Institutions to be thrown upon the officers of the Museum, the regular business of the establishment would be injuriously interfered with, unless an adequate addition were made to the working staff.

Qu. 6504,  
6567.

Qu. 6572,  
6573.  
Qu. 7576-  
7578.

112. Dr. Günther, of the British Museum, a high authority in all that relates to the Management of Natural History Collections, while he is strongly in favour of encouraging and aiding Provincial Museums, considers that the most useful and economical mode of bestowing aid would be by grants of money, to purchase from the dealers in objects of Natural History such specimens as may be required, and he believes that, from the now extended traffic in those objects, there would be no difficulty in procuring in that way all that would probably be wanted.

113. Professor Owen and Professor Maskelyne are decidedly in favour of employing the agency of the British Museum in distributing specimens to Provincial Institutions, and Professor Maskelyne is satisfied that there would be no difficulty in carrying out the plan as regards his own Department.

Qu. 7477.

114. Professor Phillips (Professor of Geology in the University of Oxford), while attaching no importance to the occasional transfer of duplicates from the Metropolitan to Local Museums, considers that it would be quite possible for the Metropolitan Museum to undertake to supply Local Museums with well-arranged Typical Collections, and that the assistance thus afforded would be of great advantage.

Qu. 3103.

115. We are of opinion, on a careful examination of the whole question, that the organization of any systematic distribution of specimens would present considerable difficulties.

116. We consider, indeed, that the authorities of the British Museum should be empowered to dispose, by gift, in favour of Local Museums, of any specimens which may be ascertained to be duplicates, and which can be dealt with by the present Staff. But we cannot conceal from ourselves that, though the extensive Colonial Dependencies of this Country, and its universally diffused commerce, make it the centre to which should naturally flow specimens from every quarter of the world, the organization of the machinery for collecting, naming, and distributing duplicates on any large scale, involves a task far more formidable than is apparent at first sight. So laborious a work could not be imposed on the present Officers of the British Museum; for extensive correspondence would be necessary to secure the collection of specimens, and much time would have to be devoted to their discrimination and classification in Typical Collections. Nor could the distribution of specimens for the maintenance of Provincial Museums be systematically and successfully carried out on such a plan without the aid of Inspectors, charged with the Classification and Arrangement of the Local Collections, and who, thus becoming acquainted with their wants, would be able, in the Department of Collection and Distribution, to provide for the supply of what was locally deficient.

While we thus point out what is the task involved in carrying the Recommendations of the Witnesses into effect, we repeat the expression of our conviction, that, without some method of collection and distribution, or some efficient supervision, Provincial Museums will probably generally continue to be, as most of them now are, very inadequately supplied with specimens, imperfectly arranged, and insufficient to prove in any way a source either of popular attraction, or of more complete instruction.

117. We recommend, therefore, that, in connexion with the Science and Art Department, qualified Naturalists be appointed to direct the collection of specimens in order to supply whatever deficiencies exist in the more important Provincial Museums; and, also, in order to organize Typical Museums, to be sent by the Department of Science and Art into the Provinces to such Science Schools as are reported to be likely to make them efficient instruments in the instruction of their own Classes, or to form and conduct subordinate classes in the surrounding country, to which specimens could be lent for the illustration of courses of teaching.

118. The Department of Science and Art has already had some experience of the conditions on which grants of Apparatus for Instruction in Experimental Science can be



usefully made; and that Department would determine under what regulations Typical Museums could be lent, or more permanently founded.

119. Whenever it was seen to be expedient, in accordance with the suggestions of Professor Phillips and other witnesses, to organize a System of Inspection of Provincial Museums, such inspection could be accomplished at little expense. Scientific men, living in the Provinces, would be eminently qualified for the duty of inspecting Local Museums. They would report on their deficiencies as typical collections for purposes of instruction; they would ascertain to what extent they were usefully employed, and whether the conditions attached to the loan or grant from the Department of Science and Art were fulfilled. These Reports would aid the Department in its administration.

#### VII. PUBLIC LECTURES IN CONNEXION WITH MUSEUMS.

120. The possibility of extending the usefulness of the Natural History Collections in the British Museum, by the delivery of Lectures, has been brought before us in Evidence. On this point, we have first to state that, of late years, parties of working men, accompanied by one or more gentlemen who take an interest in their instruction, have on several occasions attended at the Museum, to have the benefit of Demonstrations by Professor Owen and others of the Officers, explanatory of the principal objects in one or more of the galleries. The service performed by the officers is entirely voluntary. This use of the Museum has not been attended by any inconvenience, and has been warmly approved and encouraged by the Trustees.

Qu. 6501,  
6596.

Qu. 6505.

121. As to the expediency, however, of giving regular Courses of Formal Lectures, the views entertained by highly competent witnesses are widely divergent.

122. Professor Owen, Professor Flower, Dr. Günther, and (with some qualifications) Dr. Sclater, have all expressed opinions favourable to the delivery of "Lectures" by the Keepers or Assistant Keepers of the British Museum, but it is important to observe that these witnesses attach very different meanings to the word "Lectures."

Qu. 6598

123. Professor Owen understands by this term Elementary Courses of Lectures, open to the public without charge, and of a character adapted to afford Instruction to the Teachers of Elementary Schools, and proposes that 12 distinct Courses of such Lectures should be available to them; each course consisting of 24 lectures to be given by Officers of the Museum.

Qu. 6609.  
Qu. 6611.

Qu. 6857.

124. Professor Flower (Conservator of the Museum of the Royal College of Surgeons), on the contrary, understands by "Lectures" Advanced Lectures. The Lecturer is "to select some subject he happens to be working at in his duty of arranging or cataloguing the collection under his care, and to give a short course of lectures on that particular subject." Professor Flower is not of opinion that the British Museum is a proper place for giving Elementary Instruction, and says "at all events the Officers of the Museum would not be the right persons to give it."

125. Dr. Gunther (Assistant Keeper of the Department of Zoology in the British Museum) advocates a far more extensive System of Lecturing than either Professor Owen or Professor Flower.

Qu. 10,117.

First, a regular Course of Elementary Instruction to Students, such as is given in the Universities, accompanied by practical work.

Qu. 10,119.

Secondly, Lectures for the general public, such as are given at the Royal Institution.

Thirdly, Demonstrations of a popular character in the Galleries of the Museum.

Qu. 10,120.

126. Dr. Gunther proposes that the Lectures and Practical Instruction of the first class should be given by the Keepers; those of the second class by the Keepers or by persons not connected with the Museum; and those of the third class by the Assistants.

Qu. 6793.  
Qu. 6786.  
Qu. 6785.  
Qu. 6797.

127. Dr. Sclater (Secretary of the Zoological Society of London), though in favour of having Lectures at the Museum (or in its immediate vicinity), would not have mere Elementary Instruction given by the Keepers, and thinks it would be "very objectionable" to connect the teaching absolutely with the office of Curator.

Qu. 7775.

128. Again, Mr. Waterhouse (Keeper of the Department of Geology in the British Museum), whose experience as a Curator is as great as that of any of these gentlemen, does "not think it at all desirable" that Keepers or other officers of the Museum should lecture, and is of opinion that lecturing would "interfere very much with their ordinary duties."

Qu. 6556.

129. And Mr. Winter Jones, the Principal Librarian of the British Museum, considers

that the delivery of lectures "is not consistent with the proper performance of the duties" of the Keepers.

130. Professor Maskelyne (Keeper of the Department of Mineralogy in the British Museum) would preclude Formal Lectures in the Museum, but would allow a Lecturer to meet his class there to illustrate lectures he may have given elsewhere, by demonstrations in the galleries of specimens which, from their size or value, could not be exhibited in his lecture room. Professor Maskelyne considers that if a Keeper has an aptitude, and also opportunities, for delivering lectures, he should be encouraged to do so, but not in the Museum; and he would altogether disapprove of appointing a Keeper simply or chiefly because he was a good Lecturer. Qu. 746d  
Qu. 7460.

131. With regard to the Demonstrations given in the Natural History Galleries, we are of opinion that though they tend to increase not only the attractions but the usefulness of the Museum, the delivery of such Demonstrations should be in no degree obligatory on the present or future staff of Keepers, and should not receive such a development as to interfere with the discharge of the proper duties of any officer of the Museum.

132. But while favourable to the continuance of such Demonstrations, we are by no means prepared to recommend the institution, in the Museum, of Systematic Courses of Lectures; in fact, on this question we find our opinion to be entirely in accordance with the conclusions arrived at by the Royal Commissioners appointed, in 1847, to Inquire into the Constitution and Government of the British Museum, as stated in the following extract from their Report, page 35.

"At Q. 2717, and elsewhere in the course of Professor Owen's evidence, will be found some observations on the expediency of introducing the practice of lectures illustrative of the collections of the Museum. In favour of the introduction of this practice, the instances are cited of the Hunterian Collection, and that of the Jardin des Plantes and other Continental Institutions. We are of opinion, as regards the Museum, that however undeniable the advantages which might be derived from some of its collections, as materials for oral illustration, it would not be desirable either to place these collections for such purpose at the disposal of lecturers not attached to the Museum, or to add to the present duties of its officers the obligation of lecturing. We consider the Museum as essentially a repository for the conservation and arrangement of a vast variety of material objects, from which men of science, literature, and art may derive assistance to their researches. We believe that the task of its superintendence and management, with a view to this main purpose alone, is sufficient to engross the time and the ability of its own officers, and that the full attainment of that purpose might be in some degree hazarded by the pursuit of every adventitious advantage which might appear of possible attainment through the instrumentality of its stores. Without desiring to limit the discretion of the Trustees in dealing with any suggestions of this nature, we cannot take upon ourselves to recommend the systematic adoption of the practice in question, nor to advise that any building in the nature of a theatre or lecture-room should form part of any future additions to the Museum."

133. Concurring in every respect with the opinions thus expressed by the Commissioners of 1847, we would further point out that, as remarked by several of the witnesses, lecturing and curatorial work are entirely different occupations, aptitude for the one by no means implying skill in the other; and that were the possession of a talent for lecturing allowed to weigh in the selection of Keepers and their Assistants, the result would, in all probability, prove prejudicial to the interests of the Institution. Qu. 6503,  
6759, 6715-  
6716, 7776.

134. In accordance, moreover, with the view we take of the proper purposes of the Museum, we are not favourable even to the modified proposal that Lectures should be given in the Establishment by persons specially employed for that duty who are not on the Official Staff; and, indeed, we do not see that any special advantage would be gained by delivering Natural History Lectures at the British Museum; for, as the valuable specimens in the Galleries ought not to be subjected to the risk of rough usage in a Lecture Theatre, and as Special Collections would, therefore, be required for teaching, these might as well be provided and used elsewhere.

135. In considering the question of the modes of turning Natural History Museums to account as places of Instruction, it must not be forgotten that much may be done towards this end by other means than by the delivery of Lectures. By the skilful selection and arrangement of the specimens exhibited to the public; by providing Descriptive Labels instead of the meagre indication of names at present adopted; and, above all, by supplying Explanatory Catalogues suited to the wants of unscientific people, the public might be enabled to teach themselves with as much efficiency as they would be taught by the majority of Lecturers, and with far less trouble and inconvenience than are involved in the Attendance on Lectures.

136. We have formed a decided opinion that Keepers and other Scientific Officers in charge of the Collection ought not to be diverted from their proper business, which

is the naming, arrangement, and cataloguing of the specimens, by being required or expected to give lectures. The National Collection of Natural History should represent as completely as possible the totality of the forms of animals and plants, both living and fossil; and these forms ought all to be named, described, arranged, and catalogued. The task of bringing the National Collection into this ideal state of perfection is assuredly of sufficient magnitude to occupy for very many years to come the full working power of the staff of Keepers and Assistants.

137. Those whose duty or inclination it is to act as interpreters between Science and the general public should have full opportunity for doing their excellent and useful work; on the other hand, those whose duty it is to instruct the student, not only in the facts, but in the methods of Science, and those, whose no less laborious task it is to discriminate and put in order the endless variety of Natural Objects, so that they may become accessible and useful to the advanced worker, should be enabled to perform these functions without the hindrance and distraction of popular lecturing.

138. The objections, which we have just pointed out to the delivery of systematic courses of lectures in connexion with the Natural History Collections of the British Museum, do not apply with equal force to Provincial Museums, the collections of which are incomparably smaller, are of a different character, and exist for different objects; and we are of opinion that it would be of great advantage for the diffusion of scientific knowledge, that arrangements should be made for giving courses of Scientific Lectures in such Provincial Museums of Natural History as have Typical Collections of specimens, and are provided with convenient Lecture Rooms. These Lectures should be explanatory of the contents of the Museum, and accessible to all classes on the payment of a small fee. But it is not desirable that the duty of giving such lectures should be, *ex officio*, incumbent upon the Curator, on whose time, especially in the larger Provincial Museums, there are many pressing claims; and, if the specimens are to be largely used for educational purposes, a special collection should be formed for use in the Lecture Room.

139. Again, the objections to the organisation of Systematic Courses of Lectures in connexion with Museums of Natural History do not apply to those Museums, whether Metropolitan or Provincial, which contain Collections of Physical, Mechanical, and Chemical Apparatus; of Geometrical Models; or of Models illustrating the progress of invention in Machinery and in Manufacturing Processes. The objects deposited in such Collections being already fully known, and having simply to be catalogued and kept in order, the work of the Curator is to a great extent mechanical, and his time, if the Collection is not a very large one, would be well employed in making it intelligible, and, therefore, useful, to the public.

140. In accordance with this view, we think it desirable that Courses of Lectures should be given at South Kensington in connexion with the Collection of Physical and Mechanical Instruments, the establishment of which we have recommended. The object of these courses should be to illustrate the progress of Scientific and Mechanical Invention by exhibiting and explaining the improvements from time to time introduced into the instruments and methods employed in Scientific Research, and in the applications of Scientific Discovery to National Industries. The Lectures should not have an elementary character, and should be given, as occasion may arise, by persons selected on account of their special acquaintance with the most recent developments of some important branch of Science.

141. The importance of the question raised by the proposal to organise Courses of Lectures in connexion with Museums, induces us to submit in this place some further recommendations with regard to it. We have felt it our duty to express our disapproval of this proposal, so far as the great National Collections of Natural History are concerned. We also consider it to be indispensable to the maintenance of a high standard of scientific instruction, that the lectures and class teaching given in Colleges and Schools of Science should have that strictly scientific character which alone can meet the requirements of the regular Students of such Institutions; and this opinion is corroborated by the evidence\* given to us by some of the most eminent Teachers and Investigators. But we are anxious that it should be clearly understood that we do not underrate the usefulness of popular Lectures on Science, although we are convinced that they ought not to form any necessary part of the business of the working staff of a great National Museum, or of an Institution for the Training of Students. On the contrary, we have arrived at the conclusion that

\* Vide  
Qu. 1174.  
Qu. 2798 et  
seq.

Lectures on Science, accessible to all classes on payment of a small fee, should be organised in the great centres of population; and we are of opinion that the establishment of such Lectures should be promoted by the Government. In the Metropolis, Lectures on Experimental and Natural Science have already been founded by the Government, and, though tried upon a very limited scale, the experiment has been attended with complete success: We recommend, therefore, that, in the first instance, a greater development should be given to this system of instruction.

142. The Lectures should be of two kinds.—

First. Lectures of an elementary character on the General Principles and most important Facts of Science.

Secondly. Lectures specially intended to familiarize the working classes with the Applications of Science to the Arts and Industries of the Country.

143. The arrangements for both classes of Lectures would be greatly facilitated by connecting them, as far as possible, with local Scientific Institutions, and especially with the Provincial Museums, which we have already recommended should receive direct aid from the State, and of which the Collections (and, in many cases, the Buildings) would be available for Lecture purposes.

144. The importance of Lectures of the first kind, as a powerful means of diffusing knowledge among the masses of the people, and thereby elevating their condition and making them more useful members of the community, is so generally admitted, that we do not propose to dwell on it here. But the object sought to be attained by Lectures of the second kind is a more special one; and we are induced to recommend the institution of such Lectures chiefly by the following considerations.—

145. We have elsewhere stated our opinion that Instruction in the Application of Science to the Arts and Industries of the Country should not be largely mixed with the courses delivered from purely Scientific Chairs. The immediate objects sought to be attained by a purely Scientific Course, and by one applied to the Arts, are so far dissimilar, that each can only be effectually promoted by separate modes of instruction. It must, moreover, be borne in mind that the distance which separates the Strictly Scientific Course and its Laboratory from the Workshop or "Colourshop" of the Manufactory is very great, and that the education of many of our artisans is at present so rudimentary, that even if they had the time they have not the culture necessary to enable them to derive much advantage from a complete Scientific Course. What is required, therefore, is a form of instruction intermediate between pure Science and the manipulations of industry, which may spread scientific knowledge among workmen, and, by rendering the relations of Science and Industry familiar to them, promote the improvement of manufacturing processes and the progress of invention.

3rd. Report,  
para. 181.

146. A large proportion of the workmen attending the proposed Lectures will probably have received preliminary instruction in the Elementary Science Classes already founded in connexion with the Science and Art Department. We have recommended that this instruction be made more efficient by the establishment of Laboratories and Museums, which we have suggested should be founded in connexion with Schools of Science in the centre of groups of such classes. The instruction thus provided would form a fitting preparation for the proposed courses, and many workmen would by these successive means be enabled to grasp the whole theory of the application of Science to their own branch of Industry.

147. Courses of Lectures of the kind which we are here contemplating have been conducted in Paris in connexion with the "Conservatoire des Arts et Métiers," an Institution the foundation of which was begun in the year 1775. Its scope and purpose are explained in detail in a Memorandum by our Secretary, which is appended to this Report, but we may briefly state that it is a great Collection of Geometrical and Mechanical Models, of Physical and Chemical Instruments, and of Machinery illustrative of the Progress of Invention. In the Theatre of the "Conservatoire," no fewer than 14 Courses of Lectures are given by very eminent Professors on the following topics:— Geometry applied to the Arts; Descriptive Geometry; Mechanics applied to the Arts; Civil Constructions; Physics applied to the Arts; General Chemistry in its relations to Industry; Industrial Chemistry; Chemistry applied to Dyeing, Pottery, and Glass; Agricultural Chemistry and Chemical Analysis; Agriculture; Agricultural Works and Rural Engineering; Spinning and Weaving; Political Economy and Industrial Legislation; Industrial and Statistical Economy.

Appendix  
III.

148. Each Professor gives two lectures weekly in the evening to suit the convenience of the artisans, by whom they are chiefly attended. The Lectures are intended to

show the application of Science to practice; to render accessible to the workman such portions of scientific knowledge as are most directly germane to his work; and finally to bring under notice and to explain the latest refinements of invention exhibited in the Museum.

149. From a communication received from General Morin, the Director, we learn that almost all the Courses embrace a considerable range of matter, of which the whole can only be gone through in two or three, sometimes more, years; but each yearly Course begins with an exposition of the principles, or, at all events, a reminder of them, before the special subjects of the course are discussed.

150. That the classes for whom these lectures are intended appreciate them is beyond a doubt, no fewer than 250,000 persons having attended the courses of last year; and it seems as little open to question that such instruction must have had a most beneficial effect.

151. In bringing thus prominently forward the example of the "Conservatoire des Arts et Métiers," we do not necessarily imply that its arrangements are in all respects suitable for imitation in this country. Instruction on many of the topics dealt with in the fourteen courses of lectures might be given as well in other places as in a Technical Museum. But it is obviously convenient that lectures on Mechanical and Physical Instruments, and on Machinery, should be given within the building which contains the objects described—objects which are not easily moved, and the inspection of which is a needful supplement to diagrams and descriptions.

152. In making the foregoing remarks we have been guided by two convictions.

The first, that the diffusion among the people of a general knowledge of Science is in itself an object of great importance, and that, in particular, an acquaintance with the manner in which abstract science is brought to bear upon industrial occupations is of the greatest moment to the working classes of this country, not merely as tending directly to increase the skill of the artisan in his handicraft, but as the best means of awakening his intelligence, by forcing him to reflect upon the general laws which are exemplified by the processes with which he is familiar in his daily life.

The second, that no real Advancement of Knowledge and none of the higher benefits from Science as Educational Discipline are to be hoped for from merely general and occasional Scientific Instruction, whether it be derived from books or from lectures, but that such Advancement and benefits will result only from systematic and sustained study.

153. While, therefore, we deprecate the notion that no Scientific Institution ought to be supported by the State unless it contributes directly in some way or other to the Instruction or Entertainment of the General Public, we advocate the fullest extension of Popular Instruction in Science, whether by Lectures in connexion with Public Museums suited for such purposes, or otherwise.

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### Conclusion and Summary of Recommendations.

154. In concluding that part of the Inquiry Entrusted to Your Commissioners which has reference to Scientific Museums, we deem it advisable to Summarise the Recommendations which we have considered it expedient to make.

With regard to *the Natural History Collections of the British Museum*, we recommend:—

- I. That the occasion of the Removal of these Collections to the New Buildings now being erected at South Kensington for their reception, be taken advantage of to effect a change in the Governing Authority and Official Administration of that Division of the Museum.
- II. That a Director of the National Collections should be appointed by the Crown, and should have the entire Administration of the Establishment, under the control of a Minister of State, to whom he should be immediately responsible; and that the Keepers of Collections, should be responsible to the Director. That the Appointments of Keepers and other Scientific Officers should be made by the Minister, after communication with the Director and with the Board of Visitors (herein-after referred to). And that the Director should prepare the Estimates, to be submitted, after consultation with the Board of Visitors, for the approval of the Minister.
- III. That the present Superintendent be the first Director.
- IV. That a Board of Visitors be constituted. That the Board be nominated, in part by the Crown, in part by the Royal and certain other Scientific Societies of the Metropolis, and, in the first instance, in part also by the Board of Trustees; the Members to be appointed for a limited period, but to be re-eligible; and that the Board of Visitors should make Annual Reports to the Minister, to be laid before Parliament, on the Condition, Management, and Requirements of the Museum, and should be empowered to give him advice, on any points affecting its Administration.

With regard to *the Museum of the Royal College of Surgeons*, we recommend:

- V. That, should the fund at the disposal of the College, owing to changes in Medical Legislation, or from any other cause, prove inadequate for the efficient Maintenance and continued Extension of the Museum, it should receive support from the State, as an Institution intimately connected with the progress of Biological Science in this Country.

With regard to *the National Botanical Collections and Gardens*, we recommend:

- VI. That the Collections at the British Museum be maintained and arranged with special reference to the Geographical Distribution of Plants and to Palæontology; and that the Collections at Kew be maintained and arranged with special reference to Systematic Botany.
- VII. That all Collections of Recent Plants made by Government Expeditions be, in the first instance, sent to Kew, to be there worked out and distributed, a set being reserved for the British Museum; and that all Collections of Fossil Plants made by Government Expeditions be sent to the British Museum.
- VIII. That opportunities for the pursuit of Investigations in Physiological Botany should be afforded in the Royal Gardens at Kew.

With regard to *the Scientific Collections of the South Kensington Museum*, we recommend:

- IX. The formation of a Collection of Physical and Mechanical Instruments; and we submit for consideration whether it may not be expedient that this Collection, the Collection of the Patent Museum, and that of the Scientific and Educational Department of the South Kensington Museum, should be united and placed under the Authority of a Minister of State.

With regard to *Provincial Museums*, we recommend:

- X. That, in connexion with the Science and Art Section of the Education Department, qualified Naturalists be appointed to direct the collection of Specimens in order to supply whatever deficiencies exist in the more important Provincial Museums;

and, also, in order to organize Typical Museums, to be sent by the Department of Science and Art into the Provinces to such Science Schools as may be reported to be likely to make them efficient instruments of Scientific Instruction.

- XI. That a System of Inspection of Provincial Museums be organized with a view of reporting on their condition, and on the extent to which they are usefully employed, and whether the conditions of the Loan or Grant from the Department of Science and Art have been fulfilled.

With regard to *Public Lectures*, we recommend :

- XII. That Courses of Lectures be given in connexion with the Collection of Physical and Mechanical Instruments, the establishment of which we have proposed, the object of these Lectures being to illustrate the progress of Scientific and Mechanical Discovery and Invention.
- XIII. That the establishment of Lectures on Science, accessible to all classes on the payment of a small fee, should be promoted by the Government in the great centres of population.
- XIV. That, in the first instance, with the view of carrying out the preceding recommendation, the system of instruction of this kind, which has already been established by the Government in the Metropolis, should be developed by the institution of Courses of Lectures on the principal Branches of Experimental and Natural Science.
- XV. That the proposed Lectures be of two kinds. First: Lectures of an elementary character on the General Principles and most important Facts of Science. Secondly: Lectures specially intended for the Working Classes on the Application of Science to the Arts and Industries of the Country.

All of which we humbly beg leave to submit for Your Majesty's gracious consideration.

(Signed) DEVONSHIRE,  
JOHN LUBBOCK.  
J. P. KAY-SHUTTLEWORTH.  
W. SHARPEY.  
T. H. HUXLEY.  
G. G. STOKES  
HENRY J. S. SMITH.  
\* B. SAMUELSON, (Feb. 16th 1874.)

I request permission to state that I have withheld my signature from the above Report, not because I disagree with the Recommendations which it contains, but because I have been prevented from taking part in the recent deliberations of Her Majesty's Commissioners.

LANSDOWNE.

J. NORMAN LOCKYER,  
Secretary.

January 16th, 1874.

\* Having taken a part in the deliberations which led to this Report, my signature has been appended to it after its presentation to the Queen, only on account of my unavoidable absence from England when it was presented.

B. SAMUELSON.

# APPENDIX TO FOURTH REPORT.

## APPENDIX I.

STATEMENT of the AMOUNTS taken for the various MUSEUMS in the ESTIMATES for the FINANCIAL YEAR 1873-74.

ENGLAND.		Museum of Practical Geology, Jernyn Street.	
<b>British Museum.*</b>			
<i>Salaries and Wages.</i>		<i>Salaries and Wages.</i>	
1 Superintendent of Natural History	800	Director	300
4 Keepers of Departments: 1 at 600 <i>l.</i> , 3 each at 500 <i>l.</i>	2,100	Registrar and Curator	600
1 Assistant Keeper	450	Clerk and Assistant	200
2 Senior Assistants, upper section, 320 <i>l.</i> , rising 20 <i>l.</i> to 400 <i>l.</i> per annum	800	Assistant Curator	200
7 do., lower section, 150 <i>l.</i> to 310 <i>l.</i>	1,323	Attendants and Cleaners	284
4 Junior Assistants, 90 <i>l.</i> to 180 <i>l.</i>	560	<i>Purchase of Specimens, Models, Books, &amp;c.</i>	
9 First-class Attendants, 100 <i>l.</i> , 5 <i>l.</i> to 120 <i>l.</i>	1,070	Specimens for Museum, and Books for Library	500
14 Second-class do., 50 <i>l.</i> , 4 <i>l.</i> to 100 <i>l.</i>	1,183	Purchase and construction of Mining Models	200
<b>42</b>		Furniture and fittings	50
		Heating and lighting	700
		Incidental expenses	176
		Police	400
			4,054
Extra duty of attendants consequent on the opening of the Museum till 8 o'clock p.m. on Mondays and Saturdays during the summer, &c.	50	<b>Patent Museum, South Kensington.</b>	
	8,336	<i>Salaries and Wages.</i>	
Remuneration to persons not on the Museum Establishment, viz. for preparation of Catalogues of Zoology	100	Curator	450
Do. Meteorites and Minerals	50	Assistant to Curator	168
Do. Botany	200	Wages of Writer, Mechanics, and Attendants	590
	350	Police	160
<i>Purchases and Acquisitions</i>		Five Insurances on Models in Museum	25
Minerals and Meteorites	800	<i>Incidental Expenses</i>	
Books for the Department of Minerals	25	Carrriage of Models, &c.	130
Fossils	800		1,523
Books for the Department of Geology	25	<b>Royal Botanic Gardens, Kew.</b>	
Zoological specimens	1,000	<i>Salaries and Wages:</i>	
Books for the Department of Zoology	25	Director	800 0
Botanical specimens	250	Keeper of Library and Herbarium, Clerk to ditto, and two Assistants	790 0
Books for the Department of Botany	25	Curator of the Museums	140 0
	2,950	Woman for cleaning Herbarium	15 12
<i>Bookbinding, Preparing, &amp;c.:</i>		Door Keeper	46 16
Preparing, &c., Zoology, and binding Books of Reference for the Department of Zoology	705		1,792 8
Do., Geology, and binding	205	<b>SCOTLAND.</b>	
Do., Mineralogy, do.	85	<b>Edinburgh Museum.</b>	
Do., Botany, do.	100	<i>Salaries and Wages:</i>	
	1,095	Director	760 0
<i>Printing Catalogues, &amp;c.:</i>		Keeper of Natural History Museum	100 0
Catalogues of Zoology	400	Scientific and Clerical assistance	100 0
"    Botany	200	Curator and Housekeeper	335 0
"    Meteorites	10	Assistant in Natural History Museum	200 0
	610	Assistant in Industrial Museum	160 0
<i>Furniture and Fittings.</i>		Two Clerks	220 0
Fittings and furniture for the Departments of Mineralogy and Geology	388	12 Attendants, Porters, and Messengers	803 8
Do. do. Zoology	435	2 Fitters for Repairing Models	166 0
Do. do. Botany	536	1 Repairer and Labeller	83 4
	1,359	2 Printers	157 6
		1 Housemaid	26 0
		Gasmen, Cleaners, &c.	450 0
		Occasional assistance and for evening attendance	300 0
		Police	52 0
	£14,700	Purchase of Specimens, Books, &c.	2,000 0
		<i>Fittings, Repairs, &amp;c.:</i>	
		Ordinary repairs, fittings, &c.	2,200 0
		<i>Cleaning, &amp;c.</i>	
		Cleaning materials, &c.	150 0
		<i>Travelling Expenses</i>	200 0
		<i>Incidental Expenses.</i>	
		Advertisements, printing, and incidents	300 0
			9,230 1

\* The following letter has been received from the Principal Librarian of the British Museum —

British Museum, 16th December 1873.

SIR, I HAVE laid before the Trustees of the British Museum your letter of the 28th ultimo, and I have been directed to transmit to you for the information of His Grace the Duke of Devonshire and the other Members of the Royal Commission on Scientific Instruction and the Advancement of Science, a statement of the amounts included in the British Museum grant for 1873-74 specially applicable to the Departments of Natural History

I am directed by the Trustees to point out that, in addition to the estimated expenditure, as stated in the enclosed Memorandum, there is a further expenditure common to all the Departments of the British Museum of about 13,700*l.* a year. This latter amount will include the cost of the executive staff, police, labourers, stokers, &c., stationery, freight of objects, guide books, &c., the maintenance of the warming, ventilating, and fire-extinguishing apparatus, postages, &c. &c. There is beyond all this the expenditure by the Office of Works on the

British Museum buildings, supply of fuel and light, &c., and the cost of the stationery supplied by the Stationery Office.

I am, &c.  
J. WINTER JONES,  
Principal Librarian and Secretary  
Royal Commission on Scientific Instruction  
and the Advancement of Science.



Edinburgh Botanic Garden.				Royal Dublin Society.	
Allowance for the Royal Botanic Garden	£	1,400	£	Salaries and Wages of Staff	- - 1,358
Allowance to Regius Professor of Botany in lieu of a house	- -	130		Incidental Expenses, and Police	- - 910
Salary of Curator	- -	230			2,268
		1,760			
IRELAND.					
Botanic Gardens, Dublin:					
<i>Salaries and Wages:</i>					
Director	- -	300			
Labourers' Wages	- -	1,298			
Incidental expenses, including purchase of seeds, plants, &c.	- -	555			
		2,153			
Leinster Lawn (Dublin).					
Labourers' Wages and incidental expenses	200		200		
Museum of Natural History (Dublin).					
<i>Salaries and Wages</i>					
Director	- -	350			
Keeper of Minerals	- -	100			
Taxidermist	- -	100			
Assistants (two)	- -	250			
Porters (four)	- -	176			
Evening attendance, Museum being open two nights a week, and for keeping up fires	- -	82			
Purchase, collection, and preparation of specimens	- -	580			
Incidental expenses	- -	20			
Police	- -	20			
		1,678			
LIBRARY (DUBLIN).					
<i>Salaries and Wages:</i>					
Librarian	- -	250			
Clerk	- -	100			
Porters (four)	- -	200			
Evening attendance, the Library being kept open every evening till 10 p.m.	- -	206			
Purchase of books	- -	700			
Index catalogue	- -	200			
Incidental expenses	- -	50			
		1,708			
Museum of the Royal College of Science.					
<i>Salaries:</i>					
Curator of Museum and Librarian	- -	300			
Purchase of Specimens [included in a sum of 900l. taken for the Purchase of Specimens, Outfit and Illustrations for Lectures, and Books for Library, &c.].	- -				
The Royal Irish Academy,					
Included in the full sum taken, amounting to 1,600l.					

## APPENDIX II.

DOCUMENTS relating to the BOTANICAL COLLECTIONS at KEW and at the BRITISH MUSEUM.  
[See p. 5-10]

## A.—MEMORANDUM with respect to the HERBARIUM and LIBRARY at KEW previous to the Appointment of the late Sir W. J. Hooker as Director.

The question of the Commissioners requires some explanations, in order to answer it satisfactorily. The Herbarium which existed at Kew previous to the late Sir W. J. Hooker's appointment as Director, was broken up during the changes that were made when the garden was put upon its new footing as a public establishment. My personal knowledge of the Herbarium, however, antedates my father's appointment to the Directorship. From what I recollect myself, and from what Sir W. J. Hooker told me, I believe that it was, for the period, extensive, that it was arranged chiefly according to countries, and was in part at any rate classified and well named. A large portion consisted of plants collected by botanical explorers sent from the Royal Gardens to various parts of the world, and styled officially "Botanical Collectors to His Majesty." Their original instructions included the preparation of two sets of Herbarium specimens, one for Kew, the other for Sir Joseph Banks. The employment of collectors as a part of the establishment ceased when the gardens were given up by the Royal Family and became Crown property, that is, previous to my father's accession to office as Director.

Towards the close of Sir Joseph Banks's life, a house, called Hunter House, was purchased by the King with the grounds attached, and added to the Royal property. At the instance of Sir Joseph Banks, it was determined to devote this to the accommodation of a botanical Library and Herbarium worthy of the country, and for which the garden collections would afford a foundation.

One of the rooms was at the time fitted up with bookshelves, as a commencement towards carrying out this project.

At Sir J. Banks's death the plan was abandoned; the house remained empty for some years, and was eventually given as a private residence to the late King of Hanover. This house is that now occupied by the Herbarium and Library at Kew, and the bookshelves, which remained undisturbed, have been devoted to their original purpose.

Amongst the collections, of the existence of which in the garden I have evidence during the Directorship of Mr. Aiton, were extensive series of plants from Australia, New Zealand, South Africa, the Pacific Islands, and Brazil, besides named specimens of cultivated plants kept for the identification of those growing in the gardens. Sir W. J. Hooker often deplored to me the breaking up of this Her-

barium, depriving him, as it did, of the ready means of identifying many plants in cultivation at Kew which had been sent there by collectors with the native specimens transmitted from the same sources.

I have evidence to show that Richard Cunningham, one of the staff attached to Kew, was for many years engaged in the arrangement of the collections and the determination of the plants in the gardens. He corresponded during a long period with Sir W. J. Hooker, then Regius Professor of Botany at Glasgow. Writing under date January 22, 1824 (the project for using Hunter House having fallen through at that time, owing to Sir Joseph Banks's death), Richard Cunningham says, "I have at length persuaded Mr. Aiton to have a room built in the gardens to contain the herbaria altogether, which is now going on with, and as soon as I get things set straight in it, I will commence upon a series of S. African plants." He refers again to this during the following year (Nov. 3, 1825) in speaking of "the little convenience we have had till lately in the garden room to arrange and compare dried plants with the books."

I am not aware of the extent or condition of the Library at Kew previous to Sir W. J. Hooker's accession. There was one of considerable size, however, which was the private property of the Director, but was used for garden purposes, as was subsequently that of Sir W. Hooker for many years after the commencement of his Directorship. Annual cost of the present scientific staff attached to the Royal Gardens, Kew:

	£	s
Director (with house)	- -	800 0
Keeper of Herbarium and Library (with house)	- -	400 0
First Assistant	- -	250 0
Second Assistant, 60l. rising to 80l.	- -	60 0
Clerk in Herbarium	- -	80 0
Curator of the museums (3), 100l. rising to 150l.	- -	140 0
Woman for cleaning Herbarium (with rooms)	- -	15 12
Doorkeeper	- -	46 16
Total	- -	1,792 8

Jos. D. Hooker,  
Director.

Royal Gardens, Kew,  
December 17, 1873.

**B.—STATEMENT by Dr. HOOKER respecting the PURCHASE, by the GOVERNMENT, of the HERBARIUM, LIBRARY, BOTANICAL CORRESPONDENCE, MANUSCRIPTS, PORTRAITS, DRAWINGS, &c., of the late SIR WILLIAM JACKSON HOOKER.**

Royal Gardens, Kew,  
Dec 17, 1873  
SIR, IN compliance with your request, I transmit herewith a Statement of the circumstances under which the botanical collections, &c., of the late Sir W. Hooker were purchased by the Government, with the view of their being permanently attached to the Establishment at Kew, together with the documents relating thereto.

I am, &c.  
J. N. LOCKYER, Esq., F.R.S.,      JOS. D. HOOKER,  
Secretary to the Royal Commission on Science.

Sir W. Hooker, on his decease on August 12, 1865, left instructions to his Executors that his herbarium (exclusive of such specimens as were exhibited in the Museums at Kew), together with such parts of his library as were required to complete that at Kew, his botanical correspondence, collection of portraits of botanists, his manuscripts, drawings of plants, botanical scenery, &c., should be offered by his Executors to the Government for purchase at a fair valuation, "to be deposited at Kew, as part of the Crown property attached to the Royal Gardens."

In pursuance of these instructions, the offer was made, through the Right Honourable the First Commissioner of Her Majesty's Works, for the purchase of the whole, for a sum of 7,000*l.*, viz.,

Herbarium	-	-	-	£5,000
Books	-	-	-	1,000
Correspondence, manuscripts, portraits, &c.	-	-	-	1,000

The sum asked for the herbarium was based on an estimate of the actual expenditure incurred by Sir W. Hooker on the purchase of specimens and the materials for their conservation during the 60 years he had devoted to its formation. He took no account of the value of specimens presented to him by public and private bodies, nor of the value of the returns he made for them; nor of the collections made by persons employed in Government Expeditions, and which collections were presented to himself by the Government; nor of the salaries of Curators paid by himself and engaged upon the arrangement of the herbarium during upwards of 30 years.

In reference to the herbarium especially, a memorial (of which a copy is herewith enclosed), was presented to the First Commissioner of Her Majesty's Works, urging its purchase, it was signed by the Professors of Botany in the leading Universities of the Kingdom, the Presidents of the Royal, Linnæan, and Royal Geographical Societies, and by the Keeper of the Botanical Collections, and the Superintendent of the Natural History Departments of the British Museum. The Memorialists state that the herbarium was "generally acknowledged to be the most extensive in Europe," that it "is in constant and daily use by the Establishment of 'Kew Gardens,' to the due working of which, whether in a scientific or a practical or an economic point of view, we cannot but regard it as absolutely essential," and add their confident hope "that the opportunity may not be lost of permanently establishing the unity of a collection so justly celebrated amongst men of science in all parts of the world."

The offer was unconditionally accepted by the Lords of Her Majesty's Treasury, as shown in the accompanying letter addressed by the First Commissioner of Her Majesty's Works to Dr. Hooker.

J. D. HOOKER.

(Copy)

To the Right Honourable the First Commissioner of Her Majesty's Works.

We the undersigned, having understood that in pursuance of the instructions left by the late Sir William Jackson Hooker, his herbarium and botanical collections, together with such of his books as are wanting to complete the Botanical Library at Kew, have been offered through you to Her Majesty's Government, and believing that, under the above circumstances, the sum of 6,000*l.* would be accepted for the whole, beg leave to urge upon your consideration the importance to Science in general, and especially to the Establishment of the Royal Gardens at Kew, that these unrivalled collections should be secured to the Nation.

When, in 1862, this herbarium was removed from Sir

William Hooker's private residence to the late King of Hanover's house at Kew, it was already generally acknowledged to be the most extensive in Europe, the result of forty years' incessant exertion and liberal expenditure, and has since been largely increased at Sir William's private cost. It has ever been most liberally laid open to Scientific Botanists of this and other Countries, and is in constant and daily use by the Establishment of Kew Gardens, to the due working of which, whether in a scientific or in a practical or in an economic point of view, we cannot but consider it as absolutely essential.

We believe, also, that the Botanical Works not already in the National Library at Kew, but which Sir William allowed the Establishment the free use of, will be found to be numerous and of great value.

We, therefore, confidently hope that the opportunity may not be lost of permanently establishing the unity of a collection so justly celebrated amongst men of Science in all parts of the world.

CHARLES DAUBENY,  
Professor of Botany in the University of Oxford.  
CHARLES C. BADINGTON,  
Professor of Botany in the University of Cambridge  
J. H. BALFOUR,  
Professor of Botany in the University of Edinburgh  
G. WALKER ARNOTT,  
Professor of Botany in the University of Glasgow  
W. H. HARVEY,  
Professor of Botany in the University of Dublin.  
DANIEL OLIVER,  
Professor of Botany, University College, London  
JOHN J. BRUNETT,  
Keeper of the Botanical Collections of the British Museum  
GEORGE BENTHAM,  
President of the Linnæan Society of London  
RICHARD OWEN,  
Superintendent of the Natural History Departments, British Museum.

In thorough conviction of the propriety and importance of adding Sir William Hooker's Herbarium to the Botanical Collections at Kew:

EDWARD SABINE,  
President of the Royal Society  
ROD. I. MURCHISON,  
President of the Royal Geographical Society.

4498.

(Copy)

Office of Works, S W,

SIR, October 13, 1866.

REFERRING to the correspondence which has taken place on the subject of the herbarium, &c., of the late Sir Wm. Hooker, offered by his Executors, in pursuance of his instructions, to the Government for deposit in Kew Gardens, I am directed by the First Commissioner of Her Majesty's Works, &c., to acquaint you that the Lords of the Treasury have informed him that they are fully sensible of the value of this collection, and that they are willing to sanction the purchase thereof for the sum of 7,000*l.*, viz.:-

For herbarium	-	-	£5,000
" books	-	-	1,000
" portraits*	-	-	1,000

£7,000

out of moneys to be voted by Parliament, and have directed that provisions may be made in the Estimates for 1867-8, to be submitted to Parliament next Session.

Their Lordships are desirous, in the meantime, of having a proper inventory of the collection made, and I am, therefore, to request that you will inform the First Commissioner what course you propose to take for effecting this object.

I am, &c.

GEORGE RUSSELL,  
Assistant Secretary

J. D. Hooker, Esq., M.D., F.R.S.

\* Foot note.—This should have been worded "Botanical correspondence, manuscripts, portraits, drawings, &c."—J. D. HOOKER.

C.—STATEMENT BY MR. BENTHAM. [See p. 7.]  
(See Question 7205, Vol. I., p. 469.)

SIR, 25, Wilton Place, S.W., July 1872.  
SINCE the receipt of yours of the 5th instant I have procured a sight of the First Report of the Royal Scientific Commission and perused the paper handed in by Mr. Carruthers forming the Appendix XV., in which the statements I made in answer to question 7205 have been in several respects contradicted.

With regard to the comparative advantages of the Botanical Museums of Kew and the British Museum, these may be in a great measure matters of opinion upon which it would be useless in me to enter into any further discussion. I would only observe that my estimate has been gradually formed from long experience, that I have at various intervals paid frequent visits to the British Museum for the purpose of consulting the collections there from the year 1827 to the present time, that I have uniformly met with the greatest courtesy and the utmost facilities, consistent with the regulations, on the part of Mr. Brown and his successors, Mr. Bennett and Mr. Carruthers, and that I have steadily worked in the Herbarium at Kew since the private collections of Sir William Hooker and my own were there brought together in 1854. From this experience I cannot but adhere to my opinion that the facilities for study in the Botanical Department of the British Museum (owing I believe mainly to regulations and other circumstances independent of the Keepers), very limited during Mr. Brown's time, considerably enlarged under Mr. Bennett, still very far below those afforded by the Kew Herbarium and Museum. I shall be ready at any time to substantiate the details upon which this opinion is founded.

Mr. Carruthers' experience I presume to result chiefly from his connexion with the British Museum since Mr. Brown's death in 1859. I am not aware what personal experience he has of the Botanical Museum and Herbarium at Kew; I never recollect having the pleasure of seeing him there, and to this circumstance I must attribute some statements in the above-mentioned paper from which I think it right to record my dissent.

He includes in the "scientific collection of the British Museum" a "structural series" which we are given to understand was due to the different views taken by Robert Brown of the proposed study of plants from that which I had alluded to. To this I beg to observe that the Botanical Museum at Kew includes "a fruit collection," "a collection of gum resins and other products," and "a general collection exhibiting the form and structure of plants" and consisting of the larger specimens chiefly exhibited "to the public," infinitely superior to those of the British Museum, and occupying three large buildings specially devoted to them. The exhibited portion in the British Museum was only formed after the example of the one at Kew, as was evident to all those who, like myself, watched its progress during the three years it was in the course of formation before it was opened to the public. The only portion of the British Museum collection not represented at Kew is the fossil series.

It is also to the want of personal acquaintance with the history of the Kew collections that I must attribute the following statements:—

That Sir W. J. Hooker "had no public herbarium from the time of his appointment in 1841 till 1855." It is therefore evident that a great scientific herbarium is not a necessity to the efficiency of the gardens at "Kew." Sir William, during all this time, allowed his own private herbarium, the richest in Britain, to be used as a public herbarium in connexion with the gardens, although kept entirely at his own expense.

That the primary object for which Sir W. J. Hooker accepted my herbarium in 1855 was for the use of the Gardens. This was not the case. My herbarium and botanical library, of upwards of 1,000 volumes, were accepted in 1854 (not 1855), expressly for the use of scientific botanists.

I would add that I am quite at a loss to discover in which of my works I can have committed the error of treating as duplicates whatever I do not estimate at the value of species.

I have the honour to be, Sir,  
Your obedient servant,  
GEORGE BENTHAM

J. Norman Lockyer, Esq.,  
Secretary, Royal Scientific Commission.

D.—COMMUNICATIONS FROM MR. JOHN BALL.  
(See Question 7229, Vol. I., p. 473.)

I.

Athenæum Club, Pall Mall,

28th Nov. 1872.

SIR, IN accordance with the desire of the Royal Commissioners on Scientific Instruction, conveyed to me in your letter of the 15th inst., I beg that you will have the goodness to lay before them the following statement with reference to the Evidence, given by me on the 28th March 1871.—

My attention has been called by Mr. Carruthers, of the British Museum, to the answer given by me to question 7229, which, in his opinion, conveys a charge against him in his capacity as Keeper of the Botanical Department.

As printed in the first volume of the Evidence taken before the Commissioners, p. 473, my reply to a question whether there was, at that time, a large accumulation of unnamed collections in the British Museum, stands as follows:—

"There is an accumulation. I cannot venture to say how large it is. I know, because I have had a recent instance of one, that some very interesting collections have, I will not say disappeared, but cannot now be found, and they may very possibly be lying in cases there."

I may be allowed here to mention the fact that I received a proof of my evidence on the evening preceding my departure from England for a journey to Morocco, and, thus, had not the opportunity usually allowed for carefully correcting errors arising either from slight mistakes on the part of the reporter or from inaccuracy on the part of the witness.

From whichever cause the error may have arisen, the answer above quoted is in one respect inaccurate. It should have stood: "I have heard a recent instance," or otherwise conveyed to the Commissioners the fact that, with the exception of a single visit early in the same year, my recent knowledge of the collections at the British Museum was derived from others, and not from personal observation.

It seems unnecessary to add that my answer was not intended to convey, and did not, in my opinion, convey, any charge against the recent management of the Museum collections, since the remainder of my evidence renders such a disclaimer superfluous.

In the course of a correspondence with Mr. Carruthers, having especial reference to certain collections which had been supposed to have disappeared, wholly or in part, from the Museum, that gentleman has assured me that all the plants referred to are now in the Museum; and he, moreover, states, with regard generally to all the Botanical collections originally belonging to Sir Joseph Banks, that "everything that became national property in 1827 is still in the collection and available for science."

I place the same reliance on any statements made by Mr. Carruthers, or his assistants, Mr. Trimen and Mr. Britten, as to facts within their own knowledge, that I do on those of other men of science whose experience has been apparently at variance with the above assertions; but I venture to doubt whether, in so general a form, the above quoted statement is capable of full verification. In any case, it appears to me simply impossible that, along with the current duties of their department, the gentlemen above named can have verified, specimen by specimen, the existence and right classification of plants that must be numbered by tens of thousands.

I have no doubt, however, that, under the management of the late and the present Keepers of the Botanical Department, considerable progress has been made towards putting in order and making accessible the unnamed and unarranged collections at the Museum.

That a large accumulation of such collections existed under the management of Mr. R. Brown, and that some of them, being unprotected by poison, were extensively attacked by insects, are facts of which I was personally cognizant, and which were well known to many botanists at home and abroad, as I can testify from my personal acquaintance with a majority of the eminent European botanists for the last 30 years. Knowing, from a rather extensive acquaintance with herbaria, public and private, how difficult it is to get rid of accumulated weevils, I was not surprised to hear, from time to time, specific statements from various botanists as to the impossibility of finding, at the British Museum, plants belonging to some of the old collections; but I cannot say that I made enquiries with a view to fix the precise date to which such statements referred. Having, after many years' absence, resided in London since the beginning of 1870, I have but once

visited the Museum collections since that date, and on that occasion, as stated in my evidence, I examined a collection which apparently had not been opened since the time of Sir Joseph Banks.

Under these circumstances, it appears to me that the facts justified a belief in the substantial accuracy of my answer to question 7229. The degree in which that answer is inapplicable to the present state of the collections affords a measure of the activity and success that have marked the recent management of the collections, and must be a matter of satisfaction to all students of botany.

That I may not appear wanting in justice to the late Mr. Robert Brown, whose name is revered by all botanists, I may be allowed to remark that his position, in regard to the Museum collections, was peculiar and exceptional. During the lifetime of Sir Joseph Banks, the herbarium was altogether under his management, and after the death of the original owner, it became his private property. The arrangement by which the Bantian Herbarium was transferred to the British Museum, still remaining under the management of Mr. Brown, very naturally did not change the habit of mind of that eminent man. Fully engaged in his own studies, he had no desire to encourage the visits of strangers, a fact obvious to those who sought to consult the collections, though the impression might be diminished through the courtesy and kindness of Mr. Bennett, his assistant, who afterwards took Mr. Brown's place at the Museum.

At that period, the example of other large public collections on the continent afforded, to some extent, a precedent for deficiencies in order and the accumulation of arrears. So far as my knowledge extends, the first instance of a very large collection, of which every portion was maintained in a state available for immediate reference, was afforded by the herbarium at Kew, under the management of the late Sir W. J. Hooker.

Trusting that the Commissioners will be pleased to publish this statement in the Appendix to their next report,

I have, &c.,

JOHN BALL

J. Norman Lookyer, Esq., FRS

## II.

Athensium Club, Pall Mall,

December 2nd, 1872

MY LORD DUKE,

In accordance with the desire of the Royal Commissioners on Scientific Instruction, I have addressed to their Secretary a note respecting a passage in the evidence given by me in March 1871, to which exception has been taken by Mr. Carruthers of the British Museum.

I did not consider myself authorized to take that occasion for offering any suggestion to the Royal Commissioners with reference to the course they may adopt with regard to the national botanical collections; but I think I may without impropriety submit to your Grace the following observations, with the hope that in the event contemplated the suggestion made therein may appear to you not undeserving the consideration of the Commissioners.

I have reason to know that there is a nearly unanimous agreement amongst the most competent British botanists as to the inexpediency of uniting in a single museum the collections now existing at Kew and at the British Museum.

To remove the collections from Kew would be to destroy the scientific character of the foremost botanical establishment in the world, and would be regarded as an act of vandalism, not only by all competent judges in our islands, but by all cultivators of natural science in other civilized countries.

The value and extent of the Kew collections, and especially the fact that they have served as the foundation for many of the most important botanical works published during the last 25 years, make it frequently necessary for the authors of new works to resort to Kew for the purpose of study. The space required for the study and comparison of numerous specimens is considerable, and, in point of fact, the accommodation afforded in the present building at Kew is at times inconveniently limited.

But, in addition to a comparatively small number of men, engaged on works of some length and importance, who resort to the herbarium at Kew for successive weeks, or even months, there is a far more numerous class of students, or persons seeking useful information—many of them returning from the colonies or foreign countries—who seek ready access to a public collection for the purpose of comparing specimens with authentic types, or otherwise verifying the names and characters of certain plants. To require such persons to go to Kew would be inconvenient to them, and doubly so to the small and fully-worked staff

at Kew, and to the serious students, who must be disturbed if a large class, of what may be called casual visitors, were encouraged to frequent the herbarium.

On these grounds, apart from others that have been urged in evidence before the Commissioners, it seems highly desirable that the herbarium connected with the British Museum should be maintained in a state of full efficiency.

In case, however, these views should not prevail with the Royal Commissioners, and they should seriously entertain the project of uniting in one establishment the collections at Kew with those at the British Museum, it will become a matter of paramount importance that they should be enabled to judge securely as to the relative advantages and disadvantages involved in a choice between those places.

I venture to suggest that in such an inquiry there is little to be gained by going back through the past history of the collections, and that no very satisfactory result will be attained by hearing statements from the officers connected respectively with Kew and the British Museum, or from persons who, justly or not, may be supposed to have a decided leaning towards either.

A course more likely to assist the Commissioners towards a safe conclusion would be to request two or more competent persons, holding an independent and responsible position, to visit both herbaria, with a view to compare their availability for scientific research in their present condition, and the resources at the command of each for supplying deficiencies and keeping pace with the increasing range of discovery and exploration.

Although I have no means for knowing that they would undertake such a duty, I do not doubt that the professors of botany in the Universities of Oxford and Cambridge would readily do so in the interest of science.

By allowing the officers in charge of each herbarium to suggest for comparison the names of two or three genera, and adding any others they might of their own motion select, the gentlemen undertaking the inquiry could, without much labour, form a fair comparative judgment as to the present condition of the named collections in both establishments. They should examine into the extent and nature of the unarranged collections in each establishment, and the amount of arrears existing in the shape of plants named, but not intercalated. Besides reporting on the present condition of the collections, the same gentlemen should be requested to examine into the means possessed by each establishment for obtaining new and rare plants from countries still imperfectly explored. The very extensive foreign correspondences, including many remote parts of the globe, set on foot by the late Sir W. Hooker, and continued by the present Director, has probably offered opportunities for obtaining dried plants for the herbarium, along with seeds, cuttings, or living plants for the royal gardens, such as are not enjoyed by any other public institution; but this can best be tested by a comparison of the foreign correspondence of the directors of each herbarium, and of the collections actually received from such contributors during a term of years, exclusive of those obtained by purchase.

I may be permitted here to mention a practical difficulty in the way of the suggested amalgamation of the two herbaria which has not, I believe, been suggested by any of the witnesses hitherto examined. The specimens in both collections are glued down upon stiff white paper, but this is of a different size in each—that in the British Museum being the larger. As it is found that plants laid down on papers of unequal size cannot be intermixed without injury, it would be necessary to find means to equalize them. The British Museum paper could not be cut down to the Kew size without serious damage to many invaluable specimens that cannot be replaced, and it would be necessary to transfer the Kew herbarium to larger paper, or else incur the certainty of damage and inconvenience from mixing the two herbaria. The transference of the Kew herbarium to larger paper would involve the purchase of nearly 1,000 reams of paper, and the employment of from 12 to 20 competent persons, if such could be found, for a year, and, what is more serious, it would gravely interfere with the publication of four of the most important of modern botanical works—*The Genera Plantarum*, *The Flora of British India*, *The Flora of Australia*, *The Flora of Tropical Africa*, not to mention others of less importance. A minor item, yet not unconsiderable, is the fact that the amalgamation of the herbaria would in any case render useless 450 cabinets now in use at Kew each containing 16 compartments for parcels of plants.

I have, &c.

JOHN BALL

His Grace the Duke of Devonshire.

## E.—STATEMENT BY MR. CARRUTHERS.

(See Questions 7216, 7217, 7229, Vol. I, pp. 471-473, and Question 7242, Vol. I, p. 474.)

On reading the evidence of Mr. John Ball, it was apparent to me that his statements regarding the Botanical Department of the British Museum were those of a witness ignorant of the matters regarding which he ventured to testify.

One statement in his evidence (Qu. 7229), as I read it, appeared to reflect personally on me as Keeper of the department, and I accordingly applied to Mr. Ball for definite information as to the alleged facts.

A second statement (Qu. 7217), being rather a matter of opinion, I resolved to meet by obtaining the testimony of two botanists, whom no one would venture to characterize as partisans, and whose acquaintances with the herbarium at the British Museum and eminence in science would compel respect to their testimony.

I asked for an opportunity to submit the result of these inquiries to the Commissioners, that the errors might be corrected, and the false impressions contained in the evidence be set aside. In accordance with the request of the Commissioners, I now submit my observations in writing.

Mr. Ball's statement, as of fact, in reference to the Botanical Department of the British Museum, contained in his answer to question 7229, is as follows:—"I know, because I have had a recent instance of one, that some very interesting collections have, I will not say disappeared, but cannot now be found, and they may very possibly be lying in cases there."

In a letter addressed to Mr. Ball, I asked him for the names of the one collection, and the some very interesting collections which could not be found, and were very possibly lying in cases at the Museum. I knew that the single short visit that Mr. Ball recently made to the herbarium was made while it was under my charge. His statement consequently asserted that I, the Official Keeper, was ignorant of several collections in the Museum, with which he, a comparative stranger, was acquainted. In his reply, written from North Wales, on the 31st August 1872, Mr. Ball says—"I should tell you that my evidence before the Science Commission was given either one or two days before I left England. I remember that the proof was delivered late on my last evening in London, and that at a hasty glance I saw many passages that I should have wished to correct; some of them errors on the part of whoever took down my evidence; others inaccuracies on my own part. I have not yet seen the published evidence, but if it contains the passage you quote, and I take it for granted that you quote from that source, I cannot be surprised at your calling for an explanation from me." In a subsequent letter (dated 11 Oct. 1872), Mr. Ball stated that the particular error in his answer to qu. 7229 was, that it "should have been printed 'I have heard of a recent instance,' instead of 'I have had a recent instance.'" But it is most obvious that no hearsay information about one collection could supply Mr. Ball, as his answer thus amended states, with personal knowledge of several other collections. In this same letter, Mr. Ball gives me the only information which he has been able to supply as to the foundation of his statement. It is as follows:—"I have little doubt that the collection that I had in my mind at the time was that of Salt's Abyssinian plants, but, from inquiries made within the last two days, I am led to believe that the impression under which I spoke was incorrect." On receipt of this, I demanded the unqualified withdrawal of the erroneous statement, in terms which would be satisfactory to me, and this being refused, I informed Mr. Ball of my intention to use his letters in establishing the truth, and I now seek through this communication to place the facts before the Commissioners, and to secure for this statement as extensive a circulation as that given to Mr. Ball's error.

The matter of opinion to which I take exception, and which is repeated in different forms in the evidence, is plainly stated in the answer to qu. 7217, in which, while asserting that the establishment at Kew is "as near perfect as it is possible in human affairs to attain to," he declares, "that the traditions of the British Museum have not been favourable to making the collections there as available for the general purposes of science as might be desired;" and he considers "that the collection at the British Museum might be made more valuable to science and to scientific men than it now is" (Qu. 7216).

I, of course, lay no claim to celestial perfection in the management of the herbarium, but I emphatically repudiate the unfounded statement made by Mr. Ball. I venture to add, that this statement is especially offensive from its being directly associated by Mr. Ball with a name

which commands the profound respect of every student of botany throughout the world.

To meet this assertion I addressed letters to two independent botanists, whose work in the herbarium of the Museum would enable them to speak from personal knowledge, asking them to express their opinion as to the availability of the collections for the purposes of science. One of those botanists was Dr. Cosson, in whose company Mr. Ball made the only visit he has paid to the herbarium within the last 25 years. Dr. Cosson had in numerous visits gone systematically through a considerable portion of the herbarium. He writes from Paris, on the 21st September 1872, as follows:—

"Je pense, dès que j'aurai effectué le déménagement de mon herbar, que je vais transporter dans la construction que j'ai fait établir spécialement pour lui, avoir le plaisir de pouvoir continuer mes recherches dans les magnifiques collections du British Museum confiées à votre habile direction. Ces collections sont en si bon ordre et sont si faciles à consulter qu'il y pourra en bien peu de temps comparer toutes mes plantes critiques de l'Algérie, du Maroc, et de la Tunisie avec les précieux types dont le British Museum est si riche. Mon intention est de publier avec M. J. Ball une florule du Maroc et d'illustrer par des planches toutes les espèces nouvelles de ce pays, encore si peu connu, et sur lequel la récente exploration de MM. J. D. Hooker et J. Ball a fourni de si importantes documents."

"L'herbier du British Museum est le seul qui avec l'herbier du Museum de Paris offre un aussi grand nombre de collections classiques, et pour le rendre aussi utile que possible aux études botaniques, vous n'avez qu'à continuer à procéder avec le même soin au classement des riches matériaux que vous possédez, et dont chaque jour vous accrez encore l'importance par de nouvelles acquisitions."

"Je n'aurais comme amélioration à signaler à la belle installation de votre herbar qu'à vous recommander, comme je crois que vous le faites déjà, de munir chaque espèce d'une chemise spéciale portant extérieurement une étiquette indiquant le nom de l'espèce, son numéro d'ordre d'après la monographie la plus récente, et l'indication des pays d'où proviennent les échantillons. J'ai eu à regretter la disparition des étiquettes originales pour des échantillons des anciens herbiers, mais je sais que cette habitude de transcrire les étiquettes au lieu de les conserver religieusement, a toujours été rejetée par vous."

The other botanist to whom I applied was John Miers, Esq., F.R.S., Vice-President L.S. Mr. Miers has worked impartially in the herbarium of the Museum, as in that at Kew, and his numerous independent publications are the best testimonies to the extent, value, and scientific availability of the collection of plants at the British Museum.

Mr. Miers writes—"The herbarium of the British Museum appears to me well adapted for the purpose of scientific study, and deserves quite as much praise as the Hookerian herbarium in proportion to its relative extent. I should state, however, that I have invariably been able to work more easily at the British Museum than at Kew, because I have found there not only the dried plants but at the same time the cartological collections close at hand, advantages enhanced by the great facility of access to a good botanical library, especially to the rare books in the Banksian collection, together with ready means of referring to the original notes and admirable drawings of Aublet, Solander, and a host of others, necessary to be consulted for purposes of monographing, these advantages are not obtainable at Kew, where the collections of fruits and seeds are too far removed to be easily accessible. In these remarks I do not wish to detract in the smallest degree from the deservedly high character of the Hookerian herbarium, which is unrivalled for its riches, especially as I have there received all the attention I could desire. But, at the same time, I think in fairness that we should all acknowledge what is due to the Botanical Department of the British Museum for the state of its collections and the facilities there afforded to scientific workers in that branch of knowledge; I say nothing about the convenience to the general body of men of science afforded by the central position of the Museum,—one of its greatest advantages, which should never be lost sight of."

I might take further exception to statements in the evidence of Mr. Ball bearing on the herbarium, but, as he has informed me that, "with the exception of a single visit early last year, my personal acquaintance with the collections at the British Museum is derived from a few visits more than 25 years ago," it is obviously impossible for him to give any reliable information from personal knowledge.

This is true also of the evidence of Dr. Thomson in reference to the herbarium of the British Museum. I am not aware that Dr. Thomson has once visited the herbarium during the 14 years in which I have been officially connected with it, and he cannot possibly from his personal knowledge declare that "Kew is *at present* the more available for scientific research of the two." (Qu. 7242)

WILLIAM CAREWITHERS.

British Museum, May 14, 1873.

F.—MEMORIAL presented to the FIRST LORD of the TREASURY, respecting the NATIONAL HERBARIA.

[See p. 7.]

To the Right Hon. W. E. Gladstone, First Lord of the Treasury.

SIR,

THE undersigned persons engaged in the pursuit of botany, or in instruction therein, desire to call your serious attention to a subject that deeply concerns the progress of Natural Science, and that of those branches of agriculture, horticulture, forestry, and manufactures that largely depend on Botanical Research.

The First Commissioner of Works, in a Memorandum presented to Parliament before the close of last Session, clearly raised the question whether it is desirable to transfer to the branch of the British Museum about to be constructed at South Kensington, the Scientific Collections and Library now existing at Kew, and further stated that, pending the decision on that subject, he considers it his duty to take care that no new expense shall be incurred at Kew which will embarrass the Ministers of the Crown or the House of Commons in arriving at a decision.

The Lords of the Treasury, in their Minute of the 24th July, decline to refer to that portion of the above-mentioned Memorandum, and no statement on that subject has since been made by any Minister of the Crown which shows whether it has received the attention of the Government.

Being strongly of opinion that the proposed measure would be highly detrimental to the progress of Science, and injurious to all those interests that depend upon it, we beg to urge upon you that the subject is not one merely of Departmental Interest, and that it would not be unfitting your position, as First Minister of the Crown, to give your consideration to the following reasons, which we beg to urge in opposition to the proposed measure:—

1. That it appears to us that it is absolutely necessary that a great Botanical Garden like that at Kew, which is confessedly far the most important in the world, should be in close connexion with as perfect an Herbarium and Botanical Library as possible, and that these conditions are now fulfilled as far as circumstances and the present state of science will admit.

2. That such a combination of living and dead specimens is requisite for the complete study of plants, as regards their technical, physiological, and economic characters, and that the removal of the Herbarium would be a retrograde step in a scientific point of view.

3. That the records of the Colonial and India Offices will show of what immense importance the Establishment at Kew has been to the welfare of the entire British Empire, and that weighty questions are constantly submitted to the Director which require immediate attention, and which could not, in many cases, be satisfactorily answered without reference to the Library or Herbarium.

4. That every facility for the investigation of the intimate structure and general habit of plants, and the study of them in every point of view, which can reasonably be considered within the scope of pure Botany, is afforded by the Herbarium and Museum of Botany in connexion with the Garden, and that it would be easy to point out important labours in that direction which have been instituted at Kew, while the systematic treatment has always regarded the more minute characters as well as those which are superficial.

5. It has been remarked, indeed, that important works, such as the *Hortus Kewensis*, have been prepared without the aid of an Herbarium at Kew. We would, however, remark that the statement is not correct, as there was an Herbarium, which was dispersed before Sir W. J. Hooker became Director; and the conditions of Natural Science are at the present time so completely altered, that it is impossible to institute any fair comparison, the number of known species being enormously increased since the date of the publication in question.

6. That the Museums of Structural and Economic

Botany, which owe their existence and importance to the late Sir W. J. Hooker, are, often found of great value in the decision of critical points in the study of species, and that the severance of them from the Herbarium and Library would be a serious loss.

7. That in the principal Botanic Gardens on the Continent, where effective work is done, there is in every case a large Herbarium connected with them.

8. That, in the interest of Botanical Science, we think it highly desirable that, besides the collections now existing at Kew, an Herbarium, or collection of dried plants, as complete as possible, should be maintained in connexion with the Natural History Museum which it is proposed to place at South Kensington, and that the two Herbariums should be in intimate relation with each other.

9. That from the delicate and perishable nature of its contents, and the necessity of referring to numerous specimens, an Herbarium cannot be made use of by many persons at the same time, and while it is desirable that students should have ready means of access at the National Museum in London to collections which may enable them to identify the plants of any particular country, it is still more essential that the authors of important works in Botanical Science should be enabled, as at present, to pursue their labours at Kew without interruption from casual visitors.

10. That an Herbarium is the least costly of all Collections in Natural History, and that which requires the least amount of space for its proper maintenance, in proportion to the number of objects which it contains.

11. That the arrangements of the Herbarium at Kew are so perfect, and the facilities for study so great, that it is resorted to from all parts of the world, and it would, therefore, be unwise to make a change which in the result is almost certain to be detrimental, and which, we are assured, would be especially distasteful to the leading Foreign Botanists.

M. J. Berkeley, Botanical Director to the Royal Horticultural Society of London.

Charles C. Babington, Professor of Botany, Cambridge.

M. A. Lawson, Professor of Botany, Oxford.

J. H. Balfour, Professor of Botany, Edinburgh.

Alexander Dickson, Professor of Botany, Glasgow.

G. Dickie, Professor of Botany, Aberdeen.

Ed. Perceval Wright, Professor of Botany, Dublin.

Robert Bentley, F.L.S., Professor of Botany, King's College, and to the Pharmaceutical Society of London.

W. T. Thiselton Dyer, Professor of Botany, Royal Horticultural Society, London.

R. O. Cunningham, Professor of Botany and Zoology, Belfast.

W. R. McNab, Professor of Botany, Royal College of Science, Dublin.

George Henslow, M.A., F.L.S., Lecturer at St. Bartholomew's Hospital, (London), and at the Royal Agricultural College, Cirencester.

John Ball, F.R.S.

Maxwell T. Masters, M.D., F.R.S.

James Bateman, F.R.S.

R. Trevor-Clarke, F.R.H.S.

W. Wilson Saunders, F.R.S.

Geo. F. Wilson, F.R.S.

Robert Hogg, LL.D., F.L.S.

W. Sowerby, F.L.S.

D. Moore, Ph.D., F.L.S., M.R.I.A.

Andrew Murray, F.L.S.

William Munro, Major-General, C.B., F.L.S.

M. Pakenham Edgworth, F.L.S.

John Miers, F.R.S., V.F.L.S.

Frederick Currey, M.A., F.R.S., Sec. L.S.

Daniel Hanbury, F.R.S., F.L.S.

C. E. Broome, M.A., F.L.S.

Leonard Blomefield, M.A., F.L.S.

J. T. Boswell Syme, LL.D., F.L.S.

Hugh Cleghorn, M.D., F.L.S.

Clements Markham, C.B., F.L.S.

R. C. A. Prior, M.D., F.L.S.

Edward J. Waring, M.D., F.L.S.

George C. M. Birdwood, M.D.

Walter Elliot, K.C.S.I., F.L.S.

J. Forbes Watson, M.A., M.D., F.L.S.

Richard Strachey, Maj.-Gen., C.S.I., F.R.S.

E. W. Cooke, R.A., F.R.S., F.L.S.

Robert Brathwaite, M.D., F.L.S.

William Britten, A.L.S.

W. Allport Leighton, B.A., F.L.S.

William Phillips.

John Goucher, F.L.S.

J. Leicester Warren, M.A.  
 Worthington G. Smith, F.L.S.  
 M. C. Cooke, M.A.  
 James M. Crombie, M.A., F.L.S.  
 Alfred W. Bennett, M.A., B.Sc., F.L.S.  
 A. G. More, M.R.I.A., F.L.S.

Thomas Moore, F.L.S., Floricultural Director to the  
 Royal Horticultural Society of London.  
 Thomas Thomson, M.D., F.R.S., late Superintendent  
 of the Royal Botanic Garden, Calcutta.  
 Charles Darwin, M.A., F.R.S.  
 George Bentham, F.R.S.

## APPENDIX III.

## EXTRACT FROM MR. LOCKYER'S REPORT ON THE AID GIVEN BY THE STATE TO SCIENCE IN FRANCE. [See p. 21.]

## The GENERAL COLLECTIONS illustrating the SCIENCES of OBSERVATION and EXPERIMENT in FRANCE.

In England the student of natural history finds in the British Museum the most perfect and complete collection in the world, by the study of which he is enabled to increase his knowledge and to carry on his investigations. If, however, a student of mechanics, physics, chemistry, or astronomy, or of the applications of these Sciences to the various Industries, wishes to study a collection of instruments which shall help him in his studies at the British Museum helps his Natural History confrère, he finds absolutely nothing to supply his want.

This is not the case in France. Side by side with the Museum of Natural History, which may be likened roughly to our British Museum, there is the Conservatoire des Arts et Métiers which does for the students of the sciences I have named what the Muséum d'Histoire Naturelle does for the students of Natural History. I was extremely struck at the even-handed justice of this arrangement in France, and was not surprised to find that in many points in which we are behind the French, the French themselves ascribe that backwardness to the fact that we are less fortunate than they in not having such an establishment.

The relationship between these institutions from this point of view is so intimate that I have put them under the same heading, in order that a more general coup d'œil of the help given all round to Students and to appliers of Science in France may be obtained.

There is also another very striking characteristic to which I must next draw attention. Both in the Museum of Natural History, and in the Conservatoire des Arts et Métiers free lectures are given by the men most distinguished in their special branches in France on the various subjects which are illustrated by the collections of either establishment, our own small efforts in this direction—the lectures, namely, at the School of Mines—are the only representatives we have of this kind of teaching, which it is universally acknowledged has been accompanied by the happiest results. If this be so, then the enormous amount of benefit which must be derived from the courses of lectures given in these establishments in France must be obvious. Last year, for instance, the courses of lectures at the Conservatoire were attended by more than a quarter of a million of anxious students,—students who not only come to hear, but who instantly, in a great majority of cases, went to enlarge their knowledge by studying the collections themselves.

## THE MUSEUM OF NATURAL HISTORY

The Museum of Natural History is administered by a Director chosen from amongst the Professors of the Establishment; the professors, every five years, sending up the names of three candidates to the Minister of Public Instruction, by whom the choice is made.

All scientific administrative questions connected with the Museum are regulated by a Committee of Professors, which the Director calls together once a month at least, and over which he presides. One of the Professors, who is called the Directeur Suppléant, fills the place of the Director during his absence. This Directeur Suppléant is chosen by the Minister from amongst the names presented by the Committee for the functions of Director, and, like the Director, he is named for five years. The Committee of Professors names annually one of its members as Secretary. The Professors are the Keepers of the collections and are responsible for their order and arrangement. Each Professor presents annually to the Committee of Professors a Report on the state and requirements of the laboratories and collections under his charge. These Reports are transmitted to the Minister with the opinion of the Committee and of the Director. The matériel is inspected once a year.

The present personnel is as follows—

Director, M. Chevreul.

Directeur Suppléant, M. Milne-Edwards.

The professors (who are also Administrators of these Departments) are, of—

General Physiology, M. Claude Bernard.

Comparative Anatomy, M. Paul Gervais.

Anatomy and Natural History of Man, M. de Quatrefages de Bréau.

Zoology, Mammals and Birds, M. Milne-Edwards.

Zoology, Reptiles and Fish, M. Dareste.

Zoology, Insects, Crustacea, and Arachnida, M. Blanchard.

Zoology, Annelids, Mollusca, and Zoophytes, M. Deshayes.

Botany and Vegetable Physiology, M. Brongniart.

Culture, M. Decaisne.

Geology, M. Daubrée.

Mineralogy, M. Delafosse.

Paleontology, M. Albert Gaudry.

Physics, applied to Natural History, M. Becquerel.

Vegetable Physics, M. Georges Ville.

Organic Chemistry, M. Chevreul.

Inorganic Chemistry, M. Frémy.

All lectures are public and free; the time of the commencement of the course and the programme being settled each September, and submitted to the Minister of Public Instruction for his approval. Each professor gives 40 lectures annually. The lectures are followed by two classes, first, the general public (*auditeurs bénévoles*), and, secondly, the students of the Ecole Normale Supérieure of the third year who must attend at least two lectures a week.

The collections are enriched by exchanges, and there is an elaborate system of distributing duplicates from the collections not only to the local museums in France and her colonies, but also even to foreign countries. Thus from the mineralogical collection 1,800 duplicates were distributed between 1860 and 1865, 3,000 being still retained. I annex the budget for the Natural History Museum for the present year:—

	PERSONNEL	fr	fr.
Traitements de 16 professeurs, à 7,500fr.		120,000	
" de 2 maîtres de dessin, à 2,500fr.		5,000	
" d'un bibliothécaire et d'un sous-bibliothécaire		8,000	
" d'un secrétaire, agent comptable		5,000	
" de 19 aides naturalistes, de 2,000 à 4,000fr.		67,000	
" de 3 gardes des galeries, de 3,500fr. à 4,000fr.		11,500	
" d'un jardinier-en-chef		4,000	
" de 21 préparateurs, de 1,500 à 2,500fr.		42,800	
" de 20 employés, contrôleur, chef d'atelier, jardiniers, inspecteurs, de 750 à 3,000fr.		38,400	
Gages des gens de service		81,680	
			323,380
Indemnités aux voyageurs naturalistes			25,000
	MATÉRIEL.		
Galeries, laboratoires, cours, etc.		83,700	
Jardin et serres		65,100	
Ménagerie		75,000	
Ateliers et entretien		32,500	
Chauffage, éclairage, et frais divers		30,500	
Bibliothèque, frais de bureau, et de service intérieur		42,700	
			329,800
			fr 678,180

## THE CONSERVATOIRE DES ARTS ET MÉTIERS.

The Conservatoire des Arts et Métiers is the carrying out of an idea of the illustrious Descartes. It is not necessary to go into its earliest history. I may commence by stating that in 1775, Vaucanson formed at the Hôtel de Mortagne, Rue de Charonne, Faubourg Saint Antoine, the first public collection of machines, instruments, and tools destined for the instruction of the working classes. At his death he left them to the Government of the King (Louis XVIth), and in this collection we have the germ of the Conservatoire. The legacy being accepted by the Government the Hôtel de Mortagne was also purchased, and a conservator was appointed to look after the collection. At the same time it was decided that all inventors who for the future might be recompensed by the nation should be expected to enrich the collection. M. de Vandermonde was chosen to be administrator and conservator of the new industrial museum; and from 1785 to 1792 he had enriched it by the acquisition of 500 new machines.

The Revolution, which destroyed so much in France, was of the greatest assistance to the conservatoire. The Legislative Assembly had created a commission of monuments which was appointed to look after everything relating to sciences, arts, and trades. Thus, however, they did not do. In 1793 the National Convention charged the Committee of Public Instruction to undertake the work thus neglected. A temporary commission of arts was appointed, composed of Vandermonde, Leroy, Conté, Beuvelot, and Molard. Afterwards the Abbé Grégoire and the celebrated physicist, Charles, were members. More than 800 machines, instruments, and the like, were thus collected and placed in the Hôtel d'Angillon, Rue de l'Université.

The already acknowledged utility of the collection founded by Vaucanson suggested that a similar destination should be given to the collection in the Hôtel d'Angillon; and a Decree of the Convention was obtained, which ruled that there should be formed at Paris, under the name of "Le Conservatoire des Arts et Métiers," a public collection of machines, models, tools, descriptions, and books of every description of art and trade, the construction and the employment of which were to be explained by three Demonstrators attached to the establishment, and a draughtsman was also appointed. The Committee of Agriculture and Arts was charged to arrange with the Minister of Finance as to the locality of the new Conservatoire.

The establishment of this new institution was, however, delayed for some time in spite of many reports urging the necessity for its completion, in one of which I find the enunciation of the principle, "Il faut leur faire voir plus qu'il ne faut leur parler." The present locality, an ancient priory, was, however, at last chosen, and in the year 1808 all the models and machines belonging to the State, and existing in the various collections to which I have referred, were transferred to the new locality, in which they were arranged in order to realise the intention of founding a practical instruction based upon the actual seeing and explanation of the objects collected.

In 1806 M. de Champagny, the Minister of the Interior, raised, in the Conservatoire, a school for children, which soon became very flourishing. From 1810 to 1811 this school contained 300 students, who afterwards became sub-officers in the engineers, employed in the fortification branch of the army, students in the artillery school, constructors of works, chiefs of workshops, and the like. M. Schneider was one of these children.

In 1817 the conservatoire was re-organised. A sub-director was appointed and a council was created, composed of scientific men and manufacturers, the function of which council was to advise the administration of the conservatoire. The first catalogue of the conservatoire was published by the advice of this council in 1818.

In 1819 a new line of usefulness was added, it was made a high school of application of scientific knowledge to commerce and industry, by means of free public instruction. Three chairs were appointed of mechanics, chemistry, and industrial economy. In 1829 a chair of chemistry applied to the arts was added. In 1839 the number of chairs was increased to 10; the professors forming a council, one of them being chosen director under the title of "Professeur-Administrateur," on the model of the Natural History Museum.

This new organisation gave a strong impulse to the institution. The teaching of all the sciences applied to industry and the arts very rapidly took a high degree of development. Confided to scientific men of the first order, a great progress was soon observed in all branches of industry; but this was not without its drawbacks, for when the professors were appointed, the demonstrators were abolished, and the teaching of ease went with them. M. Morin informs me that, as a matter of fact, the services of the Demonstrators were never required.

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I think this hasty sketch will be sufficient to give a general idea of the growth of the institution until it came into the hands of its present distinguished director, General Morin, under whom it has become, as is universally acknowledged, one of the most important establishments to be found in France for spreading a knowledge of science amongst the working classes and others interested in the arts and manufactures.

The professors and the subjects at present taught in this establishment are as follow:—

Geometry applied to the Arts	Professor Colonel Laussedat,
successor of the late M le Baron Ch Dupin	
Descriptive Geometry	Prof. De la Gournerre.
Mechanics applied to the Arts	" Tresca
Civil Constructions	" Emile Trélat.
Physics applied to the Arts	" Edmond Becquerel.
General Chemistry, in its	
relations to Industry	" Eugène Péligot
Industrial Chemistry	" A. Guard.
Chemistry applied to dyeing,	
pottery, and glass	" De Luynes
Agricultural Chemistry and	
Chemical Analysis	" Boussingault.
Agriculture	" Moll.
Agricultural Works and	
Rural Engineering	" Hervé Mangon
Spinning and Weaving	" Alcan.
Political Economy and In-	
dustrial Legislation	" Wolowski.
Industrial and Statistical	
Economy	" Jules, Burat.

In order to give an idea of the subjects treated in these lectures, I append detailed programmes of the lectures for two seasons. These are as follow:—

*Géométrie appliquée aux Arts.*

1869-70.—Géométrie de la sphère. Construction et usage du globe céleste. Étude des phénomènes astronomiques. Instruments d'observation. Mesure du temps. Cadrons solaires. Construction des horloges et des chronomètres. Calendrier. Grandeur et figure de la terre. Détermination des positions géographiques. Système métrique.

1871-72.—Grandeur et figure de la terre. Cartes géographiques. Étude des formes générales du terrain. Instruments de lever et de nivellement. Cadastre. Travaux de terrassement. Calcul des surfaces, des déblais, et des remblais. Tracé des routes, des canaux, et des chemins de fer. Tables et instruments propres à abréger les calculs.

*Géométrie descriptive.*

1869-70.—Principes de la géométrie descriptive. Méthode des projections. Lignes droites, plans, surfaces courbes employées dans les arts. Projections cotées. Détermination des ombres sur les figures géométrales. Notions sur les surfaces réglées et les surfaces topographiques.

1871-72.—Explication détaillée des règles de la perspective linéaire et des tracés géométriques qu'elle exige. Étude des effets de perspective. Instruments de perspective. Tableaux courbes. Perspective des bas-reliefs. Décorations théâtrales. Perspectives rapides.

*Mécanique appliquée aux Arts.*

1869-70.—MACHINES À VAPEUR. Propriétés des vapeurs. Production de la vapeur. Chaudières à vapeur. Dispositions générales des machines. Théorie des machines à vapeur. Appareils de distribution. Calcul des pièces. Machines à air et à gaz. Théorie mécanique de la chaleur.

1871-72.—Principes fondamentaux de la mécanique; démonstration rationnelle et expérimentale de ces principes. Résistance des matériaux. Règles à suivre dans l'étude des questions de mécanique pratique. Effet utile des machines. Transport horizontal et vertical des fardeaux. Machines industrielles.

*Constructions civiles.*

1869-70.—MOYENS DE LA CONSTRUCTION (suite) Parois horizontales: planchers, voûtes. Combles. Couvertures. Écoulement des eaux. Bains. Clôtures mobiles. Revêtements des parois. Fosses. Aménagements propres au chauffage et à la ventilation. Transport et manœuvre des matériaux sur les chantiers.

1871-72.—Étude des éléments matériels qui entrent dans la construction des édifices. Règles relatives à leur emploi. Exemples et applications.

*Physique appliquée aux Arts.*

1869-70.—Principes généraux du dégagement de l'électricité. Applications de l'électricité aux arts: piles vol-

E



taques, lumière électrique, galvanoplastie, dorure, télégraphie, horlogerie électrique, appareils d'induction, appareils électro-magnétiques. Actions chimiques produites par la lumière: photographie.

1871-72.—Principes fondamentaux de la physique Applications diverses de la chaleur; formation des vapeurs; emploi de leur force élastique, sources de chaleur et de froid, chauffage, ventilation Production et propagation des sons Sources de lumière; éclairage, analyse spectrale Construction des instruments d'optique.

*Chimie générale dans ses rapports avec l'Industrie.*

1869-70.—Métaux. Propriétés et extraction des métaux usuels et de leurs composés. Or, argent, platine Art de l'essayeur des matières d'or et d'argent. Mercure, cuivre, plomb, antimoine, bismuth, étain, zinc, aluminium. Fers, fontes et aciers. Étude des principaux alliages employés dans l'industrie.

1871-72.—Phénomènes généraux de combinaison et de décomposition. Nomenclature et notation chimique. Histoire détaillée des corps simples non métalliques et de leurs principales combinaisons. Air atmosphérique. Eau Aacides minéraux Ammoniacque. Métaux usuels.

*Chimie appliquée à l'Industrie.*

1869-70.—Soufre Phosphore. Carbone. Azote. Phosphates. Potasse, soude, chaud, magnésine. Conservation des bois Féculeries. Fabrication de la chaux et de l'acide carbonique. Sucreries Filtres-presses Papeteries Alcool Acide acétique. Céruse Blanc de zinc Aacides stéarique, margarique et oléique. Gaz de la houille Epuration Éclairage

1871-72.—Soufre et sulfure de carbone. Acide sulfurique. Acide chlorhydrique. Soude et sels de soude. Chlorures décolorants et chlorates. Acide borique et borax. Potasse et sels de potasse. Nitrates et acide nitrique. Chaux, ciments, plâtres. Alumine, aluns, aluminium. Combustibles artificiels. Gaz d'éclairage. Phosphore et allumettes.

*Chimie appliquée aux Industries de la Teinture, de la Céramique, et de la Verrerie.*

1869-70.—Verrerie Matières vitrifiables. Différentes espèces de verre. Fabrication et travail du verre et du cristal, etc. Verres colorés Gravure et peinture sur verre Vitraux, Céramique. différentes sortes de poteries. Matière première qui servent à les fabriquer Préparation et travail des pâtes céramiques. Décoration des poteries.

1871-72.—Matières premières employées dans la composition des verres et dans la fabrication des poteries Verres blancs et colorés. Préparation et travail des différentes sortes de pâtes céramiques. Couleurs vitrifiables. Emaux. Décoration des verres et des poteries.

*Chimie Agricole et Analyse Chimique.*

1869-70.—De la terre végétale. Engrais et amendements. Développement et constitution des plantes Substances alimentaires. Démonstrations expérimentales des procédés d'analyse

1871-72.—Constitution des substances alimentaires. Alimentation de l'homme Alimentation et développement du bétail. De l'atmosphère Démonstration des procédés d'analyse. Endiométrie

*Agriculture.*

1869-70.—Continuation de l'étude de la production animale. Élevage tenu et emploi du cheval. Exposé de la production industrielle en agriculture dans ses rapports avec la culture proprement dite Étude des systèmes de culture

1871-2.—Les systèmes de culture: classement, analyse, et choix. Changement de système Les assolements. Lois, conditions, et classification Étude des principaux assolements

*Travaux Agricoles et Génie Rural.*

1869-70.—Construction et installation des bâtiments ruraux Habitations et dépendances Logements des animaux. Bâtements pour la préparation et la conservation des récoltes Chemins ruraux; clôtures Usines agricoles Examens de quelques cultures au point de vue du travail qu'elles exigent.

1871-72.—Assainissement du sol: drainage, tuyaux de drainage, curage des cours d'eau. Desèchements; polders; colmatage. Exécution des travaux de culture. Moteurs; Travaux du sol; labourage; charrues à vapeur, herseage, roulage. Semences. Récoltes; fancheuses, moissonneuses.

*Filature et Tissage.*

1869-70.—Origines, caractères et propriétés des substances textiles. Filature du coton, du chanvre, du lin, du jute, du china-grass, des laines, des soies, et autres matières animales, pures et mélangées. Moulinage, retordage, grilage et apprêts des fils. Exposé méthodique et détermination des assortiments automatiques Aménagements des usines.

1871-72.—Substances propres aux feutres, aux fils, et aux étoffes en général Filature, retordage et moulinage du coton et des duvets végétaux, du chanvre, du lin, du jute, du china-grass et autres débris des tiges, feuilles, écorces et fruits. Laines, poils, duvets animaux. Soies Transformations spéciales de la paille, du caoutchouc. Emploi des fils métalliques.

*Économie Politique et Légation Industrielle.*

1869-70.—L'économie politique: principes et définitions. La liberté du travail Le capital La propriété. L'association. Rapports entre les entrepreneurs d'industrie et les ouvriers. Corporations. Coalitions.

1871-72.—Forces productives Travail. Intelligence. Terre. Capital. La propriété. La population. L'épargne. L'échange. Lois qui déterminent l'accroissement de la production Le commerce. La monnaie. La coopération. L'association. Le crédit.

*Économie Industrielle et Statistique.*

1869-70.—Notions générales de géographie physique et commerciale Statistique raisonnée des industries agricoles, minière, manufacturière, et artistique. Revue économique des principaux produits de ces industries artistique, envisages aux divers points de vue de la production, du commerce, et de la consommation.

1871-72.—Notions générales de géographie physique et commerciale. Statistique raisonnée des industries agricoles, minière et manufacturière Revue économique des principaux produits de ces industries envisages aux divers points de vue de la production du commerce et de la consommation.

Connected with the Conservatoire and the machines in movement is a *Galerie d'Experimentation*, in which various experiments are undertaken for the different departments of the Government, and also for individuals or machines of new construction which are required to be examined. Statements of the results of the experiments made for the greater part in the presence of the inventors themselves, are at once printed and published. This branch of the usefulness of the Conservatoire is being rapidly expanded. Up to 1864 more than 200 investigations of this kind had been made for the Government, and for individuals, and no objection had been taken to the results obtained in any case, which is held by the director very justly to prove the care and the impartiality with which they are conducted. I should add that in the case of experiments carried on for individuals the work is done gratuitously by the officers of the conservatoire, excepting, of course, the necessary expenses incurred in setting up and dismantling the apparatus. The conservatoire is also the office for the French standards, and any experiments connected therewith are conducted gratuitously by the officers of the establishment.

It is found that no very great sum of money is requisite to feed the collections, the munificence of French and foreign manufacturers is perpetually creating an influx of new objects, which perhaps is not altogether disinterested. As is the case with all the other scientific establishments of France, there is a special statement given of the work done every year. This publication is entitled "*Annales du Conservatoire*," and contains a statement of all the scientific and technical researches and operations conducted in the establishment.

The collections are, as far as possible, arranged in the following groups:—

Instruments relating to weighing and measuring, geology, topography, and horology. These are on the ground floor on the north side.

On the south side we find, metallurgical galleries, galleries connected with spinning and weaving, dyeing in printing, agriculture, and machines in movement.

On the first floor on the north side are the hydraulic machines, civil constructions, geometrical models, specimens of glass work and porcelain, chemical products, printing, exemplifications of the various arrangements for warming and lighting, and a most valuable collection of instruments of acoustics and optics.

On the south side are steam engines, machine tools, specimens of the various arrangements used in divers industries, apparatus for the study of kinematics, physico mechanics, and instruments of physics.

To give an idea of the completeness of these collections, and of the extreme value of them, especially to those who may be engaged in teaching, or in applying scientific principles to the various industries, I venture to lay before the Commission some extracts from the Catalogue:—

## OPTICS.

a. *Catoptrique.*

- 1, 2 Deux miroirs cylindriques, accompagnés d'une collection de dessins d'anamorphoses sur carton.
  - 3, 4, 5, 6, 7, 8, 9, 10. Huit miroirs métalliques à facettes.
  - 11 Miroir métallique convexe.
  12. Grand miroir concave en métal
  13. Miroir monté en argent, pour faire voir l'intérieur de la bouche (brevet de Marmont)
  - 15 Écran de 3<sup>m</sup>. 87, toile peinte en blanc, tendue sur châssis.
  16. Grand écran en toile blanche crée, sur rouleau.
  17. Grand porte-lumière ou réflecteur à miroir plan en métal, de 0<sup>m</sup> 33 sur 0<sup>m</sup> 22, avec mouvement de rotation.
  18. Réflecteur, également à miroir plan en métal, diamètre 0<sup>m</sup> 11.
  19. Réflecteur à miroir de métal qui, sans être mû par un mouvement d'horlogerie, peut faire fonction d'héliostat
  - 20 Héliostat de 's Gravesand, sans horloge, incomplet
  - 21 Réflecteur en métal, pour chambre obscure.
  22. Héliostat de 's Gravesand, avec son horloge équatoriale, suivant Charles
  23. Héliostat de J.-T. Silbermann, par Soleil.
  - 24 Tuyaux, diaphragmes, verres, dépendant de différents appareils
  - 25 Miroir plan en métal, de 0<sup>m</sup>.16 sur 0<sup>m</sup>.19, monté en cuivre
  - 26 Miroir plan circulaire, de 0<sup>m</sup>.11, tournant dans sa bordure en cuivre.
  27. Miroir circulaire en glace, pouvant tourner sur son support
  28. Miroir concave de 0<sup>m</sup>.11 de diam, tournant sur son axe
  29. Grand miroir plan en métal, hauteur 0<sup>m</sup> 69, largeur 0<sup>m</sup> 49, dans un cadre
  30. Miroir de métal, à faces concave et convexe, sur son pied, diam 0<sup>m</sup> 55
  - 31 Miroir de métal, à faces concave et convexe, sur son pied, diam 0<sup>m</sup> 41.
  - 32 Miroir concave Anglais, de 0<sup>m</sup> 35 de diam, sur son pied
  - 33 Miroir convexe de même diamètre, sur son pied
  - 34 Miroir de *Buffon*, composé de 48 petits miroirs plans, avec son pied.
  - 35 Miroir à foyer variable, de *Buffon*, formé de 16 glaces mobiles
  - 36 Miroir à facettes incrustées dans une concavité, sur son pied.
  37. Miroir cylindrique concave.
  38. Miroir cylindrique convexe
  39. Miroir cylindrique, avec dessins d'anamorphoses
  40. Miroir conique, avec dessins d'anamorphoses
  - 41 Miroir prismatique, avec dessins d'anamorphoses
  - 42, 43. Deux miroirs en forme de pyramide, avec dessins d'anamorphoses.
  44. Miroir convexe à dix-neuf facettes
  45. Miroir noir, plan
  46. Chamot portant une toile peinte en blanc
  - 47 Tableau perspectif, sur plan oblique.
  - 48, 49. Deux autres tableaux semblables
  50. Miroir concave Anglais, de 0<sup>m</sup>.58, tournant sur son pied
  - 51 Miroir convexe de même diamètre, sans pied
  - 52 Miroir convexe de 0<sup>m</sup>. 36.
  53. Appareil pour vérifier le parallélisme des faces des miroirs
  54. Appareils pour les expériences sur les lois de la réflexion et de la réfraction, de J.-T. Silbermann, par Soleil
  - 55 Miroir parabolique en cuivre argenté, pouvant s'incliner à volonté, avec sa lampe.
  - 56 Miroir en acier poli.
  - 57, 58 Deux miroirs concaves, en verre étamé, de 0<sup>m</sup> 58 de diamètre
  - 59 Miroir concave sur pied
  - 60 Grand miroir réflecteur en cuivre.
  - 61 Lanterne à lampe de Carcel pour les expériences d'optique, par M. Soleil
- b. *Dioptrique*
1. Cuve en glace terminée par deux verres, l'un concave, l'autre convexe, par les expériences sur la réfraction.
  - 2 Cuve en glace
  3. Cuve en glace
  - 4 Cercle de cuivre gradué, sur un trépied, avec vis à caler, se posant dans la cuve précédente.
  5. Petite lentille à eau, sur pied.
  6. Grande lentille à eau, sur pied.
  7. Lentille à eau de 0<sup>m</sup> 22, dans son cercle en cuivre.
  8. Petite lentille à eau dans un cadre.
  10. Lentille concave de 0<sup>m</sup>.12, montée.
  11. Lentille concave de 0<sup>m</sup>.8, montée
  - 12, 33, 14. Trois loupes, de divers foyers, sur leurs pieds
  - 15, 16. Deux lentilles montées, l'une convexe, l'autre concave; foyer de 0<sup>m</sup> 33
  - 17 Boîte contenant trente verres convexes de divers foyers, depuis 0<sup>m</sup> 33, jusqu'à 3<sup>m</sup>. 33, montés en bois, pour la démonstration des propriétés des foyers simples et composés.
  18. Verre convexe de 1<sup>m</sup>.11 de foyer, monté dans un écran.
  19. Lentille de 0<sup>m</sup> 25 de diam., avec guéridon.
  20. Parallépipède de glace
  21. Prisme conique, monté sur pied.
  22. Verre réfringent de forme conique.
  23. Verre réfringent en forme de pyramide.
  24. Polyèdre de flint-glass, dit *multipliant*.
  25. Réservoir d'eau pour les expériences de réfraction dans les grandes cuves
  26. Appareil de M. Colladon pour l'expérience de la veine fluide.
  - 27 Loupe montée en corne.
  - 29 Appareil pour mesurer la distance focale des lentilles et des miroirs sphériques, de J.-T. Silbermann, par Soleil.
  - 29 Une grande lentille de Fresnel, à quatre anneaux, avec son patin, par M. François
  - 30 Deux lentilles ardentes accolées.
  - 31 Lentille de 0<sup>m</sup> 38 de foyer, pour la projection du spectre solaire.
  - 32 Première lentille de Fresnel, construite sous sa direction immédiate par Soleil, donnée par l'Académie des Sciences.
  33. Trente-quatre pièces montées avec fils de couleur, pour représenter la marche des rayons de lumière dans les divers instruments d'optique
  - 34 Appareil pour la mesure des indices de réfraction, accusant une déviation de 10 secondes, par MM Brunner frères.
  - 35 Appareil pour la mesure des indices de réfraction à différentes températures, et pour les raies ultra-violettes, par MM Brunner frères
- c. *Chromatique*
1. Appareil de sept petits miroirs plans.
  - 2 Quatre anciens objectifs astronomiques, à très-longes foyers, de 23 à 27 mètres, dont deux de Campani
  - 3, 4 Deux prismes équilatéraux, de flint-glass anglais, tournant sur leur axe.
  - 5, 6. Deux prismes semblables
  7. Prisme équilatéral de flint-glass, tournant sur son axe.
  8. Prisme équilatéral de flint-glass.
  - 9 Prisme de flint-glass français
  - 10 Prisme équilatéral de flint-glass, avec base polie, sur son pied
  - 11 12 Deux prismes de flint-glass, à section rectangulaire, polis sur leurs bases, sur leur pied.
  - 13, 14 Deux petits prismes scalènes, sur leur pied.
  - 15 Polyprismes superposés, de sept matières réfringibles différentes.
  - 16, 17 Deux prismes de cristal de roche, sur leurs pieds.
  18. Prisme scalène, en verre coloré, sur pied
  - 19 Prisme à angle variable, en flint-glass diasporamètre de Rochon
  - 20 Prisme à angle variable, en verre de Saint-Gobain diasporamètre, de Rochon
  21. Prisme à angle variable, pour l'eau, avec arc gradué, sur son pied.
  - 22 Prisme à angle variable, pour l'eau, avec deux glaces à surfaces parallèles et avec prisme achromatisant, de Naurre
  - 23 Grand prisme d'eau, équilatéral
  - 24 Grand prisme à section rectangulaire
  - 25, 26. Deux prismes d'eau, équilatéraux
  - 27, 28 Deux polyprismes à liquides, à auge parallèles
  29. Grand prisme à air, d'Hawkesbee, à section rectangulaire, en glaces parallèles
  30. Prisme de verre verdâtre, monté
  31. Grand prisme en verre français, tournant dans une chape, avec pied.
  - 32 Appareil achromatique de Dollond, à trois prismes adossés
  33. Appareil achromatique, à deux prismes, par Cauchois.
  - 34 Petit prisme d'ambre.
  - 35 Six verres plans, colorés, tournant dans leur chape pour la recombinaison de la lumière.

36. Six verres de couleur dans leur chape
- 37, 38. Deux objectifs achromatiques, non montés, à deux et à trois verres, pour la démonstration.
39. Objectif achromatique, diam. 0<sup>m</sup>.5, foyer 0<sup>m</sup> 11, pouvant prendre toutes les inclinaisons.
40. Tube pour le gaz nitreux.
41. Appareil pour la démonstration des effets d'opposition des couleurs, d'après M. Chevreul.
42. Prisme creux, monté, pour le sulfure de carbone
43. Spectre solaire de Fraunhofer, dessiné sur glace, par M. L. Dupin.
45. Lentille disposée pour montrer l'aberration de réfrangibilité, par M. J. Duboscq
46. Prisme en flint blanc, construit par M. J. Duboscq.
47. Prisme disposé pour servir à la reconstitution de la lumière par une lentille cylindrique, par M. J. Duboscq.
48. Lentaprisme.
49. Appareil à deux prismes, pour liquides, à angle variable
50. Prismes ayant servi à étudier les indices de réfraction, donnés par M. Baille (Comptes rendus de l'Académie, 1865)
51. Photographie du spectre solaire, par M. Rutherford 1863), donnée par lui

#### d. Vision

1. Œil artificiel, pour la démonstration des causes du myopisme et du presbytisme
2. Anatomie de l'œil, par Pinson, pièce en cire colorée
3. Pièce de Pinson pour le même objet.
4. Appareil à roues dentées pour faire mouvoir des disques, diversement colorés, pour le mélange des couleurs.
5. Trois appareils de de Haldat pour la vision.
6. Quatre verres de chromatopes, pour projection.
7. Appareil d'Aimé pour la persistance des images lumineuses sur la rétine, par M. J. Duboscq.
8. Appareil pour l'étude des rayons lumineux dans l'œil, par Mme. Veuve Bertaud

#### e. Instruments d'optique.

1. Verre isolé formant lunette
2. Deux loupes de botaniste
3. Petits microscopes simples pour les botanistes
4. Chambre noire à douille conique, avec glace micrométrique.
5. Chambre noire à double douille conique, avec oculaire de 0<sup>m</sup> 22 de foyer.
6. Chambre noire à prisme mobile
7. Chambre noire dite à portrait.
8. Chambre noire analogue à la précédente
9. Chambre noire avec caisse, pour dessiner de paysage.
10. Chambre noire, adaptée à un volet.
11. Écran circulaire en glace dépolie, mobile sur son pied, diamètre 0<sup>m</sup> 89.
12. Écran semblable au précédent, de 0<sup>m</sup> 35 de diamètre.
13. Instrument pour la démonstration générale de l'existence des foyers des verres et de l'effet des lunettes simples et composées.
14. Banc de lumière, dit banc de Newton, divisé sur une longueur de 2 mètres
15. Petite optique à miroir, sur son pied
17. Optique de jour, ou à réflexion.
18. Grande optique de nuit, de Charles.
19. Deux meubles contenant quarante dessins originaux, à la gouache et à l'aquarelle, par les peintres Gaudat, Prévot, Dunoy, Valenciennes et Boltard, pour servir aux deux optiques précédentes.
21. Mégascope achromatique de Charles
22. Mégascope lucernal, ou lanterne magique
24. Lanterne magique, faisant fonction de microscope lucernal transparent
24. Grand microscope lucernal, pour les objets opaques et transparents, modifié par Charles.
25. Petite boîte de porte-objets destinés à ce microscope.
26. Grand microscope solaire, de Martin.
27. Microscope solaire, avec tuyaux et verres.
28. Microscope solaire de Dollond
29. Microscope solaire de Dollond, pouvant servir de microscope simple
30. Microscope anglais de Shuttleworth, dans sa boîte, avec ses micromètres.
31. Microscope de Dellebarre, dans sa boîte avec pièce additionnelle, et deux micromètres en pelure d'ognon
32. Petit microscope simple, contenant un charançon du Brésil
33. Ancien microscope de Campani.
34. Microscope de Charles, avec ses accessoires.
35. Photomètre de M. Pouillet pour le grossissement des lunettes.
36. Collection de 50 préparations microscopiques transparentes, avec porte-liquides, pour les infusoires et les insectes, par M. Bourgogne.
37. Collection de 26 échantillons de tissus divers, recouverts de lamelles minces, par M. Bourgogne.
38. Porte-lumière avec ses accessoires pour projeter les phénomènes de polarisation et de double réfraction, soit au soleil, soit à la lumière artificielle, de M. Soleil.
39. Goniomètre de M. Babinet.
40. Goniomètre de Charles.
41. Microscope achromatique, avec goniomètre, de M. Brunner, et garniture de verres de M. Nachet.
42. Chambre noire à prisme, ou pronopioscope, montée sur un volet de la galerie.
43. Longue-vue en carton.—Voir F. c. 18.
44. Kaléidoscope.
45. Chambre claire de M. Soleil.
46. Photomètre de M. Pouillet, pour mesurer l'intensité de la lumière des corps célestes.
47. Microscope anglais, avec verres de rechange
48. Stéréoscope, avec épreuves sur verre, donné par M. Duboscq
49. Stéréoscope à lunettes, avec six épreuves, donné par M. Duboscq
50. Microscope achromatique, par M. Georges Oberhauser.
51. Microscope solaire de M. C. Chevalier, avec micromètre
52. Microscope achromatique de Georges, par Maillard
53. Trente-six préparations microscopiques, par M. Bourbous.
54. Douze tableaux de fantasmagorie simple.
55. Treize tableaux de fantasmagorie, à mouvements ordinaires
56. Huit tableaux de fantasmagorie à mouvements compliqués
57. Daguerriotype de voyage, de M. Clerget
58. Grand daguerriotype, par M. Lerebour.
59. Objectif double, pour daguerriotype, donné par M. Jamin.
60. Photomètre de M. Babinet, par M. J. Duboscq.
61. Collection d'épreuves photographiques, pour projections
62. Collection d'objets microscopiques d'histoire naturelle.
63. Six vues fondantes, pour projections.
64. Appareil de projection pour phénakistoscope.
65. Quatre tableaux pour l'appareil ci-dessus
66. Jeu de lentilles achromatiques, pour le microscope solaire.
67. Spécimen d'écriture microscopique, par G. Froment.
68. Prisme de flint-glass pour le redressement des images, par projection, par M. J. Duboscq
69. Collection de vues photographiques, pour projections, par M. J. Duboscq.
70. Tête de fantasmagorie, pour projection, par M. J. Duboscq.
71. Quatorze tableaux de fantasmagorie, pour projections, par M. J. Duboscq
72. Lunette photométrique de M. E. Becquerel, par M. J. Duboscq
73. Neuf tableaux de fantasmagorie, sans mouvement, par M. J. Duboscq
74. Deux tableaux de fantasmagorie, à mouvement, par M. J. Duboscq
75. Appareil pour l'agrandissement des épreuves photographiques, par M. J. Duboscq
76. Spectroscope à six prismes pour l'étude de la composition de la lumière, par M. J. Duboscq
77. Photomètre de M. E. Becquerel, par M. J. Duboscq.
78. Microscope binoculaire, de Smith Beck et Beck.
79. Aléthoscope par M. Ponti, de Venise
80. Collection de vues transparentes par M. Ponti, de Venise.
81. Collection de vues noires par M. Ponti, de Venise.
84. Grande lentille, pour projection, par M. J. Duboscq.
85. Microscope ancien de Ch. Chevalier, avec verres de rechange et prisme redresseur
86. Micromètre, avec division du  $\frac{1}{2}$  de millimètre en 100 parties.
87. Collection de 60 préparations microscopiques, par Fritchard
88. Collection de 70 préparations microscopiques, par Bourgogne
89. Support pour projection, avec miroir mobile, par M. J. Duboscq
90. Microscope simple à pince centrée, par la Société Genevoise.
91. Microscope composé et ses accessoires, par la Société Genevoise

92 Grand appareil photographique, avec deux objectifs de 0<sup>m</sup>. 90 de foyer, par M. Lebrun.

### f. Interférences.

1. Couverture de miroir pour les expériences de diffraction.
2. Appareil pour les anneaux colorés, par Soleil.
3. Appareil pour les anneaux colorés, par Id.
4. Appareil pour les anneaux colorés, par Id.
5. Appareil pour les anneaux colorés, par Id.
6. Appareil pour les anneaux colorés, par Id.
7. 8. Deux petits miroirs épais, montés en cuivre, pour les expériences sur les anneaux colorés.
9. Grand banc en fer pour les expériences sur la diffraction, sur les interférences et sur la polarisation, avec les dispositions de MM. Fresnel, Arago, Babinet, Pouillet, et Scherdl, etc.
10. Collection de réseaux de Scherdl, se montant sur l'appareil précédent.
11. Quatre lames minces cristallines, d'épaisseur déterminée, se montant sur les supports de l'appareil précédent, par Soleil.
12. Appareil de Fresnel, à deux miroirs, disposé suivant les indications de L. Foucault, pour produire des retards ou des avances dans les ondes, par M. Duboscq (Cet appareil se monte sur un support de banc de diffraction PG. f. 9.)
13. Appareil de diffraction, par M. Ch. Chevalier.
14. Deux modèles en plâtre, de M. Engel, représentant l'onde lumineuse de Fresnel, donnés par M. Vattexaire.
15. Réseau croisé pour le spectre.
16. Surface des ondes lumineuses, d'après Fresnel, modèle donné par M. de Saint-Venant.
17. Surface des ondes lumineuses, d'après Fresnel, nappe intérieure, modèle donné par le même.

### g. Polarisation.

1. Lunette à prisme de Rochon, par Putois.
2. Prisme biréfringent monté.
3. Appareil pour les expériences sur la réfraction conique.
4. Cyanomètre d'Arago, par Soleil.—Voir PH. g. 1.
5. Soixante-neuf cristaux et objets pour la projection des phénomènes de polarisation, par Soleil.
6. Appareil d'analyse de Norrenberg, par Soleil.
7. Appareil d'analyse d'Amici, par Soleil.
8. Appareil de Soleil pour la mesure des axes.
9. Rhomboïde de *spath* d'Islande.
10. Deux grandes plaques de tourmaline, parallèles à l'axe et collées sur verre.
11. Prismes de cristal de roche enfumés, taillés parallèlement à l'axe.
12. Prisme de cristal de roche perpendiculaire à l'axe.
13. Prisme de verre noir.
14. Prisme de verre enfumé.
15. Appareil pour l'analyse des liquides par la lumière polarisée, par Soleil.
16. Appareil propre à démontrer les actions du magnétisme sur la lumière polarisée et sur les différents corps, par M. Ruhmkorff.
17. Appareils à deux tourmalines, pour les expériences sur l'absorption de la lumière.
- 18, 19. Deux plaques de quartz à deux rotations, l'une naturelle et l'autre composée, de Soleil.
20. Plaque de quartz gauche avec plage droit, et une plage droit avec plage noire de Soleil.
21. Plaque de quartz mince, gauche.
22. Plaque de quartz parallèle à l'axe, de 1 millim. d'épaisseur, par Soleil.
23. Deux plaques de quartz.
24. Deux plaques de quartz, prismatiques, du même angle, pour produire ensemble une épaisseur variable.
25. Polariscopes d'Arago, avec addition d'un cadran divisé, par Soleil.—Voir PH. g. 2.
26. Appareil pour les couleurs complémentaires, d'Arago.
27. Prismes pour la démonstration de la double réfraction, de Soleil.
28. Morceau de crown-glass de Guinand.
- 29, 30. Plaques de flint-glass et de crown-glass, de Saint-Gobain.
31. Appareil de M. Herschel pour la polarisation par les lames minces.
32. Appareil pour trouver l'angle de polarisation des petites surfaces planes.
33. Collection de 70 polyèdres en bois, indiquant les diverses formes cristallines, donnée par Marloye.
35. Appareil de Faraday, à quatre électro-aimants, pour montrer l'action de l'électricité sur la lumière.
36. Appareil pour la projection des couleurs complémentaires, par M. Soleil.
37. Appareil de Savart pour la projection des hyperboles, par Soleil.

38. Pince de Fresnel pour la double réfraction du verre par compression, par Soleil.

39. Appareil de M. Guérard, composé d'une pyramide et d'un cône en verre noir, taillé sous l'angle de polarisation, par Soleil.
40. Appareil de Muller, pour les anneaux colorés par polarisation, par Soleil.
41. Appareil pour montrer la double réfraction de la tourmaline, par Soleil.
42. Appareil pour la projection des cristaux par la lumière polarisée, par M. Duboscq.
43. Prisme de Nicol, de 0<sup>m</sup>. 34, par Bertaud.
44. Deux prismes de cristal de roche, par Bertaud.

### h. Phosphorescence.

1. Grand appareil à tubes, pour la phosphorescence, de M. Ed. Becquerel, par M. Ruhmkorff.
2. Grand phosphoroscope en bois noir, avec roues d'engrenage, de M. Ed. Becquerel, par M. Duboscq.
3. Phosphoroscope de M. Ed. Becquerel, grand modèle, monté sur un support à vis calantes, par M. Duboscq.
5. Phosphoroscope de M. Ed. Becquerel, par M. Duboscq.
6. Tableau au sulfate de quinine, pour l'expérience de phosphorescence, de Stoke.

### ELECTRO-CHEMISTRY.

#### a. Galvanoplastie, etc.

1. Auge pour la galvanoplastie.
2. Appareil de Boquillon.
3. Dépôts galvanoplastiques donnés par Boquillon.
4. Épreuves de galvanoplastie exécutées et données par M. Gueyton.
5. Deux appareils de M. Ruolz, en porcelaine, garnis de leurs électrodes et conducteurs, par M. Bourbouze.
6. Buste de Volta en galvanoplastie, exécuté et donné par M. Gueyton.
7. Quatre tableaux de spécimens de galvanoplastie plane, exécutés et donnés par MM. Christoffe et Cie.
8. Première épreuve de galvanoplastie, exécutée par M. de Jacobi, donnée par lui.

### TELEGRAPHY.

#### a. Télégraphie optique.

1. Télégraphe de Bréguet et Bettancourt.

#### b. Télégraphie électrique.

1. Télégraphe électrique, système de M. Wheatstone, en deux parties.
2. Télégraphe électrique, système de M. Dujardin, par G. Froment.
3. Télégraphe électrique à pinceau et crayon, avec son diaphore ou manipulateur, de G. Froment.
4. Modèle de télégraphe électrique écrivain, avec tous les accessoires et moyens de démonstration, de M. Fiquillet, par G. Froment.
5. Modèle de télégraphe électrique, système de A. Foy.
6. Grande modèle de télégraphe, pour la démonstration par M. Bréguet.
7. Tendeur pour fils télégraphiques.
8. Modèle de poteau télégraphique, avec planchette de rechange pour l'isolement des fils.
9. Télégraphe à lettres, petit modèle, et manipulateur, par M. Bréguet.
10. Sonnerie, avertisseur, par M. Bréguet.
11. Modèle de télégraphe électrique, par M. Ruhmkorff.
12. Télégraphe magnéto-électrique, par M. George Henley.
13. Télégraphe électrique, système Morse, par M. Bréguet.
14. Télégraphe électrique indiquant le passage des trains sur les chemins de fer, par M. Bréguet, et composé des appareils suivants :  
Manipulateur d'indicateur.  
Indicateur à deux aiguilles.  
Interrupteur à piston.
15. Télégraphe électro-chimique, système Pouget-Maison-neuve, par M. Loiseau.
16. Manipulateur de télégraphe électrique, par M. Loiseau.
17. Parafoudre à fil droit, par M. Loiseau.
18. Télégraphe militaire, employé en Suisse, par M. Hipp.
19. Relais de télégraphe, par M. Hipp.
20. Deux tubes en bois, garnis de leurs câbles, pour télégraphes électriques, donnés par M. George Henley.
22. Manchon droit, en fonte, pour recevoir un câble de télégraphe électrique, donné par le même.
23. Manchon courbe en fonte pour le même usage, donné par le même.

28. Boussole à aim, pour télégraphe, par M. Bréguet.  
 29. Récepteur français à deux indications; deux manipulateurs, commutateurs avec parafoudre et conducteurs, donné par l'Administration des télégraphes.  
 30. Récepteur français à deux indicateurs et à relais, donné par l'Administration des télégraphes.  
 31. Modèle réunissant quatre supports divers en porcelaine, deux jonctions de fils et deux tendeurs, donné par l'Administration des télégraphes.  
 32. Modèle réunissant cinq supports différents en porcelaine, une jonction de fils et un tendeur, donné par l'Administration des télégraphes.  
 33. Collection d'échantillons de fils télégraphiques, donnée par MM. Siemens, Halske et Cie.  
 34. Télégraphe imprimeur et son manipulateur de MM. Digne, données par eux.  
 35. Isolateurs en grès, pour fils télégraphiques, de MM. Bourne et Cie.  
 36. Collection d'échantillons de câbles électriques, terrestres et sous-marins, donnée par MM. Ratier et Cie.  
 36. Sonnerie télégraphique, par M. Aubine, donné par la Société d'encouragement.

## CINEMATICS.

M Ampère, dans sa *Philosophie des sciences* (1830), a proposé de nommer *Cinématique* (*de κίνημα, mouvement*) la science qui aurait pour objet l'étude, au point de vue purement géométrique, des systèmes à l'aide desquels on transmet ou l'on modifie un mouvement déterminé. La *Cinématique* fait abstraction des forces, et n'envisage, dans le mouvement, que les directions et les vitesses relatives des points mobiles. M. Morin la désigne sous le nom de *Mécanique géométrique*, et M. Robert Willis sous celui de *Théorie des mécanismes* ou des organes mécaniques.

## DIVISION GÉNÉRALES.

- a. Guides et supports.—b. Appareils de graissage.—c. Transformation du mouvement rectiligne continu en mouvement rectiligne continu.—d. Transformation du mouvement circulaire continu en mouvement rectiligne continu, et réciproquement.—e. Transformation du mouvement circulaire continu en mouvement rectiligne alternatif.—f. Transformation du mouvement circulaire alternatif en mouvement rectiligne alternatif ou intermittent.—g. Transformation du mouvement circulaire continu en mouvement rectiligne intermittent.—h. Transformation du mouvement rectiligne continu en mouvement circulaire alternatif ou intermittent.—i. Transformation du mouvement circulaire alternatif en mouvement rectiligne alternatif.—j. Transformation du mouvement rectiligne alternatif en mouvement circulaire alternatif.—k. Transformation du mouvement circulaire alternatif en mouvement rectiligne alternatif.—l. Transformation du mouvement rectiligne alternatif en mouvement circulaire alternatif.—m. Transformation du mouvement circulaire continu en mouvement rectiligne alternatif.—n. Transformation du mouvement circulaire continu en mouvement rectiligne alternatif.—o. Transformation du mouvement circulaire continu en mouvement rectiligne alternatif, dans le cas où les axes se rencontrent.—p. Transformation du mouvement circulaire continu en mouvement rectiligne alternatif, dans le cas d'axes parallèles et situés à de grandes distances.—q. Transformation du mouvement circulaire continu, en mouvement circulaire continu, dans le cas d'axes qui ne se rencontrent pas.—r. Mouvement de rotation continu transformé en mouvements simultanés de transport et de rotation.—s. Mouvements différentiels.

## a. Guides et supports.

2. Palier en fonte avec coussinets en bronze et plaque d'appui.  
 3. Palier en fonte pour un arbre très-chargé, avec plaque d'appui pour répartir la pression sur une surface d'étendus suffisante.  
 4. Palier en fonte pour un arbre très-chargé, avec ses coussinets en bronze et sa plaque d'appui.  
 5. Palier pour un arbre horizontal et un arbre vertical, avec vis de centrage pour la coquille de l'arbre vertical.  
 6. Console pour soutenir un arbre de transmission.  
 Coulée d'une seule pièce avec la colonne, elle porte un palier avec coussinets pour l'arbre. On préfère aujourd'hui les consoles séparées de la colonne pour la facilité du montage et du remplacement.  
 7. Console pendante, pour soutenir un arbre de transmission qui doit recevoir des poulies.  
 Elle se fixe à deux solives du plafond.  
 8. Console pendante, pour soutenir deux arbres de transmission parallèles.  
 Elle se fixe aux poutres supérieures du plancher.  
 9. Console pendante pour arbre de transmission.  
 Elle se fixe à l'angle d'une poutre.

10. Support d'un arbre de transmission.  
 11. Support ou guide pour arbres verticaux.  
 Il se fixe à une poutre.  
 12. Support ou guide pour arbres verticaux.  
 Il se fixe à une poutre.  
 13. Arbre de rotation avec ses supports.  
 14. Coussinet en alliage dit métal anti-friction, par Babbitts.  
 15. Coussinet en alliage dit métal anti-friction, par Dewrance.  
 16. Coussinet en alliage dit métal anti-friction, donné par Philippe.  
 17. Modèle de la transmission établie à l'Exposition Universelle de 1855, donné par MM. Noyeu et Cie.  
 18. Chaise pendante, par M. Sellers, de Philadelphie.  
 19. Chaise d'applique, par M. Sellers, de Philadelphie.  
 20. Palier de transmission, par M. Sellers, de Philadelphie.  
 21. Chaise suspendue, avec griffe d'embrayage, par M. Sellers, de Philadelphie.  
 22. Spécimens de différentes formes de boulons employés dans la construction des machines, par M. Schroeder.

## b. Appareils de graissage.

1. Appareils de graissage continu, par Jaccoud.  
 2. Boîte à huile, avec mèche de coton agissant par la capillarité.

Cet appareil de graissage s'emploie avec succès pour les arbres qui marchent vite, mais il a l'inconvénient de laisser couler l'huile, même lorsque l'arbre ne fonctionne pas.

3. Appareil de graissage continu, à chaîne, par Decoster.  
 Une chaîne sans fin circulant dans le réservoir d'huile la répand sur les surfaces frottantes pendant que l'arbre tourne.  
 4. Palier graisseur de M. Dyckhoff de Bar-le-Duc, donné par l'inventeur.  
 5. Boîte à graisse hydro-syphoïde, par M. Froust.  
 6. Boîte à graisse, système Vallod, donnée par l'inventeur.  
 7. Boîte à graisse pour les wagons de chemins de fer, donnée par M. Diets, de Metz.  
 8. Modèle de palier graisseur, par M. Grandblancs.  
 9. Robinet graisseur pour cylindres et tiroirs de machines à vapeur, par M. J. Brechnel.  
 10. Godet graisseur automatique de M. L. Ameno.  
 11. Graisseur automatique pour cylindres de machines à vapeur, par M. Bomillon.  
 12. Graisseur automatique de M. Vatnet, donné par la Société d'encouragement. (Voir Bulletin, t. LV.)  
 13. Godet graisseur à écoulement intermittent, système Ameno, donné par l'inventeur.  
 14. Burette inversable, en caoutchouc, donnée par M. Bonnal.

## c. Transformation du mouvement rectiligne continu en mouvement rectiligne continu.

- \*1. Palans et mouffettes.—Voir K. 1.  
 \*2. Poulies fixes.—Voir K. 2.  
 \*3. Poulie avec cliquet d'arrêt, qui empêche la poulie de tourner en sens contraire, et que l'on peut dégager à volonté. Voir K. 3.  
 \*4. Palans coniques pour la tension des cordages.—Voir K. 4.

Cette disposition est vicieuse, en ce qu'elle conduit à employer des palans d'un trop petit rayon, ce qui augmente les pertes de travail produites par le frottement et par la roideur des cordes.

5. Modèle servant à vérifier approximativement que le chemin parcouru par le point d'application de la force motrice est égal à autant de fois celui décrit par le fardeau qu'il y a de brins parallèles.—\*K. 5.  
 6. Appareil pour vérifier, par expérience, la théorie des palans à poulies égales.—\*K. 6.

Même but que le précédent.

- \*7. Palans équipés à six brins.—Voir K. 8.

L'emploi des palans permet, avec un effort modéré ou un petit nombre d'hommes, d'élever de lourds fardeaux ou de produire de grandes tensions; mais ces appareils donnent lieu à une perte considérable de travail moteur par suite du frottement et de la roideur des cordes.

8. Appareil pour vérifier les propriétés de la poulie mobile.—\*K. 7.

\*9. Poulie différentielle à arrêt instantané, système Weston.—Voir K. 98.

\*10. Palan de sûreté, maintenant la charge à toute hauteur, de M. Jamet, donné par M. Bellar.—Voir K. 109.

\*11. Modèle de palan, système Weston. Voir K. 109.

\*12. Palan différentiel de M. Demoor.—Voir K. 110.

d. Transformation du mouvement circulaire contenu en mouvement rectiligne continu, et réciproquement.

\*1. Vindas à gorges avec poulies pour augmenter la tension du cordage ou la puissance du treuil.—Voir K. 18  
Appareil trop compliqué pour être d'un bon service.

\*2. Vindas à engrenage et à deux treuils.—Voir K. 10.

\*3. Cabestan avec rouleaux de friction.—Voir K. 11

\*4. Treuil avec deux roues à poignées, et deux plans inclinés garnis de rouleaux pour tendre des cinquemelles. Voir K. 12.

\*5. Treuil avec plan incliné.—Voir K. 13.

Le mouvement transmis par le treuil au poids mobile fait dégager deux dévils latéraux qui permettent au plateau chargé de descendre le long du plan incliné, quand on le juge convenable.

\*6. Treuil vertical pour élever un seau de mine et en descendre un autre par l'action des hommes, tournant alternativement dans un sens et dans l'autre.—Voir D. a. 6.

\*7. Vindas avec guide du cordage et leviers d'arrêt du treuil.—Voir K. 14.

\*8. Treuil à engrenage, à manivelle.—Voir K. 15.

\*9. Vindas avec poulie pour soutenir le cordage.—Voir K. 16

10 Rainure en forme de vis transmettant un mouvement rectiligne à une pièce guidée par une tige parallèle à l'axe de la vis, par Zureda.

\*11. Presse à vis pour exprimer les jus.—Voir L. b. 29.

12 Chèvre ordinaire servant à élever les fardeaux

13 Chèvre Chinoise à treuil différentiel.—Voir K. 59.

Le treuil a deux parties de diamètres différents. Le cordage, fixé au treuil par ses deux extrémités, passe sur une poulie mobile qui agit sur le fardeau. Le cordage s'enroule sur l'un des treuils et se déroule de l'autre. La quantité dont le fardeau s'élève est à celle dont la roue à poignées ou les extrémités des leviers se déplacent comme la moitié de la différence des rayons du treuil est au rayon de la roue ou au bras de levier de l'effort.

14 Appareil à fusée pour régulariser le mouvement de transport rectiligne d'une bande de papier ou d'étoffe qui se déroule d'un cylindre pour s'enrouler sur un autre.

15. Crémaillère à coulisse, mue par un pignon, appareil employé pour la manœuvre des vannes.

\*16. Engrenage à pignon et crémaillère.—Voir K. 68

17. Poulie de M. Fowler, pour câble métallique, par M. Clair.

\*18. Modèle de treuil à engrenage différentiel de M. Weston.—Voir K. 121.

e. Transformation du mouvement circulaire contenu en mouvement rectiligne alternatif.

1. Bouton de manivelle guidé dans un cadre, produisant le mouvement rectiligne alternatif.

2. Excentrique employé pour transmettre aux tiroirs de machines à vapeur un mouvement rectiligne alternatif avec plusieurs repos.—\*A. c. 17.

Il a l'inconvénient de donner presque toujours lieu à un mouvement saccadé.

3. Mouvement de rotation continu d'un pignon, transformé en mouvement rectiligne alternatif d'une crémaillère double.

Lorsque l'extrémité circulaire de la crémaillère arrive près du pignon, les dents de celui-ci s'appuient sur celles de la partie circulaire, et le pignon s'élève ou s'abaisse pour engrener avec l'autre côté de la crémaillère. Ce système a été présenté en 1721 par Auger (Voyez *Machines de l'Académie*). On le retrouve dans les *Artificieuses machines de Remeth* (1685).

4. Mouvement de va-et-vient transmis par un treuil armé de dents, qui agissent alternativement les unes en dessus, les autres en dessous d'un châssis traversé par le treuil.

Cet appareil donne lieu à des chocs à chaque changement de direction.

5. Mouvement de rotation continu transformé en un mouvement de va-et-vient par deux roues dentées.

Ce système est attribué à Lahire.

7. Mouvement continu de rotation produisant un mouvement de va-et-vient.—I. n. 10

8. Treuil portant deux secteurs dentés qui agissent successivement sur deux crémaillères parallèles entre lesquelles se meut l'axe des secteurs.

Il y a deux châssis qui se meuvent en sens contraires. Ce dispositif donne lieu à des chocs à chaque changement de direction, et, par suite, à des ruptures.

9. Crémaillère simple, mue alternativement par deux secteurs dentés, montés sur les arbres de deux roues d'engrenage égales.

10. Mouvement de va-et-vient d'un châssis produit par une crémaillère qui passe au-dessus et au-dessous d'une lanterne à chevilles par l'effet d'un ressort.

L'arbre de la lanterne est conduit par une vis sans fin.

11. Engrenage métré, dit de Lahire, transmettant un mouvement rectiligne alternatif le long d'un plan incliné.

12. Manivelle double conduisant deux tiges de piston par une bielle à fourche.

Les tiges traversent des guides fixés au mur. Les manivelles sont placées d'équerre, ce qui ne convient qu'aux pompes à double effet.

13. Manivelle triple, dont les boutons sont écartés d'un tiers de circonférence.

Cette disposition convient aux pompes à double et à simple effet.

Les tiges sont guidées par une bride articulée.

14. Excentrique circulaire employé pour transmettre un mouvement rectiligne alternatif aux tiroirs des machines à vapeur et autres pièces légères.—\*A. c. 52.

Ce dispositif ne convient que quand la résistance de la pièce à conduire est très-faible, autrement, il donne lieu à une perte de travail considérable due au frottement.

15. Excentrique à came dite en cœur, pour transmettre à une tige un mouvement rectiligne alternatif dont les courses sont proportionnelles aux arcs décrits par l'excentrique.—\*A. c. 53.

Il donne lieu à une perte de travail considérable par le frottement, et à des ébranlements à chaque changement de direction.

16. Excentrique triangulaire monté en dehors de son arbre, pour transmettre à un tiroir de machine à vapeur un mouvement rectiligne alternatif avec repos.—\*A. c. 54.

Il a l'inconvénient d'exiger l'interruption de l'arbre.

17. Excentrique circulaire avec sa bielle, analogue à celle des locomotives, pour conduire les tiroirs.

18. Mouvement de rotation continu transformé en mouvement de va-et-vient très-lent.

19. Manivelles quadruples transmettant le mouvement alternatif à quatre tringles parallèles par Molard.

La bonne exécution des manivelles quadruples présente de grandes difficultés.

20. Appareil de Carrère pour tracer des courbes représentatives des lois du mouvement dans les transmissions par excentriques et autres.

Cet appareil est accompagné d'une bielle et de dix excentriques qui peuvent être substitués les uns aux autres.

21. Appareil régulateur, à cônes, pour presses hydrauliques, de M. Moulis.

22. Transmission de mouvement par croisillon, par M. Clair.

23. Transmission de mouvement à retour rapide, de M. M. Ducommun et Dubied, par M. Clair.

24. Transmission de mouvement à retour rapide, de M. Whitworth, par M. Clair.

25. Engrenage ovale de M. Burdet, conduisant une tige, donné par lui.

f. Transformation du mouvement circulaire alternatif en mouvement rectiligne alternatif ou intermittent.

1. Levier de La Garouste articulé, agissant sur une crémaillère à chevilles, pour mouvoir un fardeau sur un plan. Le levier de La Garouste est décrit dans les *Machines de l'Académie* de 1702.

2. Encliquetage à frottement de M. Saladin.

Il produit le mouvement continu d'une tige ou d'un plateau au moyen du mouvement de rotation alternatif d'un levier. Le levier à bague supérieure soutient la tige pendant la reprise du grand levier et du levier à bague inférieure. En soulevant les deux leviers, à bague on rend la tige libre, et elle redescend.

3. Deux systèmes de parallélogrammes articulés, connus en Angleterre sous le nom de Lazy Tong.

Ces systèmes ont été appliqués dans la construction de certaines échelles à incendie.

4. Mécanisme destiné à imprimer, au moyen d'une manivelle alternative, un mouvement de va-et-vient à une crémaillère.

5. Modèle de moulinet ou pendule conique, à débrayage; régulateur de vannes et de soupape.—\*A. c. 104.

Les boules, en s'écartant plus ou moins selon la vitesse de rotation de l'arbre qui les porte, déterminent le mouvement du manchon d'embrayage à droite ou à gauche, et par suite le mouvement de rotation de la vis sans fin dans un sens ou dans l'autre; d'où résulte le mouvement d'ascension

ou d'abaissement d'une vanne ou d'une valve. Pour que cet appareil soit sensible, il ne doit avoir à produire qu'un embrayage offrant peu de résistance. On a même substitué au manchon d'embrayage trois poulies, dont une *folle* placée entre les deux autres, qui entraînent les roues d'angle. Le régulateur n'a dans ce cas à produire que le passage de la courroie d'une poulie à l'autre.

6. Levier à roue dentée, de La Garouste.
7. Levier multiple.
8. Parallélogramme de Watt.

Ce modèle rend apparente la marche sensiblement rectiligne de la tige du piston.

9. Modèle de chevette, à double levier de La Garouste, par M. Antoine.

g. Transformation du mouvement circulaire continu en mouvement rectiligne intermittent.

\* 1. Pignons de poudrière mis par des cames disposées en hélice sur un arbre animé d'un mouvement de rotation continu, par M. Clair.—Voir T. a. 5.

2. Pignons et bocard.—Voir D. d. 21.

Même dispositif que I. g. 1, avec cette différence que les cames ont le profil d'une développante de cercle. (Voyez D. d. 21.)

\* 3. Rouleau de tension destiné à établir ou à interrompre la communication du mouvement entre deux axes parallèles. Tire-sac des moulins.—Voir T. c. 8.

4. Modèle de machines à mortaiser, à retour rapide, exécuté et donné par MM. Ducommun et Dubied, de Mulhouse.

5. Appareil pour l'observation graphique de la loi du mouvement à retour rapide, de MM. Ducommun et Dubied.

h. Transformation du mouvement rectiligne ou circulaire alternatif en un mouvement circulaire continu.

1. Pédales du rémouleur, transformant un mouvement circulaire alternatif en un mouvement circulaire continu.

2. Transformation du mouvement circulaire alternatif d'un levier en mouvement circulaire alternatif d'un volant.

3. Conversion d'un mouvement de bascule en un mouvement de rotation continu, par Molard.

4. Transmission par manivelle à un arbre vertical, donnée par la Société d'encouragement.

a. Transformation du mouvement circulaire continu en mouvement circulaire alternatif ou intermittent.

1. Engrenage produisant un mouvement circulaire alternatif.

Un pignon, fixé à l'extrémité d'un arbre, qui peut se déplacer un peu horizontalement, conduit un plateau circulaire garni de chevilles saillantes sur une partie plus ou moins grande de sa circonférence. Quand le pignon, en agissant à l'intérieur de cette circonférence, a fait passer toutes les chevilles dans un sens, il tourne autour de la dernière, passe de l'autre côté, et agit alors à l'extérieur de la circonférence.

Comme il tourne toujours dans le même sens, il produit le mouvement circulaire alternatif du plateau.

Ce dispositif, employé dans la filature, ne convient que pour des pièces légères, marchant lentement. Dans les autres cas il donne lieu à des chocs et à des ruptures.

2. Combinaisons de vis sans fin et de roues d'engrenage.

3. Modèle du parallélogramme de Watt, et de sa roue planétaire ou mouche.

Le dispositif dont il s'agit ici est celui que Watt employa d'abord pour transformer le mouvement circulaire alternatif du balancier en un mouvement circulaire continu. Il le nomma système *Planétaire*. La roue ou *planète*, fixée à la bielle, tourne autour de la roue (ou soleil) montée sur l'arbre du volant, lui fait faire un tour entier par oscillation simple du balancier, tandis que, par l'emploi de la manivelle, l'arbre du volant ne fait un tour que pour une oscillation double du balancier.

Les chocs qui se produisaient dans l'engrenage ont fait abandonner ce système, que Watt n'avait d'ailleurs adopté et créé que parce qu'une *patente* l'empêchait d'employer la bielle et la manivelle. (Voyez A.)

4. Transformation d'un mouvement de rotation continu en un mouvement de rotation alternatif, par M. Schroeder.

5. Transmission de mouvement par croix de Malte, par M. Schroeder.

k. Transformation du mouvement circulaire alternatif en mouvement circulaire intermittent.

\* 1. Treuil à leviers articulés agissant sur des têtes armées de chevilles.—Voir K. 19.

Les leviers se dégagent alternativement des chevilles et s'engagent à volonté.

2. Treuil manœuvré par deux leviers de La Garouste modifiés.

La roue à minutes ou à rochet est fixée sur l'arbre du treuil. Le levier est terminé par un anneau qui embrasse une portée cylindrique fixée aussi sur l'arbre; et, en rétrogradant, il emporte le pied de biche qu'un ressort appuie sans cesse sur les dents de la roue. Au contraire, dans son mouvement d'abattage, il force le pied de biche à agir sur les dents de la roue à minutes, et produit ainsi le mouvement du treuil.

Ce dispositif simple et commode est fort en usage pour les treuils employées à serrer ou à empaqueter les ballois et pour faire mouvoir des vis, des vérins, etc.

3. Treuil manœuvré par deux leviers de La Garouste modifiés. Dispositif analogue à I. k. 2.

4. Encliquetage à pied de biche. Levier de La Garouste. L'écartement des chevilles détermine le nombre de dents que franchit le pied de biche dans son mouvement de retour et, par suite, l'amplitude du mouvement de rotation. Un cliquet s'oppose au mouvement en sens contraire.

5. Levier à encliquetage. Petit levier de La Garouste modifié.

Il se fixe à volonté, sur l'arbre à mouvoir, par une portée carrée.

6. Encliquetage à effet instantané et à mouvement circulaire, par M. Saladin.

Le mouvement alternatif du levier est transmis à la roue par la bride à anneau qu'il entraîne. Quand le levier se relève, la bride intérieure à anneau s'oppose au mouvement rétrograde de la roue. Quand on veut ramener la roue en sens contraire, on soulève les deux brides à la main.

7. Encliquetages de Dobo.

La roue ou plateau est à frottement doux sur l'arbre, et à l'intérieur sont des espèces de cames qui tournent avec cet arbre, mais qui sont articulées sur un axe particulier.

Ces cames touchent le rebord intérieur du plateau. La ligne qui joint leur point de contact avec leur axe particulier et celle qui réunit cet axe à celui de l'arbre forment un angle obtus. Quand on tourne l'arbre de gauche à droite, cet angle se ferme par le mouvement des cames, autour de leur axe, et le mouvement de rotation de l'arbre n'est pas transmis au plateau. Lorsque, au contraire, on tourne l'arbre de droite à gauche, l'angle tend à s'ouvrir, et les cames, arc-boutées contre le rebord intérieur du plateau, forcent celui-ci à tourner. Il en résulte un mouvement intermittent, mais dans le même sens, transmis au plateau par le mouvement de rotation alternatif de l'arbre. Un ressort de pression assez roide appuie sans cesse les cames contre le rebord du plateau, pour qu'il n'y ait pas de temps perdus dans la transmission.

8. Frein à collier, faisant fonction de clef lorsqu'on fait mouvoir un arbre cylindrique autour d'un axe.

9. Double frein à collier.

1. Transformation du mouvement rectiligne alternatif en mouvement circulaire alternatif.

\* 1. Archet de tour avec treuil de tension.—Voir G. d. 124.

m. Transformation du mouvement circulaire continu en mouvement circulaire continu, les axes étant dans le prolongement l'un de l'autre, ou à peu près.

1. Joint brisé universel, destiné à transmettre le mouvement entre deux axes qui ne sont pas dans le prolongement l'un de l'autre.

Il ne doit être employé que lorsque les directions sont peu différentes.

Ce dispositif est attribué en Angleterre au docteur Robert Hooke (1676), et en France au philosophe Milansus Jérôme Cardan, né en 1501, mort vers 1575. On a vainement cherché, dans ceux des dix volumes in-folio de Cardan que l'on a pu se procurer, la trace de cette invention; en particulier, l'ouvrage de *Sukthstalt*, où ce savant semble avoir résumé ses travaux de tous genres, ne renferme point la description du joint brisé.

Si l'on voulait assimiler à cet organe de transmission de mouvement le système de suspension des horloges et des boussoles marines, on le trouverait décrit dès 1829 dans les *Machine* del Signor G. Branca.

Joint brisé universel.

\* 3. Désembrayage instantané.—Voir D. d. 18.

En poussant le levier entre les deux plateaux, il se sépare par l'effet du plan incliné que porte l'un d'eux.

4. Embrayage et de désembrayage à vis pour les manchons très-lourds et les machines puissantes, par M. Clair.

5. Embrayage de l'arbre de la meule supérieure d'un moulin, au moyen d'un *toc* à bascule qui rend le pignon solidaire avec l'arbre.

On peut arrêter la meule volante, si elle s'engorge, en dégageant le *toc* au moyen d'une corde attachée à son extrémité.

6. Manchon de jonction de deux arbres dans le prolongement l'un de l'autre.

Dispositif vicieux. le bouton est exposé à de trop grands efforts et peut être coupé; l'arbre est affaibli par les entailles.

7. Mécanisme pour arrêter ou rétablir, à volonté, différents mouvements provenant d'un même moteur, par Molard.

Embrayage par manchon mobile et à fourche, pour des poulies.

8. Modèle de débrayage dynamométrique, par M Moison.

9. Manchon d'assemblage à vis, par M Sellers.

10. Manchon d'assemblage à filet, par M Sellers.

11. Spécimen de frein d'embrayage à genoux élastiques, par M L. Franchot.

12. Modèle d'engrenage ovale, régularisant la transmission par joint de Cardan, de M. Normand, donné par l'inventeur.

n. Transformation du mouvement circulaire continu en mouvement circulaire continu, dans le cas d'axes parallèles, situés à petites distances l'un de l'autre.

1. Engrenage composé de quatre roues dentées dans le même plan.

Un cercle fixe porte 72 dents à sa circonférence intérieure. Un pignon de 24 dents, monté sur un axe, porte un bras de levier sur lequel sont montées deux autres roues de 24 dents qui engrenent à la fois avec le grand cercle et avec le pignon. L'engrenage avec le pignon produit le mouvement de rotation des roues intermédiaires sur leur axe propre, et l'engrenage de ces roues avec le cercle fixe produit leur mouvement de transport. Ces deux roues reçoivent ainsi un mouvement de rotation sur elles-mêmes et un mouvement de translation autour de l'axe de rotation du pignon.

Quand les 24 dents du pignon central ont engrené avec les 24 dents d'une des roues intermédiaires, celle-ci s'est déplacée de 24 dents sur le cercle fixe, ou de  $\frac{1}{3}$  de la circonférence de celui-ci, et elle a fait un tour sur elle-même.

2. Engrenage de trois roues, deux d'entre elles étant intérieures à la troisième.

Dispositif analogue à I n. 1, avec cette différence qu'il n'y a qu'une roue intermédiaire et qu'elle n'est pas liée à l'axe du pignon. L'engrenage seul de ces dents avec ce pignon et avec la roue fixe produit son mouvement de rotation sur elle-même et son mouvement de translation. Dans une gorge de cette roue intermédiaire s'engage l'extrémité d'un bras de levier, fixé sur l'axe d'un treuil concentrique au pignon, et qui lui communique un mouvement de rotation, dont la vitesse dépend du rapport des nombres de dents du pignon et de la roue intermédiaire.

3. Combinaison de roues dentées, montrant les rapports entre les nombres de tours.

4. Ancienne transmission de mouvement.

5. Engrenage double, formé de deux roues appliquées l'une contre l'autre et divisées de telle sorte que les dents de l'une correspondent aux vides de l'autre, et de deux pignons disposés de la même manière, pour diminuer les inconvénients de la grandeur du pas et pour rendre le mouvement plus continu.

6. Modèles pour le moulage d'une roue droite et de son pignon, la roue et les dents devant être en fonte.

Voir, pour les variétés de ces engrenages, à la Géométrie descriptive.

7. Engrenage hélicoïdal, connu en France sous le nom d'engrenage de White.

White n'est pas le premier inventeur de ce système ingénieux, pour lequel il a pris cependant un brevet en 1803, et qu'il a décrit en 1822 dans son *Cesury of inventions*. L'idée de donner aux engrenages des dents hélicoïdales remonte au moins à l'année 1666, et elle fut alors proposée par le docteur Robert Hooke. Le modèle d'un engrenage hélicoïdal fut même présenté dès cette année par le docteur Hooke à la Société Royale de Londres, dont il était l'un des membres les plus distingués; et il a, en 1674, publié la description et exposé les avantages de cette forme d'engrenage, p. 70 du n° 2 de ses *Civillian lectures*.

" L'invention que j'ai faite, dit-il, je l'appelle la perfection en matière d'engrenage. C'est en peu de mots, premièrement, de faire un engrenage tel, que roue et pignon, si petits qu'ils soient, auront un nombre de dents

" aussi grand qu'on le voudra, sans que pourtant l'ouvrage soit affaibli et sans que les dents cessent d'être exécutables par un ouvrier ordinaire. Secondement, c'est que le mouvement se transmette de la roue au pignon sans qu'il puisse y avoir, si l'ouvrage est bien fait, aucune inégalité de force ou de vitesse. Troisièmement, c'est que le point de touche soit toujours sur la ligne qui joint les centres de rotation. Quatrièmement, c'est qu'il n'ait aucune espèce de frottement et qu'il ne soit pas d'une exécution plus difficile que celle de l'engrenage ordinaire, à cela près que les ouvriers n'en ont pas l'habitude." Le catalogue désignera donc provisoirement sous le nom d'engrenage de Hooke, qu'il porte en Angleterre, le système que l'on appelle à tort en France engrenage de White. White paraît toutefois avoir eu le premier l'idée de disposer les hélices en chevrons.

On doit ajouter qu'un engrenage hélicoïdal fait partie de la collection d'objets Chinois rapportés de Canton en 1846.

8. Engrenage cylindrique hélicoïdal de Hooke, dont les dents, disposées en chevrons, par White, sont destinées à détruire les composantes que l'on suppose devoir agir dans le sens de l'axe de la roue.

9. Engrenage de deux roues à hélice.

\* 10. Mécanisme pour imprimer, au moyen d'une manivelle, le mouvement de va-et-vient à une crémaillère double.

— Voir I. c. 7.

11. Appareil analogue à I n. 10 et à I. c. 3.

\* 12. Engrenage d'une roue droite et de son pignon —

— Voir I. c. 4.

13. Transmission par courroie entre deux arbres parallèles et très-rapprochés, par M. J. Schroeder.

14. Transmission par cadre, garnie de dents d'engrenage, par M. J. Schroeder.

15. Transmission par courbe en cœur, garnie de dents d'engrenage, par M. J. Schroeder.

16. Transmission par courbe en cœur, garnie de dents d'engrenage, par M. J. Schroeder.

17. Modèle original de l'engrenage de White, donné par l'Académie des Sciences.

18. Engrenage hélicoïdal intérieur, par M. Weston.

19. Transmission de mouvement, à rapport variable, de M. Sellers, par M. Clair.

o. Transformation du mouvement circulaire continu en mouvement circulaire continu, dans les cas où les axes se rencontrent.

1. Double engrenage conique pour transmettre le mouvement dans le même sens avec des vitesses différentes.

3. Modèles pour le moulage d'une roue d'angle et de son pignon.

Voir, pour les variétés de ces engrenages, aux collections de la Géométrie descriptive.

4. Engrenage d'une roue droite avec un pignon, et d'une roue d'angle avec son pignon en fonte, formant un appareil de transmission de mouvement.

5. Roues d'angle, hélicoïdales, de White, données par l'Académie des Sciences.

p. Transformation du mouvement circulaire continu en mouvement circulaire continu, dans le cas d'axes parallèles et situés à de grandes distances l'un de l'autre.

1. Modèles de transmissions de mouvement par courroies, appliquées à un tour, à une machine à aléser, à une machine à raboter, et à une machine à tarauder, indiquant en outre le mode de débrayage.

\* 2. Modèle de tire-sac, montrant l'emploi des rouleaux de tension pour établir ou interrompre au besoin la solidité du mouvement de deux treuils parallèles au moyen de courroies — Voir T. c. 8.

3. Poulie à expansion à six segments, employée pour régulariser le mouvement transmis par des courroies par M. Clair.

La circonférence de la poulie est partagée en six segments, portés chacun par un axe dirigé dans le sens du rayon; sur chaque axe est un pignon conique dont le moyeu forme l'érou d'une vis filetée sur l'axe. Ces six pignons engrenent entre eux de façon que, quand un tourne l'un, les autres reçoivent le même mouvement, mais alternativement en sens contraires. Les axes sont filetés à la partie qui traverse les pignons, les uns à droite, les autres à gauche, de manière qu'ils tournent tous dans le même sens en cloignant ou en s'approchant du centre les segments de la poulie, dont le diamètre varie ainsi à volonté.

Ce dispositif et d'autres analogues sont employés dans les machines à papier continu.

4. Modèle de la transmission par courroies du moulin de Saint-Maur, donné par M. Darblay, jeune.



5. Boucle pour courroie de transmission
6. Modèle de débrayage de courroie, système Herland, par M. E. Pihet
7. Deux modèles d'assemblage de courroies par des vis, par M. Scellos
8. Transmission de mouvement par tambour et corde.

q. Transformation du mouvement circulaire continu en mouvement circulaire continu, dans le cas d'axes qui ne rencontrent pas

1. Roue à dents hélicoïdales conduisant une vis sans fin avec volant à ailettes.

Dans ce cas, les filets de la vis et les dents doivent avoir sur leur axe une inclinaison beaucoup plus grande que l'angle de frottement. Ce dispositif a le défaut de consommer beaucoup de travail par le frottement, et ne doit être employé que pour conduire des pièces légères telles que volants, régulateurs. Il est en usage dans l'horlogerie.

2. Combinaison de vis sans fin et de nervure en spirale, pour transformer le mouvement circulaire continu en mouvement circulaire continu très-lent, appliqué aux compteurs de tours

3. Vis sans fin conduisant une roue à dents hélicoïdales. Ce dispositif donne lieu à une perte de travail considérable par le frottement; mais il permet de transmettre de grands efforts. Il est employé avec avantage pour les manœuvres des vannes.

4. Engrenage à vis sans fin.
5. Transformation d'un mouvement de rotation en un autre mouvement de rotation, la distance des axes étant variable, par M. J. Schroeder
6. Transmission de mouvement entre deux axes non parallèles par M. J. Schroeder.
7. Transmission par courroie entre deux axes non parallèles, par M. J. Schroeder.

x. Mouvement de rotation continu transformé en mouvement de transport et en mouvement de rotation simultanées.

1. Engrenage de trois roues (deux d'entre elles intérieures à la troisième), appliqué à une cardé. Même dispositif que n. 2, la roue centrale est mue par un balancier avec bielle et manivelle
2. Mouvement de rotation varié, et mouvement de va-et-vient, produits par un mouvement de rotation uniforme.

#### s. Mouvements différentiels

1. Engrenage différentiel hélicoïdal.
  2. Mouvement différentiel attribué à White.
  3. Modèle de mouvement différentiel, de trois roues d'angle, par M. Prat
- Quand la roue de champ a fait une révolution autour de l'arbre et un tour sur elle-même, la roue supérieure a fait deux tours
4. Mouvement différentiel, par engrenage d'angle, dans le rapport de 1 à 4, par M. Clair
  5. Mouvement différentiel, dans le rapport de 1 à 1 200, par M. Clair.

#### DYNAMOMETERS.

a. Dynamomètres.—b. Appareils d'observation pour l'hydraulique, la pneumatique et les machines à vapeur.—c. Appareils compteurs

#### a. Dynamomètres.

1. Dynamomètre à styles et fusée compensatrice, avec moteur chronométrique, destiné aux expériences à faire sur les bateaux, les charrues, avec sa transmission de mouvement pour les véhicules à roues, par M. A. Morin.
2. Dynamomètre à styles et fusée compensatrice, avec son renvoi de mouvement, par M. A. Morin.
3. Dynamomètre à styles et fusée compensatrice, à quatre lames, avec moteur chronométrique, par M. A. Morin.
4. Dynamomètre à compteur totalisateur pour charrues, avec ou sans avant-train, par M. A. Morin.
5. Dynamomètre à compteur totalisateur, par M. A. Morin.
6. Dynamomètre de rotation à trois poulies, à styles et fusée compensatrice, par M. A. Morin.
7. Dynamomètre de rotation à trois poulies et à compteur totalisateur, par M. A. Morin.
8. Frein dynamométrique, par de Prony (1826)
9. Manivelle dynamométrique à styles et fusée compensatrice, par M. A. Morin.
10. Dynamomètre de Régner
11. Dynamomètre à compteur charrue à avant-train.

12. Machine des puissances, ayant pour objet d'estimer les forces comparatives de plusieurs treuils conduits par un même moteur, par G. Weibel, de Leipzig, en 1741.

13. Pompe en fonte, divisée en deux parties, pour frein de Prony, par M. Clair.

14. Dynamomètre de Bentall, avec son avant-train, pour l'essai des charrues.

15. Dynamomètre de White, par John Eloc.

16. Grand dynamomètre de rotation, de 0<sup>m</sup>.80 de diamètre de poulie, de M. A. Morin, par M. Clair.

17. Dynamomètre de traction à six lames, de M. A. Morin, par M. Clair

18. Manivelle dynamométrique avec débrayage, de M. A. Morin, par M. Clair

19. Dynamomètre de traction, à style, avec moteur chronométrique, de M. A. Morin, par M. Clair.

20. Modèle de frein différentiel de Napier, donné par M. Sigl, de Vienne.

21. Appareil de M. A. Morin, pour déterminer les lois de frottement, par M. Clair.

22. Appareil pour mesurer le frottement, par Valtjen.

23. Appareil pour mesurer le frottement, avec injection d'air ou d'eau, construit par la Société Genevoise.

24. Ressort atmosphérique, de la force de 10 kil. et 0<sup>m</sup>.40 de course, par Audenelle.

25. Ressort atmosphérique; force 8 kil.; course, 0<sup>m</sup>.40, par Audenelle.

b. Appareils d'observation pour l'hydraulique, la pneumatique et les machines à vapeur.

1. Indicateur de la pression dans les cylindres des machines à vapeur, de Galy-Cazalat, par Saulnier.—<sup>a</sup>A e 33.

2. Indicateur dynamométrique de la pression dans les machines à vapeur, de Mac-Naught.—<sup>a</sup>A e. 34.

3. Indicateur totalisateur du travail des machines à vapeur, de Lapointe, par Paul Garner.—<sup>a</sup>A e. 35

4. Dynamomètre indicateur pour machines à vapeur, de Raymond.—<sup>a</sup>A e 36

5. Indicateur dynamométrique des pressions de vapeur, de Lapointe, par Paul Garner.—<sup>a</sup>A e. 37.

6. Indicateur de la pression, de Lapointe, par Clair —<sup>a</sup>A e. 37.

9. Module Milanais pour le jaugeage de la quantité d'eau que s'écoule dans un temps donné.—<sup>a</sup>Q. g 23.

10. Tube en fonte pour le jaugeage des cours d'eau, de Leptante, par M. Clair.

11. Petit compteur avec son moulinet, dans le tube précédent.

12. Compteur hydraulique pour le débit de l'eau.

13. Moulinet de Wolzmann pour la vitesse de l'eau

14. Tube de Pitot, en cuivre, pour mesurer la vitesse des cours d'eau.

15. Hydromètre de M. Michaud, à flotteur et à cadran, pour indiquer la hauteur des eaux.

16. Anémomètre de Bréguet, à ressort, pour mesurer la vitesse des courants d'air.

17. Anémomètre de M. Combes, à ailettes, pour mesurer la vitesse des courants d'air de petite vitesse.

18. Anémomètre de M. Combes, à ailettes fortes, pour mesurer la vitesse des courants d'air de grande vitesse.

19. Anémomètre de Régner, à plan et à ressort.

20. Anémomètre à pontage, par M. Bianchi.

21. Anémomètre à pontage, par M. Bianchi.

22. Anémomètre à pontage, par M. Bianchi.

23. Compteur à gaz de Crosley, à engrenages, marquant les nombres sur trois cadrans —<sup>a</sup>N. n. 32.

24. 25. Indicateurs de pression, pouvant tracer des courbes continues ou fermées, par M. Clair.

26. Compteur à gaz pour expériences, de MM. Scholefield, donné par l'auteur —<sup>a</sup>N b 46

27. Manomètre à cloche, pour le gaz, donné par MM. Scholefield.

28. Trois boules en bois pour l'observation de la vitesse des courants.

29. Anémomètre de M. Combes, à dimensions réduites et à débrayage, par M. Neumann.

30. Anémomètre à pontage, avec compteur jusqu'à 50,000 tours, par M. B. Bianchi.

31. Compteur à eau, par M. Donnet.

32. Anémomètre totalisateur de M. le général Morin, avec compteur jusqu'à un milliard de tours, par M. B. Bianchi.

33. Pompe pour déterminer l'état hygrométrique de la vapeur d'eau, de M. Treaca, par M. B. Bianchi.

34. Appareil de Farbaun, disposé par M. Treaca pour déterminer l'état hygrométrique de la vapeur d'eau, par M. B. Bianchi.

35. Anémomètre à pontage et compteurs jusqu'à 10,000 tours, par M B Bianchi

36. Anémomètre à pontage et compteur jusqu'à 10,000 tours, par M B Bianchi

37. Anémomètre à compteur différentiel, pouvant s'embrancher dans toutes les sens, par M A. Clair

38. Anémomètre totalisateur électrique, de M le général Morin, par M Hardy

39. Tube jaugeur de M Darcy, pour mesurer la vitesse des cours d'eau

40. Anémomètre à contact électrique de M. Derschau, donné par lui.

41. Anémomètre à contact électrique de M Derschau, donné par lui.

42. Compteur électrique pour les anémomètres précédents.

43. Enregistreur électrique pour les anémomètres précédents.

44. Anémomètre à axe horizontal et à contact électrique, par M. Hardy

45. Compteur à deux électro-aimants, pour anémomètre, de M le général Morin, par M Hardy.

46. Enregistreur pour l'anémomètre de M. le général Morin, par M Hardy

47. Anémomètre, système Combes, à manche, pouvant être disposé horizontalement et verticalement, par M. Hardy

48. Anémomètre à compteur différentiel, à moulinet hélicoïdal en aluminium, par M. Clair.

49. Compteur à eau de Siemens, donné par la Société d'Encouragement.

50. Indicateur de pression, système Richard, par MM. Elliot, frères & A. c. 97

51. Loch perpétuel, par Gould.

52. Indicateur de pression, avec pièces mobiles en aluminium et enveloppe de vapeur, de M Tresca, par M Clair.

The Conservatoire claims to exercise a most important influence upon the application of science to industry, by the following means —(1) By its collections of models, machines, and products (2) By instruction given within its walls on the application of science to industry and to the arts (3) By the various methods of experimentation which are at the service of the nation and of individuals free of charge. (4) By its library, which consists of between 20,000 and 30,000 volumes of works dealing with science and industry (5) By its almost unequalled portfolios of designs, which are open to the public, and may be freely copied (6) By its elementary school, which probably will some day be transformed into a special and higher school of arts applied to industry

The Great Amphitheatre of the Conservatoire can hold 700 persons, and the small one 360. These are often full to overflowing. In the Great Amphitheatre two lectures are given every week-day night — one at 7.30; the other at 8.45. I think I have already stated that more than a quarter of a million of persons, serious students, availed themselves of the instruction here gratuitously given during the course of last year.

I append a Programme of the Course for the Session 1873-74, and the Budget for the Conservatoire and its Subsidiary Schools.

#### COURS PUBLICS ET GRATUITS DE SCIENCES APPLIQUÉES AUX ARTS, 1873-74.

Ces Cours s'ouvriront, le Lundi 3 Novembre 1873, au Conservatoire des Arts et Métiers.

##### GÉOMÉTRIE APPLIQUÉE AUX ARTS.

Les Mercredis et Samedis, à sept heures et demie du soir.

M. LAUSSÉDAT, Professeur, ouvrira son Cours le Mercredi 5 Novembre.

OBJET DES LEÇONS.—Théorie des principales courbes employées dans le tracé et la construction des machines. Étude géométrique des organes qui servent à la transformation des mouvements. Engrenages; cames, excentriques. Articulations. Echapements. Enchéquetages. Compteurs. Instruments enregistreurs.

##### GÉOMÉTRIE DESCRIPTIVE.

Les Mercredis et Samedis, à huit heures et demie du soir.

M DE LA GOUBERNIE, Professeur, ouvrira son Cours le Mercredi 5 Novembre

OBJET DES LEÇONS.—Application de la Géométrie descriptive à la coupe des pierres et à la coupe des bois. Appareils des voûtes le plus ordinairement employées, des escaliers, des grandes arches basses. Combles et escaliers en charpente.

##### MÉCANIQUE APPLIQUÉE AUX ARTS.

Les Mardis et Vendredis, à sept heures et demie du soir.

M TRESCA, Professeur, ouvrira son Cours le Mardi 4 Novembre.

OBJET DES LEÇONS.—Examen général des progrès des arts mécaniques à l'exposition universelle de Vienne. Qualités et emplois des matériaux. Résistance et essais de matériaux. Machines motrices. Machines hydrauliques. Machines soufflantes. Machines-outils.

##### CONSTRUCTIONS CIVILES.

Les Mercredis et Samedis, à sept heures et demie du soir.

M E. TRÉLAT, Professeur, ouvrira son Cours le Samedi 15 Novembre

OBJET DES LEÇONS.—Soutiens verticaux. Soutiens horizontaux. Combles. Couvertures. Revêtements. Théorie et applications remarquables des éléments divers que le constructeur emploie dans les édifices.

##### PHYSIQUE APPLIQUÉE AUX ARTS.

Les Mardis et Vendredis, à huit heures trois quarts du soir.

M. E. BECQUEREL, Professeur, ouvrira son Cours le Vendredi 7 Novembre.

OBJET DES LEÇONS.—Principes fondamentaux de la physique. Applications diverses de la chaleur; formation des vapeurs; emploi de leur force élastique; sources de chaleur et de froid; chauffage, ventilation. Production et propagation des sons. Sources de lumière; éclairage; analyse spectrale. Construction des instruments d'optique.

##### CHIMIE GÉNÉRALE DANS SES RAPPORTS AVEC L'INDUSTRIE.

Les Lundis et Jedis, à huit heures trois quarts du soir.  
M. E. PELIGOT, Professeur, ouvrira son Cours le Jeudi 6 Novembre.

OBJET DES LEÇONS.—Première partie du Cours: Phénomènes généraux de combinaison et de décomposition. Nomenclature et notation chimiques. Histoire détaillée des corps simples non métalliques et de leurs principales combinaisons. Air atmosphérique. Eau. Acides minéraux. Ammoniaque.

##### CHIMIE INDUSTRIELLE.

Les Mercredis et Samedis, à huit heures trois quarts du soir.

M A. GIRARD, Professeur, ouvrira son Cours le Mercredi 5 Novembre.

OBJET DES LEÇONS.—Fannes et panification; pâtes alimentaires, amidons et féculs. Sures de betteraves, de cannes, etc.; glucozes et dextrine. Vins, bières et alcools. Huiles et graisses; bougies et savons.

##### CHIMIE APPLIQUÉE AUX INDUSTRIES DE LA TEINTURE, DE LA CÉRAMIQUE ET DE LA VERRE.

Les Lundis et Jedis, à sept heures et demie du soir.  
M. DE LUYNES, Professeur, ouvrira son Cours le Lundi 3 Novembre.

OBJET DES LEÇONS.—De verres. Matières premières employées. Trempe, recuit. Dévitrification. Fours. Fabrication des poteries. Préparation et travail des pâtes céramiques. Faïences. Porcelaine. Grès. Couleurs vitrifiables. Émaux. Décoration des verres et des poteries.

##### CHIMIE AGRICOLE ET ANALYSE CHIMIQUE.

Les Mercredis, à huit heures et demie du soir, et les Dimanches, à dix heures et demie.

M BOUSSINGAULT, Professeur, ouvrira son Cours le Mercredi, 12 Novembre.

En cas d'empêchement M. Boussingault sera remplacé par M. SCHLESING.

OBJET DES LEÇONS.—Phénomènes généraux de la végétation. Géologie agricole. Origine et constitution de la terre végétale. Fumier, engrais auxiliaires. Statique des cultures. Eudométrie; applications à l'étude de l'atmosphère. Démonstration des procédés de l'analyse minérale.

Les leçons de chimie agricole auront lieu les Mercredis; les démonstrations de l'analyse, les Dimanches, à dix heures et demie du matin.

##### AGRICULTURE.

Les Mardis et Vendredis, à sept heures et demie du soir.  
M. MOLL, Professeur, ouvrira son Cours le Mardi 4 Novembre.

OBJET DES LEÇONS.—Éléments constitutifs de l'entreprise agricole; l'Exploitant; connaissances et aptitudes nécessaires. La Terre; faculté productive; compo-

sition du domaine, régime, fermage, métayage. Le Capital foncier et mobilier; consommation et reproduction. L'Engrais; prix de revient; engrais commerciaux. Le Travail de l'homme, des animaux, des moteurs.

#### TRAVAUX AGRICOLES ET GÉNIE RURAL.

Les Mercredis et Samedis, à sept heures et demie du soir.  
M. H. MANGON, Professeur, ouvrira son cours le Mercredi 5 Novembre.

OBJET DES LEÇONS.—Moteurs employés en agriculture. Travail mécanique et alimentation des moteurs animés. Travaux d'extérieur, labouages, semailles; cultures; récoltes. De l'eau en agriculture, irrigations; dessèchements, drainage.

#### FILATURE ET TISSAGE.

Les Lundis et Jendis, à huit heures trois quarts du soir.  
M. ALCAN, Professeur, ouvrira son Cours le Lundi 3 Novembre.

OBJET DES LEÇONS.—Aperçu général sur les arts textiles, origines, caractères, propriétés, épuration et préparation des matières premières. Filature, retordage et apprêts des fils de coton, lin, chanvre, jute, chana-grass, laine, poil de chèvre, alpaga, soie, bourres et déchets, caoutchouc, etc.

#### ÉCONOMIE POLITIQUE ET LÉGISLATION INDUSTRIELLE.

Les Lundis et Jendis, à sept heures et demie du soir.  
M. WOLOWAKI, Professeur, sera remplacé par M. E. LEVASSUR.

L'ouverture de ce Cours aura lieu le Lundi 3 Novembre.

OBJET DES LEÇONS.—Consommation de la richesse. Exposition de Vienne; enseignements économiques qu'on en peut tirer. Consommation reproductive et improductive. Conservation des richesses. Assurances. Histoire du luxe. Rôle économique de l'État. Impôts directs et indirects. Liberté commerciale. Population; conditions générales de son accroissement et de son bien être.

#### ÉCONOMIE INDUSTRIELLE ET STATISTIQUE.

Les Mardis et Vendredis, à huit heures trois quarts du soir.  
M. J. BURAT, Professeur, ouvrira son Cours le Mardi 4 Novembre.

OBJET DES LEÇONS.—Notions générales de géographie physique et commerciale. Statistique raisonnée des industries agricole, minière, et manufacturière. Revue économique des principaux produits de ces industries, envisagés aux divers points de vue de la production, du commerce, et de la consommation.

Le Général de division, Directeur du Conservatoire des Arts et Métiers,  
A. MORIN.

TABLEAU DES JOURS ET HEURES DES COURS.

Amphithéâtre.	Dimanche.		Lundi.		Mardi.		Mercredi.		Jeudi.		Vendredi.		Samedi.	
	Petit.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.	M.M. heures.
							Laussedat - 7 ½ s. De la Gournerie - 8 ½ s.							Laussedat - 7 ½ s. De la Gournerie - 8 ½ s.
			De Laynes - 7 ½ s. Alcan - 8 ½ s.		Moll - 7 ½ s. Burat - 8 ½ s.		Mangon - 7 ½ s. Boussemguait - 8 ½ s.		De Laynes - 7 ½ s. Alcan - 8 ½ s.		Moll - 7 ½ s. Burat - 8 ½ s.		Mangon - 7 ½ s.	
			Wolowski - 7 ½ s. Foligot - 8 ½ s.		Tresca - 7 ½ s. Bocquard - 8 ½ s.		Trélat - 7 ½ s. Girard - 8 ½ s.		Wolowski - 7 ½ s. Foligot - 8 ½ s.		Tresca - 7 ½ s. Bocquard - 8 ½ s.		Trélat - 7 ½ s. Girard - 8 ½ s.	

#### BUDGET for the CONSERVATOIRE et ÉCOLES D'ARTS et MÉTIERS for 1873.

##### CONSERVATOIRE.

	Nombre de fonctionnaires et agents.	Taux du Traitement.	Sommes.	Accordés pour l'exercice, 1873.
<b>PERSONNEL.</b>				
Administration	82	De 1,100 à 10,000fr.	194,000fr.	
Enseignement	29	De 1,200 à 7,500		
<b>MATÉRIEL.</b>				
Achats de modèles, dessins de machines, entretien de galeries, frais de cours, dépenses administratives et diverses	—	—	100,000	294,000fr.

##### ÉCOLES D'ARTS ET MÉTIERS.

##### 1. Dépenses spéciales à chacune des trois Écoles.

	Châlons.	Angers.	Aix.
<b>PERSONNEL :</b>			
Administration - 43 fonctionnaires et agents de 600fr à 8,500 fr.	144,000 fr.	185,000 fr.	180,000fr.
Enseignement - 96 de 600fr à 4,500fr			
<b>MATÉRIEL :</b>			
Nourriture et infirmerie	90,600	95,000	110,500
Trousseaux, entretien, et renouvellement	26,500	32,000	35,100
Masse de petit équipement, chaussure	11,100	18,000	11,300
Chauffage et éclairage	15,800	15,500	15,700
Dépenses administratives, mobilier, blanchissages, chapelle, bibliothèque, fournitures de bureau, frais d'études, médailles, prix, etc.	17,900	14,600	10,600
Entretien des bâtiments	22,000	18,000	16,000
Matériel, main-d'œuvre, achat de matières premières	47,650	46,570	24,700
<b>Totaux</b>	<b>374,050</b>	<b>369,670</b>	<b>353,900</b>

1,097,600fr.

##### 2. Dépenses communes aux trois Écoles.

Examens et inspections	17,000fr.
<b>Totaux</b>	<b>1,408,600fr</b>

#### LONDON :

Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,

Printers to the Queen's most Excellent Majesty.

(For Her Majesty's Stationery Office.)

V122

# FIFTH REPORT

OF THE

ROYAL COMMISSION

ON



SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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Presented to both Houses of Parliament by Command of Her Majesty.

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LONDON:

PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,  
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1874.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right, Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

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# FIFTH REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty, in continuation of our former Reports, the following Report on certain Institutions of recent voluntary origin and mainly dependent on voluntary support, which have made arrangements for Advanced Instruction in Science.

The Institutions of this description to which our attention has been directed, and with regard to which we have taken Evidence, are the following :—

- I. The Two Metropolitan Colleges, viz. :—  
University College.  
King's College.
- II. The Owens College, Manchester.
- III. The College of Physical Science, Newcastle-upon-Tyne.
- IV. The Catholic University of Ireland.

## I.—THE TWO METROPOLITAN COLLEGES.

### UNIVERSITY COLLEGE, LONDON.

1. The history of this Institution, as briefly stated in its Calendar, is as follows :— It was founded in the year 1826, and opened on the 1st of October 1828, under the title of The University of London. It was incorporated as University College, London, by a Royal Charter dated the 28th of November 1836, which was annulled by an Act of Parliament passed on the 24th of June 1869, whereby the College was re-incorporated with additional powers and divested of its proprietary character. The purpose of the College, as expressed in the Act, is “to afford, at a moderate expense, the means of education in Literature, Science, and the Fine Arts, and in the knowledge required for admission to the Medical and Legal Professions, and in particular for so affording the means of obtaining the education required for the purpose of taking the degrees now or hereafter granted by the University of London.” See App. F.

2. The College was in the first instance constituted as a joint stock company, and the original deed of settlement provided for a dividend not exceeding 4 per cent. on the share capital. But, as a matter of fact, no dividend was ever paid, the expenditure of the College having from the very first absorbed the whole of the receipts from that portion of the fees paid by the students which was applicable to the purposes of a dividend. The title of “The University of London,” which was at first assumed by the Institution, did not carry with it any of the privileges of an University, or the power of granting degrees. On the 26th of March 1835 the House of Commons adopted by a large majority an address to the Crown, praying that a Charter of Incorporation might be granted to “the University of London,” containing the power of conferring degrees, other than degrees in Medicine and Divinity. Instead of giving this power, the Government determined to found a new Institution, the present University of London; and it was proposed to the College, or University of London, as it was then called, that it should give up its title in favour of the new Institution then about to be founded, and should take instead the title of “University College, London.” This proposal the Council recommended the proprietors to accept, and it was accordingly accepted by them. It was one of the conditions of the agreement between the College and the Government, when the original title was given up, that the Institution should be incorporated by a Royal Charter. It would seem that it was intended that this Charter should extinguish the pecuniary rights of the proprietors. These rights were, however, not formally cancelled, and provision was made for the transference of the shares; although all reference to any pecuniary advantage to be derived from the possession of the shares was left out of the Charter. At a subsequent period doubts were entertained as to whether the Charter had so effectually extinguished the proprietary rights as to prevent them from becoming inconvenient at some future time; and the College, with the Qu. 7132.

unanimous approval of the proprietors at a General Meeting, determined to apply, and did unsuccessfully apply, for a private Act of Parliament to settle the question. The main object of the University College Act of 1869 was to secure the extinction of the proprietary rights, but at the same time the powers of the Institution were enlarged in several directions. It then obtained the power, which it had not before, of instructing women as well as men in the College, and also of giving instruction in the Fine Arts. The Act also gives the College a licence of mortmain up to a rackrent value of 10,000*l.* per annum, exclusive of its freehold site in London.

3. By the provisions of the University College Act the government of the College is intrusted to a Council elected by a General Meeting of its members. The Members of the College consist, first of the Governors, secondly of the Fellows, and thirdly of the Life Governors. The Governors represent the registered proprietors of the shares in the College, as it was constituted under the Royal Charter; and, although all their pecuniary rights have been abolished, the right of proprietorship is still so far preserved that every Governor has the privilege of nominating by writing under his hand some person, subject to the approval of the Council, to replace him in his lifetime, or to succeed him after his death as Governor. No such power of transmission is given to the Fellows or to the Life Governors. The Fellows are former or actual Students of the College, nominated by the Council, and admitted by a General Meeting of the Members. The Life Governors are similarly nominated, either by the Council, or by twenty members of the College, and are admitted by a general meeting. They are not, however, necessarily former students of the College, but must be persons having special claims to the distinction, which special claims the Council, or the nominators, are required to state in writing at the time when the nomination is made. The Council consists of a President, Vice-President, Treasurer, and not more than twenty-one or less than sixteen other members, to be elected at a general meeting, but of the members of the College. Six of the members of the Council retire every year, but are re-eligible.

UNIVERSITY  
COLLEGE  
ACT.

4. The powers of the Council are very wide; it has "the sole and entire management and superintendence of the College, as well relating to the income and funds thereof as to the teaching of the various branches of literature, science, and art therein, and the appointment, suspension, and dismissal of professors, lecturers, and teachers, and all other the affairs and concerns thereof." The Council also has the government of the Hospital, which has been established in connexion with the College, and the control of its funds. The power of making byelaws, however, rests with the General Meeting of the Members.

5. The byelaws at present in force provide that no professor or holder of any other place of emolument in the College or Hospital shall hold the office of President, Vice-President, Treasurer, member of the Council, or Auditor, without vacating his professorship or other place of emolument. The effect of this byelaw is to exclude the professors, individually as well as collectively, from any direct share in the government of the College; but at the same time by another byelaw the professorial body is constituted into a Senate, which possesses no powers under the Act of Parliament, and which occupies with regard to the Council the position of a purely consultative body. The Senate is empowered to make suggestions to the Council with regard to the general management of the College, and especially of the libraries and the museum. Further, whenever a professorship or lectureship is vacant, the Council is required by the byelaws to communicate to the Senate the names of all the candidates, with their testimonials; or, if an advertisement has been dispensed with, the name and testimonials, if any, of any person whose appointment is under consideration. The Senate report their opinion, with their reasons, to the Council, and no appointment to a permanent professorship is to be made by the Council until either a report has been made to the Council, or until the time appointed for making it has expired. Similarly, the powers of the Council in removing any professor, lecturer, or teacher, are limited by the requirement that the Council should previously send to the Senate a written statement of the grounds on which his removal is proposed, and should request the opinion of the Senate thereupon. This scheme of government possesses several obvious advantages, and has been found in practice to work very well. The Council naturally attaches great weight to the opinion of the Senate on any academic question; and the Professors thus exercise a very substantial, though indirect, control over the management of the College as a place of education, while at the same time they are relieved from the duty of attending to the details of its financial business.

App. XIII, Vol. L, p. 42. 6. The expenditure of the College on Capital account up to the year 1870, amounted to 202,287*l.*, and was incurred as shown in the following statement :

Freehold land	30,000
Buildings and furniture	125,070
Books	4,425
Anatomical and Materia Medica Museums	6,153
Chemical, Physical, and Physiological Apparatus	4,336
Museum of Comparative Anatomy and Zoology	602
Birkbeck Laboratory of Chemistry	3,128
Expenditure on maintenance in addition to the College share of fees	18,393
Amount paid to Professors in augmentation of fees, and for annuities and pensions	10,180

7. The whole of this expenditure has been defrayed out of the original share capital of the College, and out of the sums that have been either given or bequeathed to it for general purposes from time to time. A portion of these expenses, viz., the items of 18,393*l.* for expenditure beyond the College share of fees, and 10,180*l.* paid to professors in augmentation of fees and for annuities and pensions, were not properly chargeable against the capital of the College, as they represent ordinary expenditure, which ought to have been defrayed out of the annual revenue; but the Council considered themselves justified, and no doubt were justified, in trenching upon the capital of the College for the purpose of maintaining its efficiency. In addition to the capital sum which has been expended as shown above, there are endowments arising out of various bequests which produced, in 1870, an annual income of 2,978*l.* Of this income 2,276*l.* is appropriated to special purposes. No assistance has ever been received from any Government grant.

Qu. 7132.

Vol. I.  
App. XIII,  
p. 42.

8. A school into which boys are admitted at any age between seven and fifteen has been established in connexion with University College. It forms a distinct branch of the College, and its pupils are entirely separated from the students. The Head Master is appointed and is removable in the same manner in all respects as a Professor of the College, and is subject to the control and regulations of the Council. The numbers of the school during the last few years have rapidly augmented, and the instruction in Mathematics and in some branches of Natural Science has received a very considerable development. The connexion with the School is of unquestionable advantage to the College, as a large and increasing proportion of well-prepared pupils pass from the former to the latter. The establishment of the School must originally have involved a large outlay; but during the last few years the College, in a financial point of view, has not been a loser but a gainer to a slight extent by the maintenance of the School. We are informed that the financial relations between the two branches of the Institution have "recently been carefully investigated by the School Committee of the Council, and it has thus been ascertained that for the last five years—the most prosperous in the history of the School—the net amount received from the School by the College for its general purposes has been only an average of 982*l.* 6*s.* 8*d.* per annum. But even this is subject to a large deduction for *rents*, which may be moderately estimated at 750*l.* a year for the south wing, and of 150*l.* for the portion of the main building still occupied by the School. Thus the actual profit derived from the School is reduced to about 100*l.* a year.

Appendix I.

9. There are three Faculties in University College:—(1) of Arts and Laws, (2) of Science, (3) of Medicine. There is also a Department of Civil and Mechanical Engineering.

10. The number of Professorships in the first two Faculties is thirty-one. Of these the scientific chairs are the eleven following:—(1) a Professorship of Mathematics, (2) of Applied Mathematics and Mechanics, (3) and (4) of Chemistry and Applied Chemistry (these two chairs being at present held by the same professor), (5) of Physics, (6) of Engineering, (7) of Zoology, (8) of Botany, (9) of Geology and Mineralogy, (10) of Physiology, (11) of Practical Physiology and Histology. There is, besides, a Professorship of Architecture and Construction. Of these eleven professorships, one only is endowed, Mr. T. J. Phillips Jodrell having lately presented to the College the sum of 7,500*l.* for a permanent endowment of the Chair of Physiology. Mr. Jodrell's object in founding this endowment, as stated in the deed of foundation, was to "promote, the study of Human Physiology in University College, London, and especially to encourage original research in combination with professorial teaching," and "to ensure such a provision for the professorship as shall induce men of eminence and ability, who may be willing to cultivate science for its own sake, to forego more lucrative sources of emolument, and to undertake the office on the condition of devoting to original research, either in connexion with this professorship, or any other work of a kindred nature which shall be essential and auxiliary to such research, all the time that can be

"spared from the work of a lecture room." The report of the Council on February the 25th, 1874, states that Mr. Jodrell has signified his intention of presenting the College with a further sum of 500*l.* to be applied, under the direction of the Jodrell Professor of Human Physiology, in the purchase exclusively of such additional apparatus as may be required for the effectual prosecution of original research, and that this sum will be paid over to the College as soon as provision has been made for the reception of the apparatus, arrangements for making which provision are now in progress. With the exception of this recent benefaction, the College can hardly be said to possess any endowment whatever the revenue of which is properly applicable to the support of its Scientific Faculty. The Professor of Geology, however, receives 31*l.* per annum from the Goldsmid Fund.

11. The courses of study, as indicated in the programmes of the professorial lectures, appear to be carefully arranged with a view to the requirements both of elementary and of advanced students. Great importance is attached to the laboratory instruction in Physics, Chemistry, and Physiology.

12. The College has but few Scholarships or Exhibitions, and of these none are appropriated exclusively to scientific subjects.

13. The College possesses a valuable Library, consisting of upwards of 68,000 volumes and 16,000 pamphlets, a great part of which has been derived from gifts and bequests. Within the last few years the libraries of Mr. James Morris and of Mr. J. T. Graves, the latter containing a splendid collection of works on Mathematics, Physics, and Astronomy, have been bequeathed to the College.

14. The Report of the Council already referred to states that during the Session of 1873-74 the number of pupils was 1542; of these 893 were Students in the College, and 649 Pupils in the School. Of the Students, 322 belonged to the Faculty of Medicine. In the Faculties of Arts and Laws and of Science there were 571. The fees received, exclusive of those for clinical instruction, amounted to 24,266*l.* 10*s.* 6*d.*, this sum consisting of the following items:—

	£	s.	d.
Fees for attendance on the Classes of the Faculty of Medicine	-	6,112	11 6
Fees for attendance on the Classes of the Faculties of Arts and			
Laws and of Science	-	7,053	18 0
School fees	-	11,100	1 0

15. The total payments out of these fees to the professors, teachers, and masters amounted to 16,904*l.* 8*s.* 6*d.*, leaving 7,362*l.* 2*s.* for the College share of fees.

16. In addition to the above-stated amount of fees, the sum of 2,010*l.* 7*s.* 0*d.* was received for clinical instruction in the Hospital, but these fees, as has always been the practice in this hospital, were devoted to the support of the hospital. The preamble of the University College Act recites that in the year 1832 the College appropriated "a certain portion of its land for the erection thereon of a Hospital in connexion with the Medical School of the College, and the Council obtained subscriptions from the proprietors of the College and others, whereby the North London or University College Hospital was erected on the said land, and the said hospital has since been supported by annual subscriptions, and by donations and bequests, and also by means of the fees of students of the College attending the hospital, which fees have for that purpose been relinquished by the medical officers of the hospital appointed by the Council; and the government of the hospital and of its funds since its foundation has been in the hands of the Council, who have from time to time made and altered the rules for the management thereof; and the College is now possessed of considerable investments for the benefit of the hospital." It may be added that in 1838 the College gave 500*l.* as a contribution towards building one of the wings of the Hospital. As to the present financial relations of the Hospital to the College, the Secretary, Mr. Robson, states that—

App. I.

"The College discharges gratuitously all the duties of Trustee for the hospital; it manages the investments of the hospital funds, conducts the correspondence connected therewith; acts as the guardian of the legal rights of the charity, and in various other ways carries on what may be called its external affairs, defraying out of its own funds the expenses incidental to its connexion with the hospital. Besides this, it pays each of the two Holme Professors, one of Clinical Medicine, the other of Clinical Surgery, a stipend of 100*l.* per annum, out of the income of the Holme Fund, which was bequeathed to the College for the purposes of its Medical Department. The duties of these Professors are discharged wholly within the hospital, which derives an important part of its income from the fees paid by the students for hospital practice and clinical instruction."

17. The evidence which has been laid before us clearly shows that the usefulness of

the College is greatly restricted by the insufficiency of its funds. The difficulty is felt in two respects principally; first, in providing adequate payment for the professors and their assistants, and, secondly, in providing laboratory accommodation upon a sufficient scale, together with the proper appliances for instruction and research.

18. The following are schedules of the payments received by the Professors in the session of 1872-73, and of the lectures and other instruction given by them, in each academical year:

## SCHEDULE OF PAYMENTS.

Subject	Share of Fees.	Endowment.	Total.	Remarks.
1. Mathematics	£ 370	—	£ 370	The Professor pays about 50 <i>l.</i> to an assistant
2. Applied Mathematics	123	200	323	The endowment is guaranteed by the Treasurer of the College for 5 years, of which 2 are unexpired.
3. Physics	252	—	252	—
4. Chemistry	1,484	—	1,484	This is subject to a deduction of between 400 <i>l.</i> and 500 <i>l.</i> for payment of assistants and other expenses.
5. Geology and Mineralogy	55	31	86	—
6. Botany	184	—	184	—
7. Comparative Anatomy and Zoology.	104	100	204	—
8. Physiology	468	—	468	—
9. Practical Physiology	368	—	368	The Professor has to pay an assistant.
10. Engineering	102	—	102	—

## SCHEDULE OF LECTURES.

Subjects.	Lectures per Week	Lectures per Session.	Remarks
1. Pure Mathematics { Lectures - Exercise Classes -	9 6	(about) 300 200	
2. Applied Mathematics -	9	300	
3. Physics { Lectures - Exercise Classes - Laboratory -	6 4 Daily from 10 to 5.	200 130	The Professor is more or less occupied daily in superintending the students, but no estimate of the time thus occupied can be given.
4. Chemistry { Lectures - Practical Chemistry Exercise Classes - Laboratory Work	5 (6 months). 8 (3 months). 4 (6 months). Daily from 10 to 4.	240 100	The Professor is usually engaged at the College the whole day. The above remark as to the Physical Laboratory applies to this Laboratory also.
5. Geology and Mineralogy -	2 (7 months).	60	The Professor is also occupied in the Museum of Geology, and in excursions with the students.
6. Botany -	5 (3 months).	60	
7. Comparative Anatomy and Zoology.	5 (9 months).	200	
8. Physiology -	5 (6 months).	150	
9. Practical Physiology and Histology { Lectures - Laboratory Work	7 Daily from 9 to 4 throughout Session.	180	The Professor is more or less occupied daily in superintending the students.
10. Engineering with Engineering Drawing.	13	420	

19. It will be seen from the above schedules that the Professorships, with perhaps one exception, are very inadequately remunerated.
20. The emoluments of the Professors, excepting as shown in the first schedule, are derived from a share of the gross fees paid by the students, which are divided between the College and the Professors according to a sliding scale, so arranged that in the case of the larger classes the College receives one third of the fees. In the opinion of the Secretary, "the large deductions from the fees which the College is obliged to make in order to provide for the current expenses of the institution, have a twofold injurious effect. They materially diminish the remuneration of the professors, and so far tend to deprive the College of the services of able men, and by rendering it necessary to charge fees higher than might otherwise be requisite, they must have the indirect effect of keeping down the number of our students. The result is that our Professors as a rule are very inadequately paid." The natural consequence of the inadequacy of the professorial stipends is, that in many cases the College has found it impossible to retain the services of some of its most distinguished Professors. Some striking instances of very recent occurrence, which show the disadvantage at which the College is placed in this respect, are mentioned in the evidence.
21. With regard to the second point, it is stated that the resources of the College have been quite inadequate to provide suitable and sufficient laboratories, apparatus, and assistance for the practical departments of experimental science. The laboratories have recently been extended and improved; but in order to provide for all the requirements of the professors, they would need to be much larger than they now are, and to be better supplied with fittings and apparatus. With especial reference to the Physical Laboratory, it is stated by Mr. Robson that, "when the present Professor of Physics was elected he pointed out to the Council the importance of having the means of giving practical instruction in the various subjects which he had to teach, and the Council complied with his suggestions as far as they had the means of doing so. Those means were so limited that they were sufficient merely to fit up one of the ordinary rooms as a physical laboratory, and to add a considerable quantity of modern apparatus to the stock which we previously had. The professor went over that stock very carefully, and drew up a long catalogue of the apparatus which he considered indispensable for carrying on his work, and the Council gave him what he said was absolutely necessary at once, but were compelled to withhold a large portion of what he wanted and which he said would be extremely useful." The Professor himself considers that his department is still to a great extent in want of apparatus, as well as of more suitable rooms.
22. The Chemical Laboratory, which is known by the name of the Birkbeck Laboratory, was not provided wholly out of the funds of the College. About a third part of the sum which was expended on it was obtained from subscriptions raised by a number of Mechanics' Institutions in various parts of the country in honour of the man who first suggested their foundation. With regard to this laboratory, Professor Williamson states: "The public laboratory which is attended by the students is supplied by the College with the stock apparatus, which is kept up partially by a moderate sum which is spent every year in renewing and repairing the apparatus. The Council are very considerate in the matter. I believe they have never refused any thing in that way which I have asked for; but I conceive that that is only due to the fact that my requests have been exceedingly moderate, because I knew that I should very soon get to the limit of their power of supplying them. I do not remember a case of their declining to give me anything I asked for . . . . . As to the extent of the laboratories, there are important wants for operations of greater nicety, but the general accommodation is not unsatisfactory." The important wants referred to are rooms "for gas analyses, and for operations requiring high temperatures and requiring furnaces; the accommodation for such purposes being at present scanty." Professor Williamson adds: "The first thing I should wish to do, if I had had the command of more money for the purpose, would be to get better illustrations for my lectures and better apparatus for the laboratory. I should also use available money for apparatus and materials, and for assistants in original research, and that is the bigger item of the two." The working space in the Birkbeck Laboratory is stated to be only sufficient to accommodate twenty-four students, and this number is accommodated only by allowing less space to each student than in laboratories of more recent foundation, such as that at Bonn, for example.

23. Proposals for the extension of the College buildings appear at various times to have come under the consideration of the Council, but no definite action has been taken with regard to them. Mr. Robson believes:—

"That if the Council had the necessary funds at their disposal, they would take steps to complete the two wings, already partly erected, and thus carry out the original design of the College, so far as its extent is concerned. Judging from estimates made at various times by our architect, I conclude that the cost of the work in question would be upwards of 40,000*l.*" App. p. 1.

"Among the uses to which the additional buildings could advantageously be put, I may mention, in the first place, laboratories for Practical Physics, and for original physical research; next, workshops attached to the Class of Engineering; accommodation of this kind has been greatly needed for several years past, and the want of it, there is good reason to believe, has been a serious obstacle to the full development of both the departments of the College affected by it.

"Greater space could be beneficially devoted to providing more extensive and complete accommodation for the teachers and the students engaged in the classes of Chemistry and of Practical Physiology.

"Laboratories for original chemical research, and for the practical applications of chemistry, would also require much space as well as expensive fittings and apparatus.

"The whole of the south wing, when completed, would probably be required for the use of the School, if, as there is every reason to expect, the number of its pupils should go on increasing for the next few years, as it has continuously for the past six or seven years. A large portion of the wing last built, which was finished in September 1873, having been assigned to the classes of Practical Chemistry and of Physics, to which subjects great attention is paid in the school, it is found that less accommodation than had been anticipated is available for ordinary classes, so that the school is already again cramped for space."

#### KING'S COLLEGE, LONDON.

24. King's College was founded by Royal Charter in the year 1284, "for the teaching of various branches of Literature and Science, and also the doctrines and duties of Christianity as the same are inculcated by the United Church of England and Ireland." See App. II.

The College was erected, on a site granted by the Crown, with money raised, partly by shares and partly by donations, there being no grant whatever from the Government towards the erection of the building. It is stated in a document issued by the Council of King's College in 1871, that "a number of its original promoters, both donors and shareholders, withdrew their support at the last moment in consequence of certain political differences with which the College itself was entirely unconnected, leaving 12,000*l.* of shares forfeited, besides promised donations, of which the amount cannot now be ascertained, but it is believed to have been at least 3,000*l.*" The debt thus involved in the building of the College has been in regular course of liquidation by a sinking fund which is rigorously kept up. On the other hand, new buildings have been needed, and consequent debt has from time to time been incurred in order to meet the requirements of efficient teaching, and especially, the increased demands of Physical Science, for which more accommodation is still urgently needed."

Calendar  
1873-4,  
p. 62.

25. The proprietary rights of the original shareholders and of donors have never been entirely extinguished, although they appear to be limited in point of fact to the right of nominating pupils to the School or to the College at a slightly reduced fee, and even this right is but seldom exercised. The proprietors are precluded by a provision in the Charter from receiving more than four per cent. per annum upon the amount of their shares; but as there has never been any divisible surplus they have received no dividend whatever.

The pro-  
prietors.

26. The official title of the Corporation is "The Governors and Proprietors of King's College, London." Its government is vested in a Council, which reports annually to the Court of Governors and Proprietors. The Council consists altogether of forty-two members, nine of whom are the official Governors; one is the Treasurer; eight are life Governors; and the other twenty-four, of whom six go out every year, are elected by the Court of Proprietors from a list prepared by the Governors, and containing twice as many names as there are vacancies. The Official Governors are the Lord Chancellor, the Archbishop of York, the Bishop of London, the Chief Justice of England, the Secretary of State for the Home Department, the Speaker of the House of Commons, the Lord Mayor of London, and the Deans of St. Paul's and Westminster. The Life Governors are appointed, as vacancies occur, by the Archbishop of Canterbury, who is the Visitor of the College. The elected members of the Council must be members of the Corporation; and it is further provided in the Charter that "no person who is not a member of the United Church of England and Ireland, as by law established, shall be competent to act as Governor by virtue of his office, or to be nominated or act as Life Governor, or be eligible as a member of the Council, or to fill any office in the College, except only the Professorships of Oriental Literature and Modern Languages." The Council has "full power, from time to time, to appoint, and, as they shall see

“ occasion, to remove, as well the Principal, or other head, the Professors, Tutors, and Masters, as also the Secretary and all officers, agents, and servants of the said “ College.” It has also the entire management of and superintendence over the affairs, concerns, and property of the College, and in all cases not provided for by the Charter, it is empowered to act in such manner as it may deem best calculated to promote the welfare of the College. It may further make, and vary any byelaws and regulations, touching the government of the College, the appointment and removal, number and rank, powers and duties, stipends and emoluments, of the several persons employed, and the terms and conditions upon which students shall be admitted. The appointment, or dismissal, of the Principal and of the Head Master must be confirmed by the Governors; and their consent is also requisite for the validity of any “ fundamental regulation ” affecting the discipline and course of education in the College.

27. The following is a statement of the expenditure of the Capital funds of the College from its foundation to the present time :

	£	s.	d.
Freehold lands, exclusive of sites granted by the Crown	-	-	16,448 0 0
College and School buildings and fittings	-	-	146,899 0 0
Fittings for museums and laboratories	-	-	5,738 0 0
Cost of books for general and medical libraries	-	-	5,296 11 5
Cost of museum and laboratory apparatus	-	-	6,089 14 4

28. The College possesses no Endowment applicable to General Purposes (other than the buildings, &c., upon which its capital has been expended) There are, however, endowments amounting in all to about 21,500*l.*, and producing an annual income of about 880*l.*, which are specially appropriated to certain prizes, scholarships, and professorships, none of which are scientific. In fact the whole of the expenditure required for the ordinary every-day work of the College has to be defrayed out of the fees paid by the students.

29. The general education of the College is carried on in six distinct Departments, (1) the Theological Department; (2) the Department of General Literature and Science (of this there are three divisions, the Classical, the Modern Division, and the Oriental; (3) the Department of the Applied Sciences; (4) the Medical Department; (5) the Evening Classes; and (6) the School. The whole of the arrangements of the College are under the supervision of a Principal, for whom a house is provided in the College building. The management of the School is left to a great extent in the hands of the Head Master, subject to consultation with the Principal.

30. The Students are divided into two classes, the Matriculated and the Occasional students. The Matriculated Students are those admitted to the regular and full prescribed course of study. The Occasional Students are those who, being unable to attend the whole course, are desirous of pursuing any particular subject. The Matriculated Students are expected to attend the daily service in chapel, unless specially exempted by the Principal. An exemption is allowed in all cases of conscientious objection. As, however, no register is kept of the attendances, the exemptions are not often applied for. Divinity Lectures form a part of the regular course in all the Departments, but exemptions from attendance at these lectures are likewise readily granted. As has been stated above, the Charter requires that the Professors should be members of the Church of England. No very stringent test, however, is applied in practice. In reply to the question, “ What is the nature of the declaration of conformity ? ” the Principal states that the candidate does not sign any declaration whatever, but simply says, I am a member of the Church of England.

Qu. 7084,  
7085.

31. The Scientific Professorships in the Department of General Literature and Science are (1) a Professorship of Mathematics, the Professor having the assistance of three lecturers; (2) of Natural Philosophy; (3) of Chemistry; (4) of Mineralogy; (5) of Geology (the Professor of Geology has also the assistance of a lecturer); in addition to these there are in the Department of Applied Science, Professorships (6) of the Arts of Construction; (7) of Manufacturing Art and Machinery; (8) of Surveying and Levelling; (9) of Drawing (Geometrical, Engineering, and Freehand); and, in the Medical Department, Professorships (10) of Botany; (11) of Comparative Anatomy; (12) and (13) of Physiology and Practical Physiology, the last two being held by the same Professor. The Professor of Natural Philosophy has one Demonstrator, and the Professor of Chemistry two; there is also a Lecturer in Photography. A schedule is annexed of the stipends received by the Scientific Teaching Staff, not including the payments for the Evening Classes (which, however, are very small in amount) in the year 1873 :—



Subject.	Stipend of Professors.	Number of Lecturers and Demonstrators.	Aggregate Stipend of Lecturers and Demonstrators.	
			£	s. d.
Mathematics - - - -	466 8 6	3	545	8 6
Natural Philosophy - - - -	424 12 5	1	132	3 4
Chemistry - - - -	604 17 0	2	337	3 4
Practical Chemistry				
Mineralogy - - - -	65 0 3	—	—	—
Geology - - - -	78 4 3	1	31	18 9
Botany - - - -	134 8 10	—	—	—
Comparative Anatomy - - - -	50 0 0	—	—	—
Physiology - - - -	278 14 10	1	100	0 0
Arts of Construction - - - -	100 5 5	—	—	—
Manufacturing Art - - - -	180 1 6	—	—	—
Surveying - - - -	187 19 0	—	—	—
Drawing - - - -	190 17 4	1	26	15 0

This schedule shows that, as in the case of University College, the teaching staff is very inadequately paid.

32. Great attention is paid at King's College to the Department of Applied Science, which is intended chiefly, but not exclusively, for engineering students, and students of manufacturing art. This Department appears to have met with a considerable amount of success, and there is evidence that the instruction given in it is highly esteemed by professional men. The following statement, laid before us by Professor W. G. Adams, describes the arrangements of this Department :—

"At King's College the course is divided into three sessions, with three terms in each session, affording Qu. 6885. about 11 weeks' actual tuition in each term, and includes the following subjects :—

	1st Session Hours Weekly.	2nd Session Hours Weekly.	3rd Session Hours Weekly.			
Pure Mathematics - - - -	5	5	5			
Natural Philosophy {	Mechanics (theoretical and practical)-	3	4			
				Physics - - - -	1	2½
				Physical laboratory - - - -	0	1½
Mechanical workshop - - - -	3	4	4			
Chemistry - - - -	2	2	0			
Practical Chemistry - - - -	0	0	2			
Civil Engineering and Architecture - - - -	0	2	1			
Machinery and Mechanical Engineering - - - -	2	2	0			
Mechanical and Engineering Drawing - - - -	7	6½	6½			
Surveying and Levelling - - - -	2	2	2			
Mineralogy - - - -	2 in two terms	2 in two terms	0			
Geology and Mining - - - -	1 in one term	3 in one term	3 in one term			
Photography - - - -	0	0	2			
Total (about) - - - -	28	31	30			
Fees for this course - - - -	£42	£42	£45			

Library and Matriculation fees, &c, 5*l.* 17*s.* 6*d.*, to be paid on entrance.

"The professors of civil engineering and mechanical engineering require, at regular intervals, essays on some practical subjects from third year students."

"In addition to one lecture in each week during the first two sessions, the professor of mechanical engineering takes the students in his classes to visit manufactories in the neighbourhood of London. The average time is thus two hours a week for each session."

"In addition to, or instead of certain parts of this, the regular course, the second and third years' students can, and frequently do, attend and receive instruction in the chemical or the physical laboratories, which are open to them and to others (occasional students) for several hours daily, on payment of an extra fee of from 4*l.* 4*s.* to 8*l.* 8*s.* a term, or 10*l.* 10*s.* to 21*l.* for three terms, and in which there is always a professor or demonstrator to give instruction and assistance. The engineering drawing class is also open for three hours daily (except on Saturday), and the mechanical workshop (in which the first year's students do wood work, and the second and third years' students do metal work) is open for six hours daily (except on Saturday, when it closes at 1 p.m.), and in each case there is always some one to give instruction and assistance."

Professor Adams adds: "We have every means at King's College that can be pro- Qu. 6892.

“vided for the education of engineers, except the practical engineering itself, and for “that it would be necessary that our students should go to a practical engineer to finish “acquiring a knowledge of the profession, but we have everything preparatory to that “in our present course at King’s College; the course is complete for civil or for mechanical engineering.” For some years past the number of students in this department has ranged from 75 to 95.

33. The evening classes at King’s College have been eminently successful, and provide a fairly complete course of scientific instruction for persons who are unable to attend the day classes. They were attended in 1873 by as many as 550 students, the majority of whom attended more than one class; about 300 of the 550 attending Science Classes. The students at the evening classes are usually clerks, either in the Civil Service, or in mercantile, architects’, or engineers’ offices.

34. The School appears to be in a flourishing condition, and its numbers are rapidly increasing; they amounted in the year 1872-3 to 456, and in the year 1873-4 to 521, the highest point that they have yet reached. The financial relations of the School to the College are substantially the same as at University College.

35. As in the case of University College, it is stated that in King’s College the chief impediment to its further success is “that it is so extremely poor.” The Secretary, Mr. Cunningham, says, “Our original subscriptions were 15,000*l.* short of the sum that was “actually wanted for the building, and although the Council has for many years insisted “on putting by 500*l.* a year to pay off the debt, yet the increase of new wants has “been so great that the original debt remains very much the same now as it did “originally.” “Science in all its departments” is said to have been “the chief source of “permanent outlay of late years.— In the first place, the Council, only a few years ago, “spent 5,000*l.* in building a new Hospital, with the simple object, as far as they were “concerned, of providing Clinical Teaching for their Medical Students. Within the last “five years they have spent 2,000*l.* on a new Museum, and 2,000*l.* on Chemical and “Physical Laboratories. And now, at the present moment, they have a further demand “of, I suppose, 1,500*l.* more for the new subject of Practical Physiology.” The Scientific Departments as a matter of profit and loss do not add to the resources of the College. The Department of Applied Sciences may be said almost to pay its own way, but the Medical Department has always been worked at a very heavy loss. The evening classes, for which very moderate fees are charged, and for which the Professors are very poorly remunerated, contribute little or nothing to the support of the College. The Theological and Literary Departments are, financially, more successful; and may be said to keep the College afloat. The teaching staff is paid upon the principle of dividing amongst the Professors and Lecturers in each Department three fourths of the fees paid by the students of that Department, the College reserving to itself the remaining fourth part, out of which it has to pay the whole expenses of the buildings, the interest on the debt, and the salaries of the Principal, the Secretary, and the clerks. But the Professors do not always get their three-fourths. “The Council have for the last 10 or “12 years insisted on there being 500*l.* clear profit made every year, and if that “clear profit is not made, the professors have to make good the deficiency out of their “next fees. This time last year the Council had to charge 3 per cent. upon “the whole staff to cover the deficiency of 1869, and this year they have had to “charge one and a half per cent. for the expenses of 1870.” The Council has frequently to refuse applications for increased grants from the various Departments.

36. Great efforts have been made and are still being made by the Council to raise an endowment fund of 30,000*l.*, between 11,000*l.* and 12,000*l.* of which has now been subscribed. It is proposed to apply this fund partly in liquidation of the existing debt of 15,000*l.*, and partly in extending and improving the educational appliances of the College.

#### GENERAL REMARKS ON THE TWO METROPOLITAN COLLEGES.

37. We infer from the evidence laid before us that a strong feeling exists on the part of the persons interested in University and King’s Colleges, that these Institutions have to contend upon very unequal terms against the competition of highly endowed Colleges and Schools, and especially of Institutions supported wholly or in part by Government. There does not appear to be any ground for believing that in the Government Institutions Scientific Instruction is provided at a lower rate than in these Colleges. It is rather with regard to the competition for professors, than with regard to the competition for

students, that the disadvantage is alleged to exist, it being obviously difficult to maintain an unendowed and self-supporting system of instruction at the same level of efficiency as one assisted by public funds, or endowments. We have already referred to the complaint on the part of University College, that "able professors are drawn away from it by opportunities of obtaining better remunerated posts," and that in this way it suffers directly from an unequal competition with the State. To the same effect the Principal of King's College observes, "It is clear that the Government comes into the field with the advantage of the public purse, and can pay their teaching staff very far better than we can pretend to do; the effect ought to be that they should draw the best teachers to their College by being able to remunerate them most largely. If they get the best men, their tuition ought to be the best, and if their tuition is the best, of course they will gain the greatest amount of success. I say it ought to be so, because other than pecuniary influences come in." It must, however, be admitted that the Schedules of the Professors' stipends at the Royal School of Mines, and at Cooper's Hill College, which will be found in the Appendix to this Report, do not altogether justify the apprehensions which have been expressed to us by the witnesses from University and King's Colleges.

Qu. 7136.

Qu. 7103

App. VI.,  
p. 88.

38. These witnesses further agree in entertaining the apprehension that there may be a tendency in the distribution of Government patronage to prefer students educated at Government Institutions to students educated at independent Colleges. At the time of the first establishment by the Government of the Engineering College at Cooper's Hill, it was in contemplation that appointments in the Indian Engineering Service should be confined to the students trained in that College. As the Council of King's College felt that this restriction was likely to exercise a most depressing influence on their own Engineering School, they addressed a Memorial to the India Office on the subject; and a similar Memorial was also presented by the Council and Senate of University College. The cause of complaint was, however, in great measure removed by the determination at which the Government ultimately arrived, in accordance with a resolution of the House of Commons, to allow students from other Colleges to compete, under certain conditions, for admission to the Engineering Service of India. This after action of the Government may be taken as a sufficient proof that the independent Colleges are in a position to assert successfully the claims of their own students to a fair share in the distribution of Government patronage. We have, however, thought it our duty to refer to the matter, as our attention has been called to it in the evidence, and as some importance has been attached to it by the working staff of the two Colleges.

39. The question of applying to Government for pecuniary assistance appears to have come under the notice of the authorities both of University and King's Colleges; but no formal step with this object has been taken by the Council of either Body. Speaking on behalf of University College, Mr. Robson says, "The question has been discussed several times in the Senate or body of Professors, but the Council hitherto have never discussed it in a formal manner. I speak with some amount of hesitation and reserve, but I believe that the general feeling in the Council, at all events until very recently, was that if they could maintain the Institution without making any appeal to the Government or to Parliament, they would very much prefer doing so. I think it may be truly said that every effort has been tried to accomplish that end. The financial statement which I have read shows that the Council have gone on from the first with a determination to carry on the Institution without appealing to the public, if possible; and probably if it had not been for the recent very great extension of scientific teaching in every department all over the country, they might have continued to pursue the same policy; but it is quite clear, I think, that our means and appliances, although they might have been sufficient 20 or 30 years ago, are not sufficient now; and undoubtedly the resources of the Institution have not increased of late."

Qu. 7138.

40. The witnesses from King's College speak with more definiteness. Mr. Cunningham states that the history of the College has, in his judgment, established its claim to public support, and bases that claim mainly on the following grounds: "First of all, the very large educational work on which we are engaged. Secondly, the immense difficulty of carrying it on with such very small funds as we possess. Thirdly, the new wants every day coming up which we really cannot meet. Lastly, the very large number of honours gained at the Universities by the students of King's College."

Qu. 7058.

### Recommendations with reference to the two Metropolitan Colleges.

41. After carefully reviewing the evidence laid before us with regard to University and King's Colleges, and especially taking into account the great public services which have been rendered by these two Institutions to Scientific Education in the Metropolis, we are of opinion that, subject to the reservations which we shall make hereafter, they have established a claim to the aid of Government which ought to be admitted. We think that such Government aid should be afforded, both in the form of a capital sum to enable the Colleges to extend their buildings where requisite, and to provide the additional appliances for teaching which the advance of scientific education has now rendered absolutely necessary; and also in the form of an annual grant in aid of the ordinary working expenses of the Colleges.

42. With regard to the grant of a capital sum we are of opinion that it should be appropriated to definite objects such as those above referred to; and we further think that the amount of such grants should be dependent upon the amounts raised by subscription.

43. With regard to the annual grants in aid of the income of the Colleges, we think that they also should be appropriated to definite purposes, such, for instance, as the augmentation of the stipends of certain professorships, the payment of demonstrators and assistants, or payments in aid of the laboratory and establishment expenses. An account of the yearly expenditure of each Institution receiving such assistance should be reported to Government. As the suspension or withdrawal of the annual grant would always remain in the power of Parliament, we do not think that it would be necessary or desirable to give the Crown a voice in the appointment of the professors, or any control over the management of the Colleges, other than such visitatorial jurisdiction as would be implied by an annual presentation of the accounts.

44. As we do not consider that a day school in the metropolis ought to receive pecuniary assistance from an Institution which is itself in receipt of such assistance from Government, our recommendation of Government aid to *University College* is subject to the reservation that its financial arrangements shall be such as, while enabling the College to do full justice to the School, may prevent the School from becoming a charge upon the funds of the College on an average of years. Our recommendation is also subject to the reservation that the finances of the Hospital, and of the purely Medical Departments, shall be kept distinct from those of the College generally. Our inquiry has not extended to Medical Schools, and it is not within our province to make any recommendation with respect to Government aid to such Schools, whether associated with Scientific Colleges or not. In the case of *University College*, where such an association exists, we think it expedient that the annual outlay on the purely Medical Department should be kept distinct, in order to enable the Government to consider separately the question of aid to the Scientific Department. At the same time, we do not think that there is any reason why the boys' School and the Hospital should not continue, as at present, under the management and control of the Council of the College.

45. The same reservations apply to our recommendations with regard to King's College. Indeed, so far as King's College Hospital, and the Medical School connected with it, are concerned, the need of such a reservation is more obvious, because it is admitted that these institutions are a heavy burden upon the resources of the College.

46. With regard to King's College, we would further suggest that the College should apply for a new Charter, or for an Act of Parliament, with the view of cancelling the proprietary rights of its shareholders, and of abolishing all Religious Restrictions (so far as any such exist) on the Selection of Professors of Science, and on the Privileges extended to Students of Science. We consider that any grant of public money which may be made to King's College should be conditional on such a reconstitution of the College as should effect these objects. And we suggest that advantage might be taken of the opportunity thus afforded to introduce into the government of the College such other modifications as the experience of the persons concerned in its management may have shown to be desirable.

## II. THE OWENS COLLEGE, MANCHESTER.

47. This College owes its origin to the bequest of a merchant of Manchester, Mr. John Owens, who in 1846 bequeathed the principal part of his property to Trustees, whom he appointed in his will, to found within the limits of the Parliamentary Borough of Manchester, or within two miles of its boundary, "An institution for providing or aiding the means of instructing or improving young persons of the male sex—and being of an age not less than fourteen years—in such branches of learning and science as were then and might be thereafter usually taught in the English Universities." The original Trustees were either personal representatives of Mr. Owens or officially designated; and the government of the College was for many years in the hands of fourteen Trustees appointed under the will of the Founder; the work of instruction, the maintenance of discipline, and the ordinary executive, subject to the general control of the Trustees, having been during this period entrusted to the Principal and Professors, at first six and afterwards nine in number.

See Appendix III.

See Minutes of Evidence. Statement B. Owens College Extension, Vol. I, p. 481.

48. Before proceeding to open the College the Trustees made very extensive inquiries as to the course which they ought to pursue and as to the subjects of study, consequently the College was not opened until 1851. They had no power to spend any portion of the original endowment in the purchase of land or erection of buildings, but having first hired a house and land in Quay Street, they were relieved from immediate difficulty by Mr. George Faulkner, who purchased these premises for 4,500*l.*, and presented them to the College. This building in the progress of the College was found to be quite inadequate and inconvenient, though "an auxiliary fund" had been raised, a portion of which, amounting to about 4,300*l.*, had been expended in the erection and fitting up of a chemical laboratory, and in building and fitting up class rooms.

49. It may be convenient to state what were the original resources derived from the bequest of Mr. Owens, and what have been the subsequent accumulations; though, in doing so, the history of the College in its scholastic relations will necessarily be somewhat anticipated.

50. The endowment of the founder consisted of 91,325*l.* 3*s.* 4*d.*, and the gross income arising from it amounted in 1871 to 3,197*l.* 1*s.* 5*d.* In the history of the College since its opening in 1851 numerous proofs have been given of the interest taken by the inhabitants of Manchester and the neighbourhood in its success, as will appear from the following list of benefactions:—

Vol. I, p. 477.

Vol. I, p. 481. Statement B. Owens College Extension.

The Auxiliary Fund, consisting of donations from 118 merchants and others, made about the year 1852, for the erection of a chemical laboratory, the formation of a library, and generally in aid of Mr. Owens' bequest	£9,610
Land and buildings, the gift of the late Geo. Faulkner, Esq., originally valued at	4,500
The Victoria Scholarship (Classics)	500
The Wellington Scholarship (Greek Testament)	500
The Dalton Memorial Fund for Scholarships in Mathematics, Chemistry, and Natural History	4,125
The Shuttleworth Scholarship (Political Economy)	1,250
The Shakespeare Memorial Fund for a Scholarship in the English Language and Literature	1,071
The Cobden Memorial Fund for the further endowment of the chair of Political Economy, and for prizes	1,966
The Grammar School Scholarship	1,060
	<b>£24,582</b>

Recently a further sum of 10,000*l.* was bequeathed by Mr. Langworthy, and will soon be available.

Minutes,  
Vol. L  
p. 482.

51. In 1867 an important movement originated for the extension of the College. The classes had become more numerous; the number of the students had increased; the College had been affiliated to the University of London, and 180 of its students had matriculated in that University, one half of whom had proceeded to the higher examinations for degrees. Probably no institution of the kind at that time conducted the instruction of its students in so confined a space. It was apprehended that unless ample and more appropriate accommodation could be provided, the prosperity of the College would suffer a decline as steady as its growth had been till that time; it was therefore determined to raise a fund for the erection of new buildings. The promoters organised themselves into an Extension Fund Committee, with the view of furnishing "the highest general education leading to degrees in Arts and Science, and the special training required for professional and mercantile life." They proposed to found various new professorships, and to provide them "with all the apparatus for complete and successful study; to set aside considerable sums for the extension and regular maintenance of the Library and of the Physical and Natural History Department; and, above all, to place the Chemical Department in a position of efficiency worthy of the present state of the science, and of its importance in relation to the interests of this district." The consequences of this movement were not confined to the amount of the contributions obtained for the general fund. It was accompanied by subscriptions towards special objects, such as the establishment of a fund to endow a chair of Civil and Mechanical Engineering, and the building of a Chemical Laboratory; and by the gravitation to the College of the buildings and collections of the Natural History and Geological Societies; and, more recently by the absorption of the Manchester Medical School into the scheme of the College.

52. The amounts subscribed may be classified as follows:—

<i>A. For Land and Buildings.</i>		
General fund	-	£83,000
Subscriptions, Laboratory	-	3,500
Subscriptions — Medical School — including one-half of Miss Brakenbury's gift	-	10,300
Realised value of old buildings in Quay Street	-	13,000
		109,800
Part of estimated value of building and site transferred by the Natural History Society, available for contemplated Museum only		5,000
		£114,800
<i>B. For Endowment.</i>		
General and specific endowments including Mr. Langworthy's bequest		27,000
Endowment for Chair of Civil and Mechanical Engineering		13,500
Residue of value of the Natural History Society's property (for Natural History only)		8,000
Medical School endowment—other half of Miss Brakenbury's gift		5,000
		53,500
Total		£168,300

53. The Land and Building Fund has been in part expended in the following manner. A site of about four acres has been acquired at a cost of 31,000*l.* and a part of the College buildings has been erected, upon plans prepared by Mr. Waterhouse, at a cost of 54,000*l.*, to which must be added an estimated outlay of 15,000*l.* for internal fittings. These buildings, now completed, contain (1) lecture rooms of various sizes for the Classical, Mathematical, English, and other Arts Departments; (2) lecture rooms, laboratory, workshops, drawing room, and museum, for the Natural Philosophy and Engineering Departments; (3) lecture rooms for the Natural History and Geological Departments, and temporary accommodation for the Natural History Museum; and (4) temporary library, room for examinations, Governors' council room, private rooms for the Principal and Professors, Registrar's room, Students' common room, and Offices. The new College Buildings also include a large and complete Chemical Laboratory, containing provision for upwards of 100 students, together with a Lecture Theatre capable of holding 400 persons, which will be generally appropriated to the Chemical Classes.

54. The buildings for the Medical School are also in course of erection, at an estimated cost, including internal fittings, of 15,000*l*.

55. The whole immediate outlay, already incurred or under contract, for buildings and land is estimated at 131,934*l*. Towards this outlay the Extension Fund Committee report that (including the realised value of the old site and buildings, and the Brakenbury bequest) they have available the sum of 109,885*l*., leaving an immediate deficit of 22,049*l*. App. III.

56. Other buildings comprised in Mr. Waterhouse's plans, and required for the Museum, Library, and Hall, but not yet erected, the Committee estimate will cause a further expenditure, within a few years, of 60,000*l*., towards which outlay there is in hand 5,000*l*., derived from the Natural History Society's building fund. There is therefore on these proposed future extensions a deficit of 55,000*l*.; so that, in order to carry out the intentions of the Court and Council of the College, a further sum of 60,200*l*. will be required for building.

57. In the original organization of the College, the Trustees felt themselves under an obligation to introduce at once into the curriculum all the subjects of a liberal education, "that is to say, Classics and Mathematics pure and applied, Logic and Mental and Moral Philosophy, History, English and Modern Languages;" but whereas Natural Philosophy was at that time treated as a branch of Mathematics, and Chemistry was regarded in the light of a Chair of the second and not of the first rank, in the course of about 10 years a great change had to be made in order to give to the practical departments of Experimental Science, and especially to Chemistry, their proper position in the curriculum. The Chairs which Principal Greenwood, who is also Professor of Greek, reports to have been established (31st March 1871), and the fixed salaries paid to the Principal, the Professors, and Assistant Lecturers are shown in the following table. Although our inquiry only extends to Owens College regarded as a Scientific Institution we give the statistical facts relating to the Classical and Literary Professorships, because in the case of this College these professorships are partly remunerated by fixed stipends, and we desire to show the total charge upon the income of the College. Qu. 7253.  
See Minutes of Evidence, Vol. I., p. 478.

PRINCIPAL - - - - £700.			
<i>Arts.</i>	<i>Professors.</i>	<i>Science.</i>	
Professor of Greek - - -	£350	Professor of Mathematics (half) -	£175
"    Latin - - -	250	Senior Professor of Natural Philosophy, and Director of Physical Laboratory - - -	400
"    English Language and Literature and of Ancient and Modern History - - -	300	Junior Professor of Natural Philosophy - - -	150
Professor of Mathematics (half) -	175	Professor of Civil and Mechanical Engineering - - -	300
"    Logic and Mental and Moral Philosophy and of Political Economy - - -	250	Professor of Chemistry - - -	150
"    Jurisprudence and Law - - -	120	"    Natural History - - -	250
Professor of Oriental and Modern Languages - - -	100	Lecturer in Geology - - -	140
Lecturer in French (paid by fees only).			
	<u>£1,545</u>		<u>£1,565</u>
<i>Arts.</i>	<i>Assistant Lecturers.</i>	<i>Science.</i>	
Classics - - - - -	£150	Mathematics (transferred to Arts for evening lectures) -	£125
English Language and History -	150	Natural Philosophy - - -	100
Mathematics - - - - -	125	Engineering - - -	120
		Chemistry, Senior Assistant -	200
		"    Junior - - -	200
	<u>£425</u>		<u>£745</u>
Total	<u>£1,970</u>	Total	<u>£2,310</u>

The following Table contains the proportion of fees paid to the Professors and Lecturers in addition to the above fixed stipends.

SHARE OF FEES paid to Professors and Lecturers, 1872-3.

		I.— <i>In the Day Classes.</i>		
		£	s.	d.
Professor of Greek	- - - -	180	2	6
„ Latin	- - - -	233	13	6
„ English and History	- - - -	314	5	6
„ Mathematics	- - - -	301	5	0
„ Logic, Political Economy, and Philosophy	- - - -	39	4	4
„ Jurisprudence and Law	- - - -	59	6	0
„ Modern Languages (German)	- - - -	93	10	6
Lectures in French	- - - -	190	11	6
Professors of Natural Philosophy (two)	- - - -	297	3	11
Professor of Engineering	- - - -	109	8	0
„ Chemistry	- - - -	1,213	6	6
„ Natural History	- - - -	52	3	2
Lecturer in Geology	- - - -	37	14	5
„ Free hand Drawing	- - - -	16	16	0
„ Mineralogy	- - - -	6	6	0
„ Organic Chemistry	- - - -	54	12	0

£3,199 8 10

II.—*In the Evening Classes.*

		£	s.	d.
Lecturers in Classics (three)	- - - -	100	10	0
„ English and History (three)	- - - -	59	16	3
„ Mathematics (three)	- - - -	42	0	0
„ Logic and Political Economy (two)	- - - -	28	0	0
„ Natural Philosophy (two)	- - - -	28	10	0
„ Chemistry (two)	- - - -	128	13	3
Lecturer in German	- - - -	39	7	6
„ French	- - - -	80	0	0
„ Engineering	- - - -	26	13	6
„ Geology	- - - -	11	5	0
„ Harmony	- - - -	23	2	6

£567 18 0

3,199 8 10

567 18 0

Total - £3,767 6 10

58. In addition to the Professorships enumerated in the first Table, the Chairs of Practical Physiology and Systematic Physiology in the School of Medicine have since become available to the Students of the College.

59. The following are the sources of income out of which the College defrays its general expenditure and the fixed stipends and other emoluments of the several Professors and Lecturers (not including the Medical Department):—

Original endowment	- - - -	£3,182	0	0
New general endowment fund	- - - -	550	0	0
Transient rentals, temporary endowments, and other miscellaneous sources	- - - -	1,640	0	0
Cobden Fund	- - - -	60	0	0
Ashbury Fund—Engineering	- - - -	188	0	0
Engineering Professorship Fund	- - - -	388	0	0
Geological Professorship Fund	- - - -	105	0	0
Law Professorship Fund	- - - -	63	0	0
		<u>£6,176</u>	<u>0</u>	<u>0</u>
Fees received from Students, 1872-3	- - - -	5,289	0	0
Total	- - - -	<u>£11,465</u>	<u>0</u>	<u>0</u>



This income (1872-3) was expended in the following manner, viz. :—

The fixed salaries of Professors and Lecturers -	£4,940	0	0
Share of fees appropriated to Professors and Lecturers -	3,767	0	0
Departmental expenses, including Library -	1,248	0	0
Establishment expenses, including rates, taxes, water, gas, wages, &c. -	1,432	0	0
	<u>£11,387</u>	<u>0</u>	<u>0</u>

60. It will be seen from the above financial statements that some of the professorships are inadequately paid. Thus, though the Chair of Latin has been separated from that of Greek, it has not been found possible to provide a full stipend for the new Chair. And though the Natural History Chair has been divided, its Professor being now charged with lecturing on Animal Physiology and Botany, the Chair of Geology has been assigned, not to a professor, but to a Lecturer with a very inadequate stipend. The Lecturer in Mineralogy, though a well-trained and skilful Mineralogist, receives practically neither stipend nor fees.

The financial statement also shows that with the present resources of the College, it is impossible, however much the Governors may desire it, to provide a more adequate remuneration for the Chairs in question.

61. It is also certain that the new buildings will involve a very considerable increase in the establishment expenses, and that some of the temporary sources of income enumerated in paragraph 59 will fail. The annual deficit which may thus arise is estimated at about 1,500*l.*

62. With the prospect of this deficiency the Governors of the College cannot at present undertake the establishment of any new Chairs. If, however, they had adequate resources, it has been stated that they would probably proceed to divide the Professorship of English and History, and to found new Chairs of Mixed Mathematics, of Applied Geology and Mining, of Astronomy and Meteorology, and of Architecture.

63. We have already stated that the estimated cost of the buildings of the Medical School, which are now in course of erection, and which will probably be completed in October next, amounts to 15,000*l.*, towards which, as we have shown, a special fund of 10,300*l.* has been given. It is intended that after the completion of the buildings, the expenses of the Medical School shall be covered by separate endowment, so that the union of the School to the College will not entail any burthen on the latter.

64. The following table shows the number of students attending the various Day Classes :—

Day Classes.	1872-3.	1873-4.
Total number of students -	337	356
Average number of classes attended by each student	4 78	4 6
Entries to the classes of —		
Greek - - - - -	128	129
Latin - - - - -	152	162
English Language and Literature	156	165
History - - - - -	134	118
Mathematics - - - - -	169	165
Natural Philosophy - - - - -	169	170
Engineering - - - - -	66	81
Logic and Political Economy -	25	42
Jurisprudence - - - - -	49	52
Chemistry - - - - -	309	312
		besides
Mineralogy * - - - - -	7	31 medical.
Botany		6
Zoology } Natural History -	41	58
Geology }		besides
		29 medical.
Practical Physiology - - - - -	"	1
		besides
		54 medical.
French - - - - -	128	98
German - - - - -	60	42
Hebrew - - - - -	10	9
Freehand Drawing - - - - -	10	12
Harmony - - - - -	"	14
	<u>1,613</u>	<u>1,636</u>

The number of students in the Medical School is 140. These have not been included in the above table.

65. The ages of the students attending the day classes are shown in the following table, which, with the former, has been furnished to us by Principal Greenwood:—

	Under 16.	16-18	18-20.	Above 20	Total.
1871-2	41	99	69	118	327
1872-3	34	121	75	107	337
1873-4	37	117	75	127	356

66. The evening classes, which were originally established in 1852-3, form an interesting feature of the College. In the first two years instruction was given in Classics and Mathematics only, the classes being then intended for the use of schoolmasters alone; and these subjects being the most desirable for them. Only 28 students attended in the first year; but, after a few years, the classes were thrown open to all applicants, by the absorption of an institution called the "Working Men's College," conducted by the Professors of Owens College and other gentlemen in Manchester. The range of subjects taught has been gradually enlarged so as to include the whole of those comprehended in the day classes; and the fees have been reduced so as to bring the instruction within the means of a larger number. In order to provide some additional remuneration for the teachers of each class, 500*l.* a year is contributed by two friends of the College, Mr. Henry B. Jackson and Mr. Samuel Watts. This subscription secures 10*l.* per annum to the lecturer in each class, as well as the offer of an exhibition of 2*l.* 10*s.* 0*d.* to the most successful student in each class, and of other exhibitions ranging from 2*l.* 10*s.* 0*d.* to 10*l.* 0*s.* 0*d.*, on graduation in the London University, according to the rank taken by the candidate. These arrangements have been followed by remarkable success. The number of students entering during the last two years, and the average number of entries in each class, are shown in the following table:—

Evening Classes.	1872-3.	1873-4.
Total number of students	557 individual students.	889 individual students.
Average number of classes attended by each student	1.58	1.76
Entries to classes of—		
Greek	88	90
Latin	83	151
English and History	94	182
Mathematics	105	168
Natural Philosophy	41	123
Engineering	41	101
Logic and Political Economy	94	114
Chemistry	89	177
Natural History	18	56
French	128	239
German	63	110
Harmony	37	50
Total entries to different classes	881	1,561

Qu. 7257.

67. We have had evidence from the Principal of Owens College, who is also the Professor of Greek, and from Dr. Roscoe, the Professor of Chemistry, on the beneficial reciprocal influence of literary and scientific studies in the courses pursued by the students. Thus Principal Greenwood says:—"Our regular courses are directly fashioned to meet the requirements of the London University degrees; and as the London University demands of all those who seek its degrees, whether in Arts or in Science, or in Law, or even in Medicine, that they must first of all matriculate, every holder of a degree in the University of London must needs at one stage of his preparation for the degree have gone through a preliminary culture both in Science and Literature. Thus a Bachelor of Science must have shown himself possessed of the minimum of Classics, and a Bachelor of Arts or Laws of the minimum of Science. Therefore in this way our own conclusions are materially aided by the line taken by the London University."

Qu. 7254.

68. These conclusions are expressed in the following terms by Principal Greenwood:—"Not only do men of science undergo a useful influence from the co-existence in the same College of language studies, but for another reason they should desire this

"combination," "The influence of the introduction of experimental Science into our regular curriculum, not merely on those students who are going into some scientific profession, but also on the ordinary students, has been of the most beneficial kind."

69. The course adopted by the Science students is thus described by Professor Roscoe:—"We lay down a distinct course of study in Science adapted especially for the Science degrees of the London University, with which, as has been stated, we work. In the first year the course in Science and Literature is identical, being the preparation for the London University Matriculation. In the second year the Science course consists of Mathematics, Natural Philosophy, Mechanics and Physics, the junior class of Chemistry and laboratory practice two days a week, Anatomy and Physiology, together with French or German. I have all along insisted very strongly on the necessity of introducing the study of these two modern languages in connexion with our Science course. In the third year the Science students take the following subjects: Logic, Mental and Moral Philosophy, Mathematics, Mathematical Natural Philosophy, the senior class in Chemistry, laboratory practice two days a week, Geology, and Botany." The prescribed courses in Science and in Engineering (as in Arts) are not obligatory; and a majority of students in all departments, except Engineering, take courses varying more or less from those laid down. In the present session the number of students following these courses is in Science 27, and in Engineering 22. Thus of a total of nearly 200 students who may collectively be described rather as students in Science than in Arts, only 49, or about one in four, are following the prescribed course. The least departure, however, from the curriculum causes them to be classed as *occasional* and not as *regular* students; but a majority of them are really as thorough students as the 49.

Vol. I,  
p. 497.  
Qu. 7364.

70. In the Science Course, the fees for the first year are 15 guineas, and for the second and third years 22 guineas each. We take the following comparison between the cost of Science and Arts students from Principal Greenwood's evidence:—"Each Science student costs the endowment 27*l.* 15*s.* and each Arts student, or non-science student, costs the endowment 11*l.* 13*s.*, and that although, from the nature of the case, the fees paid by the Science men are much heavier than those paid by the non-science men. Every Science student on the average pays 17*l.* 10*s.*, and every Arts student pays 9*l.* 7*s.*; so that while the Science men pay on the average twice as much as the non-science men, they yet cause a net expenditure to the endowment of 27*l.* 15*s.*, against a net expenditure of 11*l.* 13*s.*, in the other case. Of course the addition of the two sums will give about 45*l.* as the gross cost of each Science man, against, in the other case, about 20*l.*"

Vol. I,  
p. 479.  
Qu. 7259.

71. As the course of instruction is intended to meet the requirements of the London University, it is interesting to ascertain how many students have recently matriculated in each year, and how many of these have proceeded to take degrees in that University. We have therefore procured the following return from the Principal:—

	Matriculation	1st B.A. (not held till 1859)	2nd B.A. (including B.A. up to 1859)	M.A.	1st B.Sc. including Preliminary Sc. (M.B. (instituted in 1860).	2nd B.Sc.	D.Sc.	1st LL.B. (instituted in 1866)	2nd LL.B.	LL.D.
1851 to 1867.	125	26	42	5	25	7	1	—	3	1
1868	10	1	4	—	5	2	—	—	—	—
1869	7	1	2	—	3	—	—	—	—	—
1870	6	1	4	1	1	1	3	—	—	—
1871	21	2	1	1	5	—	—	—	—	—
1872	20	9	6	—	10	3	—	2	—	—
1873	34	7	6	2	13	5	—	—	—	—
1874, Jan.	3	—	—	—	—	—	—	—	—	—
Totals	226	47	65	9	62	18	4	2	3	1

72. This summary of the principal characteristics and of the history of Owens College would be incomplete without an account of the arrangements made for incorporating the results of the efforts of the Extension Fund Committee with the institution founded by the original Trustees. This Committee was instructed to proceed, in conjunction with Mr. Owens' Trustees, to make application to Parliament for an Act or Acts for the incorporation of the Governors under the extension scheme, so as to enable the Trustees of the Owens College to unite that Foundation with the Institutions which might result from the exertions of the new body. The requisite Acts of Parliament have since been passed, and in virtue of them the College received a new Constitution on the 1st of September 1871.

73. The Constitution thus conferred may be briefly described as follows:—The essential conditions of Mr. Owens' will are embodied in the Acts; but the age below which the College is not bound to admit students is raised from 14 to 15 years; "and the restriction of Mr. Owens' will as to the sex of students may, subject to certain qualifications, be set aside at the discretion of the Governors." In lieu of a body of Trustees renewable by private co-optation, the Act provides for the appointment of a body of 42 Governors, 24 to be selected from gentlemen residing within 50 miles of Manchester, and 15 to be nominated, so as to secure a definite and characteristic but a somewhat wider rerepresentation of public interests. It is provided that three shall be nominated by the President of the College, three by the Lord President of Her Majesty's Privy Council, or other Minister of Education, and three by the Governors themselves from amongst the Members of Parliament for the counties and boroughs of Lancashire, Cheshire, Yorkshire, and Derbyshire; two by the Council of the city of Manchester, and one by that of the borough of Salford. With the object of introducing into the Governing Body distinguished alumni of the Institution, the nomination of three Governors is intrusted to the Associates of the College. The Principal of the College and two Professors, to be elected by the body of Professors, complete the number.

The 42 Governors elect a President, and with him form, as the Court, the supreme Governing Body.

The Court appoint out of the Governors a Treasurer and 10 members of Council, who, with the Principal and two Professors, form the Council, or the Executive Committee of the College. The Principal and Professors form the Senate of the College.

The Council, subject to the control of the Court, conducts the whole of the ordinary, so to speak, secular business, and the external relations of the institution; and the Senate, subject to the control of the Council, the whole of its internal or academic business. The President is the Official Head of the Court, the Treasurer of the Council, and the Principal of the Senate.

74. The Owens College has now been twenty-three years in operation, and we have briefly traced the principal stages of its development. It has acquired considerable reputation, and has a staff of twelve Professors, without including those of the Medical School, many of them distinguished in Arts or Science. The income from endowments and fees is about 11,500*l.* a year. Its lectures are attended by more than 350 students, exclusive of the Medical School, and of the evening classes which are attended by nearly 900 persons. The whole capital accumulated in its foundation, including the original bequest of Mr. Owens, exceeds a quarter of a million sterling, and is of purely local origin, being derived from public subscriptions, from benefactions, and from the amalgamation of local institutions owing their origin solely to private contributions. Its government has the character of a public trust; and the large capital embarked in it, together with the Acts of Parliament by which its constitution is defined, affords sufficient guarantee for the maintenance of the principle of its foundation, and of the character of its administration. It is placed in the midst of a population already possessing many secondary schools, some of which are in a state of growing efficiency, and capable, therefore, of supplying students prepared to pursue the courses of education which it provides. These advantages are offered to the entire population without distinction of class, and without any religious disqualification. The entire scheme of the College has not yet been carried into effect. The Extension Fund Committee report that a further sum of 60,200*l.* is required for the completion of the buildings. It is also estimated that 3,000*l.* a year in addition to the present income is needed for the support of the Chairs now existing or imperatively required.

### **Recommendation.**

75. Considering the strenuous and persevering efforts made by the great commercial community by which the Owens College is surrounded, and the cordial sympathy which these efforts have evoked, and which has manifested itself in the incorporation of other Societies and Schools with the College, and in the subscriptions and benefactions for special objects by which the exertions of the Governing Body have been seconded; We are of opinion that this Institution has established a claim to aid from the National Funds. We, therefore, recommend, in accordance with the views which we have expressed with regard to the two Metropolitan Colleges, that the Owens College should receive assistance from Government, both in the form of a capital sum, to be regarded as a contribution towards its Building Fund, and also in the form of an Annual Grant, in aid of its working expenses, with the especial view of enabling it to complete the curriculum of studies by the establishment of New Chairs.

### III.—THE COLLEGE OF PHYSICAL SCIENCE, NEWCASTLE-UPON-TYNE.

See Appendix IV.

76. The University of Durham is provided with Professorships of Mathematics and Astronomy, and with a Readership in Natural Philosophy. It also possesses a Museum of Natural History, and an Astronomical Observatory. It is in intimate connexion with the Medical School at Newcastle-on-Tyne, and is thus in a position to give a complete system of instruction in Medicine, and to grant degrees in that Faculty. The University further confers a certain academical *status* on Mining or Civil Engineers who reside for three Terms, and pass two Public Examinations. But as this University cannot be said to have any complete Scientific Faculty, or to offer any complete System of Instruction, or of Examinations in Science, we have not thought it our duty to take any evidence with regard to the older foundations connected with it, but have confined our attention to the efforts which it has recently made to advance Scientific Instruction by assisting in the establishment of a College of Science at Newcastle-upon-Tyne.

77. This College was founded in 1871 for the teaching of Physical Science, particularly in its practical application to Engineering, Mining, Manufactures, and Agriculture. The funds necessary for its endowment were provided in part by the University of Durham, which gave in the first instance 1,000*l.* a year in perpetuity, which has since been increased; and, in part, by a subscription raised in the north of England.

Qu. 8757.

78. The circumstances which led to the foundation of the College are stated in the evidence of the Dean of Durham. It appears to have been felt that the instruction afforded by the University of Durham did not completely meet the educational wants of the north, and that the chief reason which had originally led to the Foundation of that University, namely, the expectation that it would attract a large number of students from among the people of the north country, had almost entirely ceased to exist. Under these circumstances, it was thought that to render the University more generally useful the best step that could be taken would be to establish a School of Physical Science in connexion with it. The question then arose, what would be the proper place at which to found this school. Opinions were to a certain degree divided as to whether it should be placed at Durham itself, or at Newcastle; but it was found that almost all the eminent employers of labour were strongly in favour of Newcastle upon a variety of grounds.

79. We have also received the following statement from the Dean of Durham as to the amounts contributed from local sources (in addition to the endowment given by the University of Durham), and as to the arrangements which are now in contemplation for amalgamating with the College the other Scientific Institutions in Newcastle:—

Appendix IV.

- “ 1. Sums equivalent to 30,000*l.* have been paid or guaranteed to the College of Science.
- “ 2. A subscription has lately been raised to found a Memorial to the late Mr. Albany Hancock, and the sum promised amounts to 17,000*l.* It is proposed to devote this sum to a building for a Museum to form part of a larger building for a College of Physical Science.
- “ The sum thus subscribed would, if added to that already subscribed to the College of Science, amount to about 50,000*l.*; and it may be proper also to mention that the value of the Museum itself and of its permanent building amounts to at least 10,000*l.*
- “ In addition to this the Medical College of Newcastle is desirous to join in the erection of a Joint College, and will subscribe the sum of 10,000*l.* for the purpose.”

80. The amount originally subscribed was of course insufficient to provide buildings for the new institution, and the College has at present to pay rent for the premises which it occupies. It is the opinion of the witnesses that it is extremely desirable that the College should be provided with buildings of its own. Mr. Lowthian Bell says, that “the buildings are very good, but they are deficient in laboratory accommodation. I should greatly prefer a building expressly erected for the purpose of the College.” Sir William Armstrong adds: “We consider the present accommodation as a makeshift, but without Government assistance it would be scarcely possible to undertake” to provide separate buildings appropriated solely to the College.

Qu. 9198.

81. The College is under the government of a Body consisting of 47 members, of whom nine are *ex-officio*, and the remaining 38 are elected for a term of four years by various representative bodies. These Governors elect out of their own number a

Council consisting of 15 members, in whose hands the ordinary administration of the College is placed. It was proposed in the first instance to provide four Professorships, viz., of Pure and Applied Mathematics, of Chemistry, of Experimental Physics, and of Geology. To these Professorships lectureships have been added in literary subjects, in Greek and Latin, in English History and Literature, in French, and in German, besides a lectureship in Mechanical Drawing. It is thought very desirable by the Founders of the College that other Professorships of Science should be added to those already founded. Mr. Lowthian Bell, speaking immediately before the foundation of the College, expresses the opinion of its promoters, "We are quite unanimous upon the branches of knowledge which we ought in the first instance to undertake . . . Pure and Applied Mathematics, Chemistry, Geology, Mineralogy, and Physics. We are quite unanimous upon these as a commencement, and we are also unanimous, I think, that as soon as the College has the means, we should have other chairs; for example, a chair of Biology, and a chair of Mining, and Civil Engineering. I have no doubt that these will follow." Of these we observe that the Professorship of Biology has already been established and is on the point of being filled up.

Qu 9153

82. The number of students in the year 1873-4 was 78. An account of the number of students attending the various classes during this session will be found in the Appendix. The course of study for regular students is one of two years, and there are two examinations, one at the end of each year, besides a Matriculation Examination at entrance, for which, however, any examination recognised as a qualification for registration as a Student of Medicine, is accepted as a substitute. The candidates who pass the Final Examination in Physical Science at the end of the second year receive the title of Associate in Science of the University of Durham; but not the B.A. degree. The fees paid by the students are five guineas a year for each course of lectures, the fee for admission to the College being one guinea, and a separate charge being made for the use of the laboratory. Four Exhibitions of 15*l.* a year, tenable for two years by Students at the College, are offered for public competition every year.

Appendix IV.

83. There appears to be every reason to think that the Newcastle College of Science is serving a most useful purpose in its own neighbourhood. The experiment of introducing an engineering course into the curriculum of the University of Durham has been tried, and must be considered to have failed. The reason given for this failure by the Dean of Durham is that a great number of young men who would wish to attend that course live in Newcastle, or near Newcastle, and have to come some distance to Durham, and that consequently very few of them do come. And there can be no doubt that local Colleges in the great centres of manufacturing industry are in a position to meet local requirements which Central Institutions in London, or the National Universities are unable to do. Sir William Armstrong says, "I think what we want is local Colleges. London is far too distant. We want a College to be established in the locality, so that young men can attend it without going from their homes. I do not think that a College in London would have any practical effect in realizing the object that we have in view." "If local Colleges were as efficient as central ones, there is no question that they would be preferred by all classes."

Qu. 8773.

Qu. 9218.

Qu. 9220.

Qu. 9222.

84. According to the same witness, the character of the instruction should be mainly, or almost entirely, of a purely scientific character, because at present there is no difficulty as regards practical knowledge, while on the other hand there is no means of acquiring scientific knowledge. Sir William Armstrong does not think that practical instruction should be combined with scientific instruction in the College itself, because "practical knowledge is better acquired in the workshop and in offices, in actual business in fact." He would not attach any workshop to the College, believing that what the College can give is "the facility of acquiring theoretical information, such as can be applied to practice in actual business."

Qu. 9223.

Qu. 9224.

Qu. 9225.

85. The claims which the promoters of the College consider themselves to have upon the Government for assistance are founded upon the National usefulness of the Institution, and on the amount of local support which it has received. Sir William Armstrong's view is that the promoters "have a very sound claim upon the Government, considering how liberally the scheme has been supported locally. I think it would be a very fair thing if the Government, considering how much the nation benefits from the establishment of such Colleges, in every case were to contribute a sum proportional to what has been raised in the locality towards the attainment of the object." And Mr. Lowthian Bell states that, in his opinion, "It is essential for the progress of the industry of this country, looking at the footing upon which it is placed now, that those to whom is entrusted the management of large concerns

Qu. 9213.

Qu. 9152.

- Qa. 9157. "should have generally a higher class of education than that which they possess  
 " at the present time. At the same time, I am bound to say that very great progress  
 " has been made by many in spite of their want of instruction upon those questions  
 " which, in my opinion, are of vital importance." " Personally, I entertain a very  
 " very strong opinion in favour of receiving aid from the Government. I cannot help  
 " feeling, when I come to London, and I go to Jermyn Street, to Kensington, or  
 " elsewhere, and I find Government money applied, I do not say otherwise than very  
 " properly applied, for the purposes of instruction, that London is not the best  
 " place for teaching many of those sciences. You have no means of seeing their  
 " application
- Qa. 9159. Mr. Bell would not " desire, that such schools should be entirely supported by the  
 " Government." He considers that " the best guarantee which a community like that  
 " of Newcastle can give to the Government, of the necessity of establishments of this  
 " kind, is by doing something themselves, and asking the Government to assist to a  
 " certain extent."

86. We concur to a considerable extent in the opinions expressed by these witnesses. The degree of success which has attended the College of Physical Science at Newcastle-upon-Tyne, both in the collection of local subscriptions and in the organization of its system of instruction, leads us to express with confidence the hope that by further efforts of the same kind it will before long be placed in a position to establish its claim to assistance from the State.

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## IV.—THE CATHOLIC UNIVERSITY OF IRELAND.

87. The following account of the establishment of this Institution is given in its Calendar for the year 1869:—

"The foundation of a Catholic University in Ireland, upon the model of the Catholic University of Louvain, had been strongly recommended by Pope Pius the Ninth, in the Rescripts by which he condemned the Queen's Colleges, and was formally resolved upon by the National Synod of Thurles in 1850. In order to carry out this intention, a committee was appointed, consisting of the four Archbishops, four Suffragan Bishops, eight other ecclesiastics, and eight laymen. The business of this committee was to make the public familiar with the objects of the University and the means necessary for securing its establishment, to collect funds, to arrange the details, and take all the other necessary steps for the actual opening of the University. The first public collection was held on St. Patrick's Day, 17th March 1851.

"At length, in May 1854, the bishops, assembled in synodal meeting in Dublin, canonically erected the University. The first Rector, the Very Rev. J. H. Newman, D.D., was installed on Whitsunday, 4th June, following. In the autumn of the same year several Professors were appointed, and the Schools of the University were formally opened on the feast of St Malachi, 3d November 1854. The Pope was again pleased to express his approval of the work by a special brief, in which he bestowed on the new Institution all the canonical rights and privileges held by other Universities, and gave to the Rector the faculty of conferring degrees."

88. By the Statutes of the University, as approved by the Episcopal Board in 1869, its government is vested in the hands of a Rector, assisted by a Rectorial Council, consisting of the Vice-Rector, the Dean of Faculties, one of the Heads of Colleges or Collegiate Houses (to be elected annually by the others), and six additional members to be chosen annually by their respective Faculties, viz., two representatives from that of Philosophy and Letters (one from each of its divisions), and one representative from each of the others." There is besides a Senate, composed of the Vice-Rector and Secretary, the Professors, permanent Lecturers, and the Heads and Tutors of Colleges or Collegiate Houses. With regard to the Senate, it is further provided that those who, hereafter, being of at least seven years' standing, shall have taken the degree of Master, Doctor, or other of the higher degrees, in the University, may be admitted Members of the Senate, on such conditions as the Senate itself shall fix." All the authorities of the University are subject to the control of the Episcopal Board, consisting of the Roman Catholic Prelates of Ireland. The Rector, Vice-Rector, and Bursar are appointed by this Board, with power of revocation, "*pro nutu et arbitrio*." The definitive appointment of the Professors also rests with the Bishops, but "whenever a Professorship is to be filled up, it is the duty of the Rector, having consulted the Faculty in which the vacancy occurs, to present to the Bishops the names of (at least) three candidates." All the officials of the University, "though subject to removal by the same power that appointed them, are secure of the permanence of their appointments till they forfeit them by some offence against religion or morals, by inordinate conduct, contentiousness, incapacity, or other obvious disqualification, according to the judgment of the *Cæsus Episcoporum*, or the Episcopal Board of the University."

89. The intentions of the founders of the University were that it should be organised upon a very complete scale. Accordingly, the original plan embraced five Faculties: Theology, Law, Medicine, Philosophy and Letters, and Science. The Faculty of Theology, although provided with professors, and granting theological degrees, is not in operation as a teaching Faculty. The Faculty of Law has also been constituted, and Professors have been appointed; but we do not learn from the evidence that any system of instruction has as yet been commenced in this Faculty. The Faculty of Medicine, however, has had a fair measure of success, and in the academical year 1873-4, which has just come to a close, had 86 students. The number of resident students in Science and Arts was, in the same year, 30.

Appendix V,  
p. 36.

90. The Professorships which it was intended to establish in the Faculty of Science were as follows: (1.) Mathematics, (2.) Physics, or Natural Philosophy, (3.) Chemistry, (4.) Geology, and Mineralogy, (5.) Botany, (6.) Zoology, and (7.) Physiology, to which (8.) a Professorship of Astronomy was to have been added. The Chairs that have been actually established are those of Mathematics, Natural Philosophy, Chemistry, and Physiology. There are, however, Lecturers on Botany and Zoology, and on Geology.

91. The resources of the University have always been very limited. At the time of its foundation a fund was subscribed, which in the year 1855 amounted to 58,070*l.* 1*s.* 5*d.* Of this sum 27,616*l.* had been collected in Ireland, 16,000*l.* in the United States, 4,166*l.* in England and Scotland, and the balance in different Roman Catholic countries. The University since that time has been supported by voluntary contributions, obtained chiefly by an annual collection in the Roman Catholic churches of Ireland. The whole sum contributed up to the present time, including the original fund and a recent bequest of 2,000*l.*, amounts to about 187,000*l.* Of this sum, 10,000*l.* was raised in the year 1873-4.

Appendix V,  
p. 36.

92. A comparatively small part of these funds remains unexpended. About 18,500*l.* was invested in the purchase of buildings; about 2,500*l.* was expended on laboratory fittings, apparatus, and specimens (exclusive of those in the mineralogical cabinet); and about 5,000*l.* was lost in the course of the proceedings in connexion with the Clonliffe estate. But by far the larger part of the money contributed has been treated as income, and has been applied year by year to the maintenance of the Institution, and to the payment of the stipends of the Professors. Dr. Lyons says:
- Appendix V. "The annual expenditure for maintenance and Professorial stipends has been about 6,000*l.* per year, and has been this year increased to about 7,000*l.* Of this sum over 5,000*l.* are absorbed in the salaries of Professors and officers.
- "Not less than 10,000*l.* a year would, however, be required to maintain the Institution in a moderate degree of efficient work, and at least twice that sum annually if it is to be developed to meet the full requirements of the Catholic population of the country."
- App. V. and Qu. 13,461. The amount required for the Professorial stipends is explained by the statement that "the fees paid by University students in the Faculty of Science are little more than nominal, and are paid into the University chest." The stipends of the Professors in the Faculty of Science are estimated at about 300*l.* per annum.
93. At one time it was in contemplation to erect very large University buildings. In accordance with the suggestions contained in a Report laid before the Episcopal Board by the Professors of the Scientific Faculty, the Clonliffe estate, a piece of ground of the extent of 34 acres, upon the north side of Dublin, was purchased at a considerable cost; plans were obtained, and the foundation stone was laid on the 20th of July 1862, it being hoped that no less a sum than 200,000*l.* might ultimately be provided. The University, however, became involved in litigation with a railway company, and was ultimately obliged to abandon its purchase. It has also failed, owing to legal difficulties, in an attempt to extend its original site in St. Stephen's Green, which it still occupies; and which has a frontage of 270 feet and 260 in depth. It appears, however, that, if funds were forthcoming, there would be no difficulty at the present time in obtaining additional ground. The present buildings are stated to possess considerable commercial value, but not to be very well suited for the purposes to which they are applied, although there are some rooms of considerable size. The Museums and Laboratories are described as having been adequate to the wants of the time when the University was first founded, but we infer from the evidence that they would require very considerable extension to meet the more recent requirements of Scientific teaching.
94. It has been already stated that the University grants degrees in Theology. In point of law, it does not possess the right to grant degrees in that, or any other Faculty; and, as a matter of fact, it has never granted any other degrees than Theological ones, not desiring to raise any question which might bring it into collision with the authority of the Crown. Nevertheless, examinations for the degree of Bachelor of Arts and Bachelor of Science are advertised in the Calendar referred to above; and the degrees of Bachelor and Master of Arts are recognized in the Statutes. As is well known, it has been a standing subject of complaint by persons interested in the Catholic University that the privilege of conferring degrees has never been conceded to it. They state that "the fact of attaining a degree in an University is one of the most potent incentives to students to flock to the University, and no matter what inducements in the way of scientific teaching are held out, where a degree cannot be got in the end to cap a student's labour, and so present to the public a proof that he followed an University career, it adds enormously and incalculably to the difficulties which any teaching body so circumstanced has to contend against. We have constantly addressed successive Governments on the subject, and as it is a matter of public history and notoriety, you are aware that the subject has been in one way or another before the public now for many years, and some tentative efforts towards its solution have been essayed by more than one Government." The University has adopted the title of Scholar for those students who, having reached the middle of their course, have attained a certain degree of proficiency; but it has been found that this title is not practically recognised by the public, and that no value is attached to it comparable to that which is attributed to the old degrees.
- Qu. 13,415.
- Q. 13,390.
- Qu. 13,391.
- Qu. 13,372. 95. There is a considerable number of Scholarships and Exhibitions in the Catholic University; and as much as 700*l.* per annum is expended in this manner. The regulations, however, vary from year to year. Only a small proportion of the scholarships is devoted to science. There are three Limerick Exhibitions for Mathematics, of the value of 40*l.*, 30*l.*, and 20*l.* respectively; two Conolly Exhibitions for Mathematics of 20*l.* each; and two for Experimental Science of the same value, viz., one for Chemistry, and the other for general Physics. These exhibitions are all given away yearly, and are tenable for a year.

96. The courses of scientific study, as described in the Calendar, appear to be organized with as great an approach to completeness, as the limited numbers of the professorial staff allow. We are not informed that there is any laboratory instruction in Physics, although the cabinet of physical apparatus is described as having been fairly complete at the time when it was formed, and although the lately-appointed Professor of Natural Philosophy has given a sum of 750*l.* to supplement the stock of apparatus with instruments required for efficient teaching. The practical instruction in Chemistry has been very successful, and acquired a very considerable development under the management of Professor Sullivan, who, till lately, held the Professorship of Chemistry. The Chemical Laboratory belongs both to the Faculty of Medicine and to the Faculty of Science; and it is stated by Professor Sullivan that it was the first laboratory in Ireland in which medical students received regular practical instruction in Chemistry.

Qu. 13,488  
and Appen-  
dix V.

97. The Students are divided into two classes, the Resident and the Non-Resident, or Affiliated Students, the latter being those who receive their education not in immediate connection with the University itself, but in Colleges in the country, which are affiliated to it, and which are visited and inspected by it. The Resident Students are either Interns or Externs. The Intern Students are those who reside in the Colleges, or Collegiate Houses, in Dublin (three such Houses are mentioned in the Calendar); the Extern Students are those who either live with their friends in Dublin, or its neighbourhood, or who reside in lodging houses licensed by the Rector for the reception of students. Both these classes of students are, by the Statutes, and by the regulations published in the Calendar of the University, placed under very strict religious discipline, even the Externs being required to attend Mass and General Communion on certain days in the year, and being required on Sundays and other days of obligation, to assemble in cap and gown before Mass, to answer to their names, and then proceed in a body to the church. But it is provided in the Statutes that, with the permission of the Rector, and on payment of the proper fees, any person may attend the schools of the University or any particular course of Lectures. Such persons are called *Auditors*. Except in the lecture-room, they have no connection with the University, which is in no wise responsible for their conduct or their success in studies. In order to become formally *Students*, and consequently Members of the University, entitled to all its privileges, the candidates for admission must pass the matriculation examination, and place themselves under the guidance and discipline of the University. And it appears from the evidence that non-Catholic Auditors have been constantly admitted to the lectures; and even to compete for and to hold exhibitions, although this last privilege is not secured to them by the Statutes. But, whatever may be the privileges of non-Catholic Pupils, it must be taken as certain that no dissident from the Roman Catholic religion could be admitted as a professor or teacher in the University. The Statutes require that each Professor shall make the Profession of Faith, according to the form prescribed by Pope Pius IV. in the presence of the Rector. The Rector, who must always be in Priest's orders, has to make the same Profession, in addition to the following promise:—"Ego N., nominatus Rector Universitatis Catholicæ, fidelis et obediens ero costui Episcoporum Hiberniæ et pro viribus juxta illorum mentem curabo honorem et prosperitatem dictæ Universitatis." The principle of the restrictions imposed by the Statutes is stated with great clearness by the present Rector, the Very Rev. Canon Woodlock, who says, in his address at the Inauguration of the Session of 1867-8, "Our Faculty of Medicine does not exclude Protestant Students from its lectures, but neither do our other Faculties. We recommend or prescribe, as the case may be, religious observances to the Catholic Medical Students under our care, as well as to our Students in Letters or in Science; but our rules on this subject do not comprise those who decline to accept the teaching of the Church. But there is one point on which we stand firm, and which equally regards our Faculty of Medicine and the other Departments of this University; we will have Catholic Students taught by no Professors save those whose principles we know to be in accordance with the teaching of the Catholic Church in faith and morals." It is stated in the evidence that there has never been any difficulty in finding Catholics qualified to fill the Professorial Chairs; but, on the other hand, in the Report of the Professors of the Scientific Faculty, to which we have already adverted, great importance is attached to the desirability of selecting for the Scientific Chairs persons who have been educated on the continent of Europe, owing to the impediments which up to that time prevented the cultivation of the Natural Sciences by the Catholics in Ireland. It is remarkable that the first Rector, Dr. Newman, at the time of the Foundation of the University, was prepared to admit non-catholics to the Professorships, on the ground of the importance of maintaining a high standard of excellence in teaching.

Qu. 13,398.

Qu. 13,396.

98. It is contended, on behalf of the Catholic University, that it might, if it could obtain a more complete development, be in a position to render great services to education

in Ireland. It is pleaded that the people of Ireland have very little knowledge of what an University education as distinct from a school education should be; that it is of great importance for them that they should have a Resident and Teaching University as opposed to a merely Examining University; and that neither of the two Teaching Universities—the Queen's University and the University of Dublin—commands the confidence of the large masses of the people. The comparative want of success which has attended the Catholic University is attributed, first, to its inability to grant degrees; secondly, to its want of funds, which has prevented the appliances for instruction and the courses of instruction from being made so complete as they ought to be; and, lastly, to the general poverty of the country; which precludes the existence of any large class of students able to support themselves for a sufficient time at the University.

Qu. 13,443.

99. Our attention has been also called to the relations between the Catholic University and the Catholic Schools in Ireland. Most of these schools are under the control of Roman Catholic Clergymen, and are greatly in need of Scientific Teachers. It is urged that it would be much more easy for scientific teachers educated in the Catholic University, and stamped, as it were, by its approval, to obtain appointments in such schools, and thus to spread a knowledge of Science in them, than it would be for teachers who had been brought up in a non-Catholic University. It is stated that the University has already in this way exercised a very beneficial influence upon the schools; there being but few of them that do not now attempt to teach a little Chemistry and some of the elements of Physics. The remarks of Professor Sullivan upon the present condition of the Irish Schools are certainly deserving of attention. He thinks, "that not more than 5 per cent. of the Catholics of the higher and middle classes go to any other schools than clerical schools. There are about 50 of them in the country, and those schools will not, and as a matter of fact do not, come in contact with any other educational institution in the country; they have no confidence in the present University of Dublin, and I may say they are in open hostility with the Queen's Colleges and the Queen's University, and, therefore, they have no source from which to get any inspiration in Science, no channel of communication with the scientific world, except through the Catholic University."

Qu. 13,456.

100. On a review of this evidence we are satisfied that the establishment of the Scientific Faculty of the Catholic University has not been without advantage to the instruction of the Irish people, an advantage which might be considerably increased if this Faculty could be more completely organized, and its Professors increased in number and supplied with adequate means for practical teaching. And we have not failed to observe that at the present time fresh efforts are being made by the persons interested in this Institution, to improve and to render more widely available the Instruction afforded by it.

101. It is also indisputable that the Catholic University has received, and still continues to receive, a large amount of pecuniary support. The permanency, however, of this support, which proceeds, to a large extent at all events, from annual subscriptions levied by clerical agency, cannot be predicted with any certainty.

102. The peculiar organization of this Institution; the religious restrictions imposed upon the selection of its Scientific Professors and Lecturers—restrictions the removal of which it would be idle to anticipate; the incompleteness of a large portion of its arrangements for the teaching of Science, and the uncertainty of its income; preclude us from recommending that it should receive a grant from public funds.

In conclusion, we humbly beg leave to submit this Report for Your Majesty's Gracious Consideration.

Sign ed)      DEVONSHIRE  
                   LANSDOWNE  
                   JOHN LUBBOCK.  
                   J. P. KAY-SHUTTLEWORTH.  
                   B. SAMUELSON.  
                   W. SHARPEY.  
                   T. H. HUXLEY.  
                   G. G. STOKES.  
                   HENRY J. S. SMITH.

J. NORMAN LOCKYER, Secretary,  
 August 4th, 1874.

## APPENDIX TO FIFTH REPORT.

## APPENDIX I.

## UNIVERSITY COLLEGE, LONDON.

6, Old Palace Yard, London,  
May 29, 1874  
SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to furnish the Commissioners with a statement of the salaries paid to the Scientific Professors at University College.

I have, &c.  
J. NORMAN LOCKYER,  
Secretary.

John Robson, Esq.  
University College, London.  
May 30, 1874  
DEAR SIR, HAVING been informed that the Commissioners on Scientific Instruction wish to have information on several matters in reference to this College, I beg leave to request you to submit to them the following statements:—

(I) *The projected Extension of the College Buildings.*

I must premise that what I am about to say on this subject is founded upon inferences from various sources of information of an informal and unofficial kind, since the Council has not yet had the subject before them in any definite shape, nor adopted any resolutions upon it.

I believe, however, that if the Council had the necessary funds at their disposal, they would take steps to complete the two wings, already partly erected, and thus carry out the original design of the College, so far as its extent is concerned. Judging from estimates made at various times by our architect, I conclude that the cost of the work in question would be upwards of 40,000*l*.

Among the uses to which the additional buildings could advantageously be put, I may mention, in the first place, laboratories for Practical Physics, and for original physical research; next workshops attached to the Class of Engineering, accommodation of this kind has been greatly needed for several years past, and the want of it, there is good reason to believe, has been a serious obstacle to the full development of both the departments of the College affected by it.

Greater space could be beneficially devoted to providing more extensive and complete accommodation for the teachers and the students engaged in the classes of Chemistry and of Practical Physiology. As an illustration of the shifts to which we are at present driven to resort, I may mention that when Professor Sanderson recently represented to the Council his need of an additional laboratory for purposes of original research, the required accommodation could be obtained only by dislodging the museum of Materia Medica, which, at considerable expense, had to be removed into an upper and less convenient room.

Laboratories for original chemical research, and for the practical applications of chemistry, would also require much space as well as expensive fittings and apparatus.

The whole of the south wing, when completed, would probably be required for the use of the school, if, as there is every reason to expect, the number of its pupils should go on increasing for the next few years, as it has continuously for the past six or seven years. A large portion of this wing last built, which was finished in September 1873, having been assigned to the classes of Practical Chemistry and of Physics, to which subjects great attention is paid in the school, it is found that less accommodation than had been anticipated is available for ordinary classes, so that the school is already again cramped for space.

(II) *The Financial Relations between the School and the College.*

This subject has recently been carefully investigated by the School Committee of the Council, and it has thus been ascertained that for the last five years—the most prosperous in the history of the school—the net amount received from the school by the College for its general purposes has been

only an average of 982*l*. 6*s* 8*d* per annum. But even this is subject to a large deduction for *rent*, which may be moderately estimated at 750*l* a year for the south wing, and of 150*l* for the portion of the main building still occupied by the school. Thus the actual profit derived from the school is reduced to about 100*l* a year, or less than 1 per cent of the gross income of the school.

(III) *The Financial and other Relations existing between the College and the Hospital.*

For information on this subject, I beg leave first to refer the Commissioners to the preamble of the College Act of Incorporation, in pp 4, 5 of the copy herewith sent to you. As to finance, I may state that the College discharges gratuitously all the duties of Trustee for the Hospital; it manages the investments of the hospital funds, conducts the correspondence connected therewith, acts as the guardian of the legal rights of the charity, and in various other ways carries on what may be called its *external* affairs, defraying out of its own funds the expenses incidental to its connexion with the hospital. Besides this, it pays each of the two Holme Professors, one of Clinical Medicine, the other of Clinical Surgery, a stipend of 100*l*. per annum, out of the income of the Holme Fund, which was bequeathed to the College "for the purposes of its Medical Department." The duties of these Professors are discharged wholly within the hospital, which derives an important part of its income from the fees paid by the students for hospital practice and clinical instruction.

Should the Commissioners desire me to attend them personally, I shall be happy to do so.

I remain, &c.  
(Signed) JOHN ROBSON,  
J. N. Lockyer, Esq., F.R.S. Secretary.

P.S.—Since the above was written, I have received your letter of the 29th inst. I will obtain and send to you the desired information in a day or two.

The accompanying table, showing the proportion of U. C. Students who have obtained the degrees of the University of London, may be of some interest in connexion with the investigation conducted by the Commissioners.\*

University of London Degrees.	Total No of Degrees conferred to end of 1873.	No gained by students of U. C. College	Per-centage of U. C. Degrees
LL.D. - - -	27	11	40 74
M.D. - - -	281	108	38 43
M.S. - - -	9	3	33 33
D.Sc. - - -	20	6	30
D.Lit. - - -	1	1	100
M.A., Branch I -	58	19	35 85
" II -	35	22	62 85
" III -	136	46	33 82
LL.B. - - -	191	64	33 5
M.B. - - -	374	74	27
B.S. - - -	38	14	60 87
B.Sc. - - -	118	29	24 58
B.A. - - -	1,497	435	29 06
Totals - - -	2,665	832	32 03

\* N.B. This table is based upon the Lists of Graduates published in the University Calendar for 1874, and it differs, therefore, in some respects from the general table printed in p. 154 of that Calendar, especially in omitting to take account of deceased Graduates, or of the lower degrees in the case of Graduates who have subsequently taken the higher degrees.

Incomes of the under-mentioned Professors in University College, London, in Season 1872-73.

Subject.	Share of Fees	Endowment.	Total.	—
1. Physiology	£ 468	—	£ 468	—
2. Chemistry	1,484	—	1,484	—
3. Comparative Anatomy and Zoology.	104	100	204	—
4. Practical Physiology	368	—	368	The professor has to pay for an assistant
5. Botany	184	—	184	—
6. Hygiene	10	—	10	—
7. Mathematics	370	—	370	The Professor pays about 50l. for an assistant.
8. Applied Mathematics.	123	200 guaranteed for 5 years only by the Treasurer of the College	323	—
9. Physics	252	—	252	—
10. Geology and Mineralogy	55	31	86	—
11. Engineering	102	—	102	—
12. Architecture	82	—	82	—

UNIVERSITY COLLEGE, LONDON.

Regulations made by the Council and the Senate, or by the Council, affecting Professors and other Teachers.

1 Every Professor or other teacher is required to attend at the time appointed for the delivery of the first three lectures of his course or courses announced in the prospectus of the Faculty; but unless at least four students

shall have entered to his class by the date of the fourth lecture, the course may be discontinued for the season.

2. Except with the permission of the Senate and of the Committee of Management, no Professor or other teacher shall fail to commence his course at his appointed time, or shall discontinue it before the appointed time.

3 Any Professor or other teacher having occasion to omit or postpone any lecture or lesson, shall, if possible, give notice to his class at a preceding meeting of his intention to do so, and shall also, as early as possible, give a similar notice to the Secretary.

4. A Professor or other teacher, by leave of the Senate, confirmed by the Council, may in alternate years omit giving his course of lectures.

5. The beads of each Faculty and of the Hospital is provided with a book entitled "Register of Omitted Lectures" and it is the duty of the beads, whenever a lecture or attendance is omitted, to bring the book to the Professor or other teacher, physician, or surgeon, at his next attendance, in order that the omission may be registered with his signature. The books are laid on the table of the Committee of Management at every meeting, and the Committee report thereon to the Council, whenever they deem it desirable to do so.

6. No class in the College is to meet at any other times than those announced for its meetings in the prospectus of the session, unless by express permission of the Senate and the Committee of Management; But this regulation is not to prevent a Professor or other teacher from holding an extra meeting of his class on an emergency, at an hour convenient to all the students of his class.

7. Each Professor or other teacher shall examine his own class; but the Faculty may, if they think fit, appoint one or more additional persons to examine any class. Copies of the questions proposed at the class-examinations shall be deposited in the libraries.

8 The 21st part of the gross amount of fees (representing the difference between pounds sterling and guineas) paid in a session for the class or classes of any Professor or other teacher is first deducted and retained by the College. When, after such deduction, the fees so paid do not exceed 125l., nine-tenths of the amount are to be paid to the Professor or other teacher; when they are above that sum, but not more than 300l., the Professor or other teacher shall receive 100l. and one-half of the remainder; when they are above 300l., two-thirds of the amount shall be paid to the Professor or other teacher.

9 The sons of members of the Senate, of former members of the Senate who have died during their tenure of office, and of the Secretary, are admitted to all classes of the College without payment of fees. A similar privilege is enjoyed by the daughters of the same persons in respect of all College classes to which ladies are admissible.

September 1871

APPENDIX II.

KING'S COLLEGE, LONDON.

6, Old Palace Yard, London,

May 19, 1874

REV. SIR,

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to enclose a statement furnished to the Commission by University College, and I am to say that the Commissioners would be glad to have a similar statement with regard to King's College, as they are now considering their Report with regard to these Colleges.

I have, &c.

J. NORMAN LOCKYER,  
Secretary

The Rev. Dr. Barry

King's College, London, W.C

May 23, 1874.

DEAR SIR,

In compliance with your letter of the 19th inst., I have the honour to enclose herewith—

1. A return of the salaries paid in this College in 1873 to the members of the staff engaged in teaching various branches of Science. This Return does not include either the school or the evening classes.

2 A statement of the expenditure of the Council since the foundation of the College on lands, buildings, libraries, and museums. I have every reason to believe that this Return is accurate, but, without more time than I have at

my disposal before this Return is wanted, I am not able strictly to verify every item, but the Return is sufficiently accurate.

3. A Return showing the endowments which the College now possesses, and the particular objects to which each may be applied. We have no endowments applicable to general College purposes, except our buildings, which have been paid for by shares and donations. The College is otherwise wholly dependent on the fees received from students.

I remain, &c.

J. W. CUNNINGHAM,  
Secretary.

J. Norman Lockyer, Esq.,  
6, Old Palace Yard.

STATEMENT OF EXPENDITURE.

	£	s.	d.
Freehold lands, exclusive of sites granted by the Crown	16,448	0	0
College and School buildings and fittings	146,599	0	0
Fittings for museums and laboratories	5,238	3	3
Cost of books for general, and medical libraries	5,296	11	5
Cost of museum, and laboratory apparatus	6,039	14	4

KING'S COLLEGE, LONDON.

STATEMENT OF ENDOWMENTS.

Purpose of Endowment.	Annual Income.	Name of Fund.	Where invested.						
			Reduced 3%	Consols.	London and North-Western Railway			General Re-emergency Company.	East India Railway.
					4% Debenture Stock.	5% Preference Stock.	4% Preference Stock.		
£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d		
For the encouragement of the study in this country of the language and literature of China.	88 13 6	Chinese Endowment.	—	—	2,092 0 0	—	—	—	—
To encourage the prosecution of original research in Chemistry, founded by subscription in honour of the late Professor Daniell.	30 13 2	Daniell Memorial.	—	—	50 18 10	572 2 4	—	—	—
“For the specific purpose of providing Scholarships for meritorious Pupils educated in King's College School”	92 17 8	Forest Scholars.	—	3,141 11 6	—	—	—	—	—
To provide for an annual course of lectures on the subject of Banking	50 0 0	Gilbart Endowment.	—	—	1,250 0 0	—	—	—	—
To provide for Scholarships in Modern History and English Literature, in memory of the late Sir Robert Harry Inglis.	141 1 0	Inglis Endowment.	—	—	3,526 0 0	—	—	—	—
To provide for a bronze medal, to be given annually in each department of the School and College, in memory of the late R. W. Jeff, D.D., Principal.	10 0 0	Jeff Memorial.	—	—	—	—	250	—	—
To provide for diversity prizes in the Medical Department.	8 17 5	Leathes Endowment.	800	—	—	—	—	—	—
For an annual Hebrew and Old Testament prize, in memory of the late Rev. A. McCaul, D.D.	10 17 0	McCaul Memorial.	—	—	—	217 0 0	—	—	—
To provide for an annual gold medal (this is to be made up shortly to a sum producing 10 <i>l.</i> per annum.)	4 16 8	Mathematical Medal.	—	—	121 0 0	—	—	—	—
Towards forming an endowment for a Professorship of Commerce	3 17 0	Professor of Commerce	—	—	95 6 2	—	—	—	—
To provide an annual prize in Books for an English Essay	1 14 0	Stephen Prize.	—	57 12 5	—	—	—	—	—
To provide for a Medical and Surgical Registrarship attached to the College and Hospital	128 1 8	Sambrooke Registrarships.	—	—	453 0 0	—	—	2,000	—
To provide for a Professorship of Economic Science and Statistics, in honour of Thomas Tooke, Esq., F.R.S.	50 0 0	Tooke Endowment.	—	—	1,350 0 0	—	—	—	—
To provide for an annual Greek Testament prize, in honour of Archbishop Trench, late Professor of the Exegesis of the New Testament.	6 4 8	Trench Greek Testament Prize.	—	—	156 0 0	—	—	—	—
To provide for a medal and prize in Books to Students attending the Medical Clinical Lectures of King's College Hospital, in memory of the late E. B. Todd, M.D.	6 13 0	Todd Memorial.	—	—	—	183 0 0	—	7	—
To provide for a prize in the class of Obstetric Medicine in King's College Hospital, in memory of Dr. Thomas Hawke Tanner	10 10 0	Tanner Prize	—	—	—	—	—	—	200
Given by the Rev. Samuel Wilson Warneford, LL.D., to provide for Scholarships at entrance to the Medical Department.	800 0 0	Warneford Scholarships	—	—	4,400 0 0	—	—	—	—
Given by Dr Warneford to provide for prizes in the Medical Department.	40 0 0	Warneford Prizes.	—	—	1,000 0 0	—	—	—	—
Bequeathed by Lieut.-General Sir Henry Worsley, K.C.B., for the education of Missionaries for the British Possessions in India.	64 13 7	Worsley Endowment.	—	2,197 16 0	—	—	—	—	—
Reversionary on the death of Miss S. A. Bequeathed by the late Thomas Godfrey Sambrooke, Esq., to provide for General College Scholarships.	—	Sambrooke Scholarships	—	—	—	—	—	10,000	—

6, Old Palace Yard, London, S W.  
May 29th, 1874.  
DEAR SIR,  
I AM directed to ask whether, in the statement which you have been so good as to furnish to this Commission respecting King's College, the sum of 146,899*l.* includes the expense of building the Hospital.  
I am, &c.  
J. W. Cunningham, Esq. J. NORMAN LOCKYER.

King's College, London, W C.,  
June 1, 1874.  
DEAR SIR,  
THE statement which I have made to you includes 5,000*l.*—five thousand pounds, which the Council gave towards the building of the Hospital, looked on as part of the teaching establishment of the College, but otherwise the whole sum has reference to the College buildings only. You can deduct 5,000*l.* from the 146,899*l.*, if you think it better to do so.  
I have, &c.  
J. W. CUNNINGHAM, Secretary.

J. Norman Lockyer, Esq.,  
6, Old Palace Yard.

6, Old Palace Yard, London, S W.  
July 3, 1874.  
SIR,  
I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to favour the Commissioners with additional information with regard to King's College on the following points  
1. With reference to King's College School, the Commissioners would wish to know how far the financial arrangements of the School are kept distinct from those of the College?  
Whether the School is at present a source of profit or loss to the College?  
Whether the buildings used by the School have been constructed entirely at the charge of the College?  
Whether the original establishment of the School involved any other charges to the College, and what the total amount of such building and other charges has approximately been?  
Whether the arrangement by which one-fourth of the fees is reserved for the College extends to the School?  
2. With reference to the list of salaries furnished by you on a former occasion (a copy of which I enclose), the Com-

missioners would ask you: (1) to add to that list the Professorship of Comparative Anatomy; (2) to fill up the blank relating to the Teachers of Drawing; (3) to verify the number (4) of Teachers of Mathematics, as three only appear to be mentioned in the Calendar; (4) to indicate, if in your judgment it can conveniently be done, what the salary of the principal Professor of each subject is, instead of only stating the gross amount payable to all the Teachers of each subject.

As the Commissioners are now considering their Report, they would be glad to receive these additional particulars as soon as you can conveniently send them.  
I have, &c.

J. W. Cunningham, Esq. J. NORMAN LOCKYER.

King's College, London,  
July 10, 1874.  
DEAR SIR,  
IN reply to your letter of the 3d instant, I have to inform you,—

1. That in the College books a separate account is kept of the receipts and expenditure of each Department, and therefore necessarily of the School.
2. The masters are paid on the principle of receiving in the aggregate three fourths or thereabouts of the school fees. This is not so strictly carried out as in the College, but the effect is practically the same.
3. The one fourth of the school fees reserved to the Council more than covers the expenses of the school; so the school is a source of profit to the institution.
4. The cost of the school buildings is included in that of the College, and no separate account has been or could be made of school buildings.

5. (1) The income of the Professor of Comparative Anatomy has never exceeded 50*l.*; for which he has given three lectures a week during May, June, and July, and one a week from October 1 to March 31 in the evening.

- (2) There are two teachers of Drawing
- (3.) Four Mathematical teachers are right. Mr Heywood appears as a Classical teacher, but he has been for some years transferred to the Mathematical Side

I remain, &c.

J. W. CUNNINGHAM,  
Secretary.  
J. Norman Lockyer, Esq.,  
6, Old Palace Yard.

### APPENDIX III.

#### THE OWENS COLLEGE, MANCHESTER.

6, Old Palace Yard, London, S W.  
June 12, 1874.  
SIR,  
I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to cause the statements desired in the accompanying memorandum, with regard to Owens College, to be furnished for the information of the Commissioners.  
I have, &c.

The Principal of Owens College. J. NORMAN LOCKYER,  
Secretary.

Two statements, showing capital and expenditure under two divisions.

#### A.

Cr.—All available assets for buildings and fittings.  
And against this—  
Dr.—Money expended under the above head  
" Liabilities under contracts already entered into under ditto.  
" Liabilities under other engagements, if any, under ditto  
" Erections and fittings in addition to the above, forming part of the present plans, under ditto.  
And deficiency on balance of Dr and Cr

#### B.

Cr.—Available assets for endowments.  
And against these—  
Dr.—The capital sum required to satisfy existing endowments.  
" To satisfy contemplated endowments  
And deficiency on balance of Dr. and Cr.

NOTE.—If any endowments for specific purposes should be in excess of the expenditure thereon, but incapable of being transferred to other endowments, state this in each instance.

The Owens College, Manchester,  
June 20th, 1874  
DEAR SIR,

I SEND by this post answers to the questions received by me on the 13th inst. Our Treasurer, with the aid of an accountant, has been busily engaged upon the document which I now transmit for several days during the past week, and we hope that the accounts will be found both clear and well adapted for the purposes of the Commission. In one or two particulars, I am requested to say, it was scarcely practicable to frame these accounts exactly in accordance with the questions, but we believe that substantially your inquiries will all be found adequately and clearly answered.

I am deared, however, by my colleagues on the council to draw attention to one important particular. The deficiency on our building account (Account A.), will be seen to be estimated at about 22,000*l.*, whereas in the statement recently supplied by me by way of correction up to the present date, of the accounts given by me in March 1871, this deficiency was spoken of as about 5,000*l.* It is necessary therefore to point out the source of so large a discrepancy. The explanation is as follows: my corrections of the former figures were drawn from a recently prepared annual statement for issue to our subscribers, in which no account was taken of augmentations due to additions to, and modifications of, the original contracts, whereas in the statement now supplied this source of prospective expenditure has been carefully estimated and included. By this and possibly one or two minor sources of error, the difference between the two statements will be found fully accounted for.

Allow me to add that any elucidations, should they be found necessary, will be readily furnished by us, and believe that I am

Your faithful servant,  
J. Norman Lockyer, Esq. J. G. GREENWOOD.



ACCOUNT A.

THE OWENS COLLEGE, MANCHESTER.

RETURN, AS TO THE FINANCES OF THE COLLEGE, TO THE ROYAL COMMISSIONERS ON SCIENTIFIC INSTRUCTION, &c.

Dr. Liabilities (estimated on the 20th June 1874 for the year ending 31st July 1874) Available Assets for Buildings and Fittings. Cr.

Dr.		Cr.	
Liabilities (estimated on the 20th June 1874 for the year ending 31st July 1874)		Available Assets for Buildings and Fittings.	
Amount paid for site in Oxford Road	£ 30,189 9 1	Transferred by trustees of J. Owens, 1st September 1871	£ s d.
Less sums received for sale of engines and machinery	160 0 0	Buildings and fittings in Quay Street taken then at 8,874 10s 8d, but since sold for	13,000 0 0
Buildings materials	1,019 16 4	Transferred by Owens Extension College, 1st September 1871	
Land to Corporation	1,700 0 0	Site in Oxford Road purchased by Extension College	£30,189 9
	£379 16 4	Expended in new buildings	17,051 8
Expended on new building to May 16th, 1874	27,909 12 9	Benefaction of Miss Brackenbury for Medical School Building Part of 30,000 held by Manchester Corporation	5,000 0 0
Amalgamation expenses from Oct. 1st, 1871 to July 31st, 1873	65,822 11 7	Cash in Bank of Heywood, Bros. & Co	12,877 8 8
Extension Committee expenses from Oct. 1st, 1871 to July 31st, 1873	948 13 3	Received from subscribers from September 1, 1871, to June 2, 1874	64,497 19 10
	773 11 9	Interest accruing on Brackenbury Fund to July 31, 1873, Medical School Building	28,732 16 3
Estimated sum still to be provided for buildings and fittings in existing contracts and for expenses	£114,048 8 4	Subscriptions yet to come in	£17,882 0 6
	17,880 8 5	Deficiency	£109,385 12 8
			£2,049 4 1
			£181,834 16 9
	£131,934 16 9		£181,834 16 9

ACCOUNT B.

THE OWENS COLLEGE, MANCHESTER.

RETURN, AS TO THE FINANCES OF THE COLLEGE, TO THE ROYAL COMMISSIONERS ON SCIENTIFIC INSTRUCTION, &c.

Dr. INCOME (Estimated on the 20th June 1874 (for the year ending 31st July 1874). EXPENDITURE. Cr.

Dr.		Cr.	
INCOME		EXPENDITURE	
Permanent income available for general objects of College		Balance from last year	£ 56 5 0
Nett dividends on stocks	£ 8,195 14 0	Transfer to India stock reserve fund (sinking fund)	29 10 4
Nett dividends on mortgage bonds	553 0 0	Annuity under the will of John Owens	19 15 0
Cobden Professorship Fund	60 0 0	Educational staff	
Engineering Fund (Professorship)	380 0 0	Professors	3,803 4 6
Ashbury Fund, Drawing	120 0 0	Lecturers and Assistants	1,824 16 5
Do. Engineering	81 0 0	Share of fees	3,854 0 10
Geological Professorship Fund	126 18 7		8,982 1 9
Law do	60 0 0	Permanent annual charges, departmental expenses	
Shuttleworth History Prize Fund	3 4 0	Natural Philosophy Department	398 0 0
	4,579 11 7	Engineering Department	161 0 0
Students' fees and Locker fees		Chemical do.	818 12 1
Day students	£4,978 18 6	Natural History do.	75 11 6
Evening students	92 9 0	Physiological do.	160 0 0
Locker fees	5,981 7 6	Geological do.	12 14 2
	18 17 8	Library	176 9 11
	5,950 5 0	Prizes	175 9 11
Transfers from special funds applicable this year, but not necessarily in future years		Arts Classes	1,477 17 7
Brackenbury Professorship Fund for apparatus	400 0 0	General management expenses	
Philosophical Apparatus Fund	26 11 0	Salaries and wages, rates and taxes, coal, gas, and water, advertising and printing, &c. &c.	3,006 17 0
Workshops' fund	96 15 0	Special grants to departments, extraordinary for apparatus, &c.	
	523 6 0	Physiological Department	400 0 0
Temporary endowments from annual subscriptions which must be regarded as precarious, and other precarious incomes		Workshops, tools, and fittings	103 11 8
Rentals from property	12 8 0		503 11 8
Temporary endowments	816 3 6	Special expenses connected with removal and opening	193 7 8
University of London local examinations, balance of fees and expenses	88 5 0		
	917 16 6		
Balance	2,298 6 9		
	£14,269 5 10		£14,269 5 10

MEDICAL SCHOOL.

Dr.		Cr.	
INCOME.		EXPENDITURE.	
Balance from last year	£ 597 6 0	Lecturers, salaries, and wages, rents, rates and taxes, coal, and gas, &c.	1,785 4 5
Brackenbury Professorship Fund	300 0 0	Balance	586 0 7
Fees received from students (A portion of these fees are to cover future sessions.)	1,598 19 0		
	£2,321 5 0		£2,321 5 0

ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION, ETC.

MUSEUM TRUST FUND.				
Dr.	INCOME		EXPENDITURE.	Cr.
		£ s. d.		£ s. d.
Balance from last year	- - -	449 10 6	Salaries and wages, chief rent, interest, rates, and taxes, cleaning, &c.	- 1,168 15 4
Rents and contributions towards expenses, and sale of old furniture and fittings	- - -	290 18 6		
Balance	- - -	449 6 4		
		<u>£1,188 15 4</u>		<u>£1,188 15 4</u>
BALANCES.				
From Medical School	- - -	586 0 7	From General Fund	- 2,898 6 9
Total estimated deficit	- - -	2,161 12 6	From Museum Trust	- 449 5 4
		<u>£2,747 18 1</u>		<u>£2,747 18 1</u>

THE OWENS COLLEGE, MANCHESTER

Capital invested.	Description of Investment	To what Fund belonging	Rate of Interest per Cent.	Annual Gross Amount of Interest
£ s. d.				£ s. d.
500 0 0	Corporation of Manchester bond	Victoria Scholarship	4	20 0 0
500 0 0	Mersey Docks and Harbour	Wellington Scholarship	4½	22 10 0
500 0 0	Corporation of Manchester	Dalton Scholarship Prize Fund	4	20 0 0
4,125 0 0	Ditto	Shuttleworth Scholarship Fund	4	165 0 0
1,250 0 0	Ditto	Shakespeare Scholarship Fund	4	50 0 0
1,071 0 0	Ditto	Cobden Professorship and Prize Fund	4	42 18 8
1,942 0 0	Ditto	Engineering Instruction Fund	4	77 18 8
9,472 15 0	Ditto	Ashbury Endowment Fund	4	378 18 2
3,500 0 0	Mexican Railway	Political Economy Lecture Fund	4	280 0 0
1,396 0 0	Corporation of Manchester	Geological Professorship Fund	4	55 16 10
300 0 0	Mersey Docks and Harbour	Law Professorship Fund	4	13 10 0
200 9 10	Corporation of Manchester	Medical School Fund	4½	4 0 4
500 0 0	Ditto	Dunville Surgical Prize Fund	4	20 0 0
2,667 14 0	Uninvested	Shuttleworth History Prize Fund	4	108 14 2
500 0 0	Corporation of Manchester	Braeknbury Professorship Fund	4	20 0 0
1,012 14 0	Mersey Docks and Harbour	Turner Medical Prize Fund	4½	45 11 4
5,000 0 0	Corporation of Manchester	Platt Physiological Scholarship Fund	4	200 0 0
500 0 0	Mersey Docks and Harbour	Rumney Scholarship Fund	4	22 10 0
80 0 0	Corporation of Manchester	Ramsbottom Scholarship Fund	4	3 4 0
5,000 0 0	Ditto	Langworthy Endowment Fund	4	200 0 0
418 18 0	Mersey Docks and Harbour		4	97 16 10
2,500 0 0	Ditto		4	112 10 0
1,000 0 0	Ditto		4	46 0 0
1,000 0 0	Ditto		4	45 0 0
10,000 0 0	Recently received and not yet invested			
55,186 8 10				£1,978 12 0

APPENDIX No. IV.

COLLEGE OF PHYSICAL SCIENCE, NEWCASTLE-ON-TYNE.

6, Old Palace Yard, London, S W.  
July 6, 1874.

SIR,  
I AM directed to ask you to be so good as to supply for the information of the Commissioners (in addition to the information which you have already been good enough to furnish respecting the College of Physical Science, at Newcastle-on-Tyne), (1), a financial statement, showing the amount received towards establishing and endowing the College, and how the amount has been expended or invested, and (2), the annual receipts and expenditure, indicating the salary paid to each professor.

I have, &c.

The Secretary,  
College of Physical Science,  
Newcastle-on-Tyne.

College of Physical Science,  
Newcastle-upon-Tyne.

DEAR SIR,  
In reply to your inquiries of the 6th inst., I beg to inform you that the total amount of donations promised to the College was 23,147*l.*, and of this sum 19,560*l.* has

been collected, the payments being extended over a term of six years. In addition to these donations the following annual subscriptions are received three of 100*l.* each, one of 20*l.*, and one of 10*l.*

The University of Durham makes an annual grant of 1,000*l.*, besides some additional payments to extra teachers, &c.

Rather more than 1,000*l.* per annum is received for fees, about two thirds of which is paid over to the Professors, in addition to their stipends.

About 15,500*l.* of the donations received has been invested in railway and other stock, the balance having been applied in establishing and partly maintaining the College, which has been nearly three years in existence. The total annual expenditure of the College may be stated at 3,000*l.*, and the receipts hitherto have nearly equalled that amount, a deficiency of only 250*l.* last year having been drawn from the capital account. It is expected, however, in future that the expenditure will not exceed the receipts.

I am, &c.

The Secretary of the  
Royal Commission on  
Scientific Instruction.

THOS. WOOD BURNING.

COLLEGE OF PHYSICAL SCIENCE, NEWCASTLE-ON-TYNE.

Account of the number of students attending the various classes, Session 1873-74.

Total day students	-	-	78
First year students	-	-	57
Second year students	-	-	21
From Medical College	-	-	23
Total evening students	-	-	42
Mathematics	-	-	34
Do. evening advanced	-	-	—
Do. do. elementary	-	-	16
Chemistry	-	-	61
Do. evening	-	-	14
Laboratory	-	-	46
Geology	-	-	31
Do. evening	-	-	—
Experimental physics	-	-	36
Do. evening	-	-	22
French	-	-	9
German	-	-	4
Drawing	-	-	9
English history	-	-	2
Do. literature	-	-	1
Natural Philosophy	-	-	—
Latin	-	-	5
Greek	-	-	4
Political Economy	-	-	—

SIR, College of Physical Science, Newcastle-upon-Tyne,  
July 15, 1874

We think it desirable to bring before the notice of the Royal Commission on Scientific Instruction the fact,

that since the time when evidence was given before the Commission by certain members of the College of Physical Science at Newcastle, some large subscriptions have been made to the Museum of Natural History, which now proposes to unite itself more closely with the College of Physical Science.

1. Sums equivalent to 30,000*l.* have been paid or guaranteed to the College of Science.

2. A subscription has lately been raised in memorial to the late Mr Albany Hancock, and the sum promised amounts to 17,000*l.* It is proposed to devote this sum to a building for a museum to form part of a larger building for a College of Physical Science.

The sum thus subscribed would, if added to that already subscribed to the College of Science, amount to about 50,000*l.*, and it may be proper also to mention that the value of the museum itself and of its permanent building amounts to at least 10,000*l.*

In addition to this the Medical College of Newcastle is desirous to join in the erection of a joint college, and will subscribe the sum of 10,000*l.* for the purpose.

The Council of the College of Physical Science of Newcastle-upon-Tyne have thought it right to bring these additional facts before the notice of the Commission, as they have had no opportunity of doing this hitherto, and they venture to hope that the Commission may consider that sufficient grounds have been alleged to enable them to recommend that the College may be assisted by a parliamentary grant.

Signed on behalf of the Council,

W C. LARK,  
Dean of Durham

J Norman Lockyer, Esq.

## APPENDIX V.

## CATHOLIC UNIVERSITY OF IRELAND.

SIR, 6, Old Palace Yard, London, S W,  
June 20th, 1874

With reference to the evidence given by you before this Commission on the 18th of July 1872, respecting the Catholic University of Ireland, I am directed by the Duke of Devonshire, the Chairman of the Commission, to apply to you for further information on the following points:—

I. The Commissioners desire to have laid before them a financial statement relating to the Catholic University. It appears from your evidence that "fully 150,000*l.* have been collected by voluntary contributions, mainly in Ireland, and applied to the purposes of the University." The Commissioners wish to know in what manner this fund has been applied, and, in particular,

(i.) What amount has been expended in the purchase of the site, and in the erection or adaptation of buildings?

(ii.) What amount has been expended in the purchase of objects for Museums, in the establishment of the Physical Cabinet, and of the Chemical Laboratory, and in other permanent appliances for the purposes of instruction?

(iii.) What amount has been expended year by year in the maintenance of the institution, and in the payment of the stipends of the professors and other officers?

(iv.) What was the amount lost in the legal proceedings referred to in your evidence, *qu* 13,376?

(v.) What amount still remains invested in stock, or otherwise? Is the whole of such remaining amount applicable to the general purposes of the University, or is the application of any part of the same limited by special trusts?

(vi.) Have any sums been received by bequest in addition to the sum of 150,000*l.* mentioned by you, and if so, what has been the application of such bequests?

II. The Senate is described by you (*qu* 13,368) "as an assembly of the entire University corps." Can you favour the Commissioners with a more precise definition of the constitution and powers of this body?

III. What was the number of medical students in any one year, for example, in the year 1872-73; and what was the number in the same year of students other than medical students?

IV. The Commissioners infer from your answer to *qu* 13,376 that the present site of the University is its original one, and that no attempt to obtain an extension of that site, or an entirely new one, has hitherto been success-

ful. They would be glad to know if this impression is correct?

The Commissioners would also be much interested to obtain further information on two other points not expressly adverted to in your own evidence:—

(1) In Professor Sullivan's evidence (*qu* 13,426) it is stated that the chair of geology has been "established but not filled up." What is the state of the case at the present time with regard to this chair?

(2) The Commissioners would also be glad of more precise information on the points adverted to by Professor Sullivan in his answers to *qu* 13,449-13,452. What were the emoluments in any one recent year, for example, in the year 1872-73, of the scientific professors, and how far were those emoluments derived from fees, and how far from the funds of the University? Are the fees of each student paid to the professors whose lectures he attends, or are they paid into a common fund.

(3) In the Calendar for the year 1869 (which the Commissioners have been informed is the last that has been published), it is stated that "the foundation of a Catholic University in Ireland, upon the model of the Catholic University of Louvain, had been strongly recommended by Pope Pius the Ninth, in the rescripts by which he condemned the Queen's Colleges, and was formally resolved upon by the National Synod of Thurles in 1850." The Commissioners would be glad to have these rescripts (if they are accessible in print) laid before them, and if not, to have some account of their general tenour.

Lastly, the Commissioners would desire to be informed of any changes of importance which may have taken place in the organization of the University since the date of your evidence, and, in particular, they would enquire, whether any other degrees than theological ones are now granted; and, if not, whether it is in immediate contemplation to grant such degrees?

As the Commissioners are now considering their Report on the evidence laid before them, it will be a convenience to receive the additional information herein requested at the earliest possible moment.

I have, &c.

J NORMAN LOCKYER,  
Secretary.

Dr Lyons.

8, Merrion Square West, Dublin,  
June 28th, 1864.

SIR,  
I HAVE the honour to acknowledge the receipt of your letter of 20th June 1874, on the part of His Grace the Duke of Devonshire, and other members of the Royal Commission on Scientific Instruction and the Advancement of Science, in which you ask for further information in addition to the evidence given by me on 18th July 1872, with regard to the Catholic University of Ireland.

In answer, I have the honour to furnish replies, so far as I am able, in the following returns to your various queries, taking them in order as set forth in your letter. I assume that you have copies of said queries, and I shall reply to them paragraph by paragraph, as numbered in yours of 20th June.

L.—FINANCIAL STATEMENT AS TO THE CATHOLIC UNIVERSITY OF IRELAND.

I find that by a Report of their Lordships, the Catholic Archbishops and Bishops of Ireland, addressed to Sir George Grey, Bart., under date January 1866, there had been furnished up to June 30th, 1865, by voluntary contributions in aid of the University a total sum of—

	£	
		125,000
From that period to 1872	-	45,000
In the year 1872-73	-	4,000
In the year 1873-74	-	10,000
		184,000
This does not include a recent bequest of	-	2,000
Not a sum devoted to the Physical Cabinet	-	750

In addition to the foregoing amount, considerable sums have, *de anno in annum*, been devoted to exhibitions, burses, and prizes of various amounts

(1) Amount expended on purchase of site, &c., and on erection of buildings.

The University has purchased at various times certain mansions and adjacent houses at the south side of Stephen's Green, lying together, and, as before stated, representing an area of 270 feet by 260 feet. These sites were purchased as occasions offered for the following sums—

	£
	4,500
	3,400
	1,100
	1,200
Church erected by the late rector, Very Rev Dr Newman, at cost of about	7,000
Of which, however, only 2,400l came out of the University chest, the remainder having been generously furnished out of his private funds by Dr. Newman himself.	
Medical School	1,300
	18,500

It is to be observed that a considerable ground rent, amounting in all to about 200l, is annually payable for great part of the above site, but the premises are held on long tenures nearly equivalent to perpetuity.

(2) Amounts expended on Museums, Physical Cabinet, and Laboratories

\**Mineralogical Cabinet*.—Chiefly organised by Professor Sullivan. Specimens numerous and valuable, amount expended not well ascertainable; collection believed to be of considerable value, and has been visited and examined by many eminent persons

*Physical Cabinet*.—Amount originally expended about 500l, for recent additions see answer to subsequent paragraph.

*Chemical Laboratory*, about 800l.

*Etangs, &c*, about 200l

*Physiological and Biological Museum*, with specimens illustrative of comparative anatomy, about 200l.

(3) Amount expended, year by year, on the maintenance of Institution, and on Stipends of Professors, &c.

The annual expenditure has been about 6,000l. per year, and has been this year increased to about 7,000l. Of this sum over 5,000l. are absorbed in the salaries of professors and officers. Salaries in Faculty of Science, 150l. to 400l. per annum

Not less than 10,000l. a year would, however, be required

to maintain the Institution in a moderate degree of efficient work, and at least twice that sum annually if it is to be developed to meet the full requirements of the Catholic population of the country.

(4) Amount lost on Clonliffe Estate, as specified in Question 13,376.

The amount already stated, 5,000l., is believed to represent, as accurately as can be stated, the loss sustained in money, as it involved complicated legal and other procedures, rent, &c; but the time involved was of great consequence to the prospects of the University. I should add that the loss is estimated by Mr. Scrutton, Secretary (who is the person most familiar with all the facts), at nearer to 10,000l. in all.

(5) Amount of Corpus of Fund remaining invested in Stock.

A part of the original fund remains in stock, which is applicable to the general purposes of the University, but is not now very large, having regard to the continuous expenditure on site, buildings, salaries, materials, &c.

(6)

Bequests have from time to time been made to the University, one recently of 2,000l., as before specified, which have been applied to the general purposes of the University. There are no special limitations or special trusts, except in regard to certain of the prizes, burses, &c

II.—POWER AND CONSTITUTION OF SENATE.

I beg leave to enclose the Statutes governing the Senate I desire to call attention to the fact that provision is made for the admission of Graduates of the University to the Senate, and the carrying out of this large and liberal provision is only impeded by the want of legal recognition of the University.

III.—NUMBER OF STUDENTS.

In the current year 1873-74, which has just come to a close, the number of students

In Medicine was	-	86
In Science and Arts, attending lectures in the University buildings, Stephen's Green	-	30

It is, however, to be observed under this head that the examiners from the University visit periodically various schools and colleges affiliated with the University, and examine students for matriculation and honours.

Furthermore, students from various parts of the country attend at the University from time to time for examination, and in the current term not less than 40 thus submitted themselves for examination.

IV.

The present site is the original site, and if funds were now forthcoming an opportunity exists for acquiring a large accession of valuable and most suitable ground in immediate proximity to the University. Another site, with more ample grounds, has been pointed out by myself, and could, I believe, be acquired if the necessary funds were available.

In reply to your further queries, I beg to say (1) in reference to Question 13,426, as to the Chair of Geology: Owing to want of funds no permanent appointment has been yet made to this Chair, but a temporary provision has been made by the nomination of Professor O'Reilly, of the Royal College of Science, as lecturer. He has delivered a full and valuable course in the course of this session, ably illustrated by his own hand drawings, which are of great excellence.

(2) In reference to Questions 13,449-13,452, as to emoluments of professors:

The fees paid by University students in the Faculty of Science, are little more than nominal, and are paid into the University chest.

(3) In reference to the Rescripts of Pope Pius IX., I beg leave to enclose copy of the Synodical Address of the Council of Thurles, appended to which will be found the texts of the rescripts in question.

(4) In reference to degrees. No degrees other than theological have been granted. So far as I am aware, it is not contemplated to confer degrees in the other Faculties, but it is under consideration to grant certificates testifying the result of the examinations.

In conclusion I beg leave to say that some important additions have been made to the material and to the

strength of the University Staff, particularly in the Faculty of Science, since the date of my evidence, as I will now proceed to explain

*Physical Cabinet—Instruments.*

In addition to the instruments in regard to which evidence has already been given, a sum of 750*l.* has been recently furnished by the present Professor of Natural Philosophy, out of his private means, to supplement the stock with instruments required for the efficient teaching of Physical Science. (Rev. Dr. Molloy, *vice* Professor Hennessy, F.R.S.)

The Professor is just now engaged in improving at considerable expense the material arrangements of his Lecture Hall, and fitting up a Physical Laboratory in connexion with it, for the preparation of his Class Experiments and for the purposes of private research. The actual number in daily attendance on this class is now 23. Annexed will be found a Syllabus of the Lectures delivered in the present term

Besides his systematic Class Lectures, the Professor proposes to give every year a course of popular public lectures on the most recent discoveries and inventions in Physical Science.

The Professor has also made a proposal, which is now under consideration, of giving from time to time short courses of systematic Elementary Lectures, to a class of select National Schoolmasters, chosen from the various schools throughout the country, thus fitting them to teach the elements of Physical Science in the primary schools. These lectures would be at first somewhat on the scale marked out in the Science Primers recently published by Macmillan & Co., and written by Professors Huxley, Balfour-Stewart, Roscoe, &c.; but he ultimately contemplates a much more enlarged course for this purpose

The Professor hopes, with the means at his disposal, to be able to carry out these plans with moderate efficiency, but it is needless to say that to give them full effect on the scale contemplated, very large additions should be made to the resources of the University. It is believed that the Catholic University commands greater facilities for reaching the masses of the people in the matter of scientific education than any other existing institution in Ireland. Herewith is sent a syllabus of the lectures delivered in this department in the current term; also a copy of a work by the Professor, "on Geology in its relation to Revealed Religion." This book, it may be stated, has gone through two editions in this country, and has been republished and stereotyped in America, and a translation of it into French is now in course of publication in Paris.

*Higher Mathematics and Mathematical Physics.*

Dr Casey has been appointed to this Chair. It is unnecessary to refer to his scientific position and attainments, or his qualification as an able and original teacher and investigator

See *inter alia* his paper on Cycloides and Sphero-quartics, &c. (Phil. Trans.).

Dr Casey has introduced in the course of Mathematics in the Catholic University the highest and most recent Mathematics

2 He has already some preparations made, and intends immediately to commence the publication of a series of Manuals for the use of the University, and for the affiliated schools and colleges. In these he intends to bring the subjects up to the present state of information on the different branches of Mathematics of which they treat

3 He also intends to propose to the Board of the Catholic University to bring the Mathematical masters of the affiliated schools and colleges to Dublin annually for examination, to divide them into three classes corresponding to Mathematical assize, scholar, and moderator in Trinity College, Dublin, with a suitable salary to each class. He will himself instruct them during their vacations if they come to Dublin for that purpose, so that after a few years he hopes to have a number of able men as Mathematica masters in these affiliated colleges and schools.

*Other Appointments*

Dr Campbell has been appointed to the Chair of Chemistry in the Faculty of Science, and also in the Faculty of Medicine

Professor O'Reilly has been nominated Lecturer on Geology, and has delivered in the current term an important and interesting course.

Dr Sigerson has been appointed Lecturer on Botany and Zoology, and has delivered several courses well illustrated and largely attended. (See Prospectus enclosed.)

The Faculty of Law has also been constituted and Professors appointed.

*PRESENT POSITION OF THE UNIVERSITY.*

The position of the University in relation to the country since the date of my evidence is practically well illustrated by its increased efforts for the advancement of knowledge, and the important accessions to its teaching staff above referred to, while the large voluntary collection of the current year 1873-74 reaching 10,000*l.*, shows how these exertions have been appreciated, and how generously they have been met and supported by the Catholic people of Ireland

In prizes and burses fully 1,000*l.* a year is now given by competition

Within the last year direct affiliation has been effected with numerous Colleges and Higher Schools throughout the country, and the University is now in a position, if supplied with adequate material resources, to exercise an immense and an enduring influence on the higher scientific education of the people of Ireland. Through no other existing educational machinery can the various strata of the Irish people be reached, and if aid for Scientific teaching be withheld from the Catholic University, the cause of education in the Physical and Natural Sciences can make but little, if any, progress amongst the Catholics, who constitute the great majority of the Irish people

I append a paper containing facts and arguments to show the educational wants and the intellectual resources of Ireland (Herewith, "Intellectual Resources of Ireland. Supply and Demand for an enlarged system of Irish University Education," by Dr Lyons).

I have, &c

ROBERT D. LYONS.

## APPENDIX VI.

## STATEMENT of the SALARIES of the PROFESSORS in the ROYAL SCHOOL of MINES, and in the INDIAN CIVIL ENGINEERING COLLEGE.

## INDIAN CIVIL ENGINEERING COLLEGE, COOPER'S HILL.

## RETURN of the SALARIES and LECTURE FEES paid to the Professors of the Royal School of Mines.

Name.	Professor of	Salary per Annum	Average of Share of Lecture Fees during Five Years
Edwd. Frankland -	Chemistry -	200	£ s. d. 183 3 8
Thos H Huxley -	Natural History -	"	104 19 0
John Percy -	Metallurgy -	"	79 1 6
Warrington W. Smyth -	{ Mining and Mineralogy - }	"	74 14 0 78 11 6
Andrew C. Ramsay	Geology -	"	148 5 6
Thos. M. Goodeve	Applied Mechanics -	"	94 15 6
Frederick Guthrie -	Physics -	"	66 2 8
J. H. Edgar -	Mechanical Drawing	100	--

With reference to this return, I have to observe that the fees derived from the Students working in the Chemical and Metallurgical Laboratories are received by the respective Professors, with a distinct understanding that all the expenses of Assistants, materials, &c, with the exception of gas and fuel, are paid by those Professors. It is believed that the expenses in the Biological, Physical, and Mechanical Laboratories exceed the fees paid by the Students.

June 2, 1874.

TRENHAM REEKS,  
Registrar.Cooper's Hill, Staines,  
June 1, 1874.

SIR,

In reply to your letter of the 29th ulto, I am directed by the President of the College to forward a statement of the salaries paid to the various Professors and Instructors of this College.

Four of the resident Professors who live in the College buildings have quarters unfurnished, with coals and gas; the other five occupy unfurnished houses within the College grounds, and receive an allowance of 35*l.* a year in lieu of coals and gas.

The non-resident Professors and Instructors receive no allowance in addition to their salaries.

I have, &amp;c

(Signed) J. BALL,

Secretary.

The Secretary,

Royal Commission on Scientific  
Instruction and the  
Advancement of Science,  
6, Old Palace Yard, S W.

## SALARIES of the PROFESSORS and INSTRUCTORS of the INDIAN C. E. COLLEGE, Cooper's Hill.

	£
Professor of Mathematics -	600
" Applied Mathematics -	450
" Construction -	700
" Hydraulic Engineering -	450
" Experimental Science -	600
" Surveying -	600
Instructor in Surveying -	450
" Geometrical Drawing -	450
" Architectural ditto -	350
" Free-hand ditto* -	300
Lecturer in Hindustani* -	350

The Lecturer on Geology receives a fee for each course of lectures.

\* Non-resident.

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For Her Majesty's Stationery Office.

V125

# SIXTH REPORT

OF THE

ROYAL COMMISSION

ON



SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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Presented to both Houses of Parliament by Command of Her Majesty.

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LONDON:  
PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,  
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1875.

[C.—1279.] *Price 5s. 3d.*

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

---

*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

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# SIXTH REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty, in continuation of our former Reports, the following Report on the Teaching of Science in Public and Endowed Schools.

## I. Preliminary Remarks.

1. In dealing with that branch of the Inquiry entrusted to us which has reference to the Scientific Instruction given in the various Secondary Schools throughout the country, we have been induced by the circumstances of the case to deviate from the mode of obtaining information which we had hitherto adopted. The number of Secondary Schools is so considerable that any attempt to obtain the facts by examination of Witnesses would have necessitated the attendance of a very large number, while, by adopting a different method of procuring information we were enabled not only to economise time, but to obtain a comparative survey of the various Systems and Appliances of Instruction employed in the different Schools.

2. With this view our Secretary, Mr. Lockyer, was appointed Assistant Commissioner with reference to this branch of the Inquiry, and by means of personal visits, and by the circulation of various forms of questions agreed upon between him and the Commissioners, much information has been obtained, which will be found in an Appendix to the present Report.

Appendices  
II—IV.

3. The following are the Public and Endowed Schools to which attention was specially directed:—

Eton College, Rugby School, St. Peter's College Westminster, Harrow School, Winchester College, Charterhouse School, Marlborough College, Dulwich College, City of London School, University College School, King's College School, Taunton College School, Wellington College, Rossall School, Clifton College, Cheltenham College, Christ's Hospital, and the Manchester Grammar School.

4. Information was also sought from the Head Masters of the 202 Schools which appear in the Report of the Schools Inquiry Commission as possessing Endowments of over 200*l.* per annum, and from 128 of these Schools replies have been received.

Report of  
the Schools  
Inquiry Com-  
mission,  
Vol. I.  
pp. 337-435.

5. The Evidence thus placed before us conclusively proves that in our Public and Endowed Schools, Science is as yet very far from receiving the attention to which, in our opinion, it is entitled. For instance, the Returns furnished to us show that, even where Science is taught, from one to two hours' work per week may be regarded, with very few exceptions, as the usual time given to it in such Classes as receive Scientific Instruction at all. Moreover, the Instruction in Science is generally confined to certain classes of the School.

6. Among the 128 Endowed Schools from which we have received returns, Science is taught in only 63, and of these only 13 have a Laboratory, and only 18 Apparatus, often very scanty. Out of the 128 Schools, definite information has been received from 87. Of these 30 allot no regular time whatever to scientific study; 7 only one hour a week; 16 only two hours; while out of the whole number only 18 devote as much as four hours to it. The neglect with which it is treated is also clearly shown by that portion of the Assistant Commissioner's Report in which the weight attached to Science in the School Examinations is stated, whence it appears that among the higher grade Schools from which information has been received, only two attach a weight to Science in the Examinations equal to that of Classics or Mathematics; while in the case of the 128 Endowed Schools from which information has been received, only 13 give any weight at all to Science in the Examinations.

See Analysis  
of the  
Returns,  
Appendix V,  
p. 255.

7. Languages and Mathematics are by universal consent regarded as indispensable parts of a System of Education, but any System from which Science is excluded must, in our opinion, be incomplete and unsatisfactory.

8. We feel it the more incumbent upon us to insist on the Introduction of Scientific Training as an integral part of School Education, because in our Third Report we have

Third Report, p. x. recommended that Students at the Universities should, at an early period, if not from the commencement of their Academical Course, be left free to choose for themselves among the principal lines of study, and should not be hampered by being compelled to pass Examinations in subjects having no direct bearing on their subsequent career. But we made this Recommendation conditionally; that is, upon the understanding that the Student should be well grounded in the principal branches of Knowledge before his entrance into the University; for, while asserting that Literary Cultivation, up to a certain point, is indispensable for the Scientific Student, we expressed the opinion that, "in like manner, evidence of corresponding Scientific Culture should be required from the Student of Classical Literature or of Theology;" and we consider that no one should receive a Degree who has not proved himself to be well grounded in Science as well as in Languages and Mathematics.

Third Report, p. xi.

## II. Opinions in favour of the Teaching of Science in Public and Endowed Schools.

9 Our opinion on the importance of introducing Science as an integral part of our Public School Instruction is in general accordance with the Recommendations of two previous Royal Commissions—the Royal Commission appointed in 1861 to Inquire into the Revenues and Management of certain Colleges and Schools (shortly styled the Public Schools Commission), and the Royal Schools Inquiry Commission appointed in 1864. The same view has been also adopted by the Special Commissioners appointed for the Purposes of the Public Schools Act of 1868, and the Commissioners appointed for the purposes of the Endowed Schools Act of 1869.

10. The Royal Commissioners appointed in 1861 say:—  
 Report, p. 32. "Natural science, with such slight exceptions as have been noticed above, is practically excluded from the education of the higher classes in England. Education with us is, in this respect, narrower than it was three centuries ago, whilst science has prodigiously extended her empire, has explored immense tracts, divided them into provinces, introduced into them order and method, and made them accessible to all. This exclusion is, in our view, a plain defect and a great practical evil. It narrows unduly and injuriously the mental training of the young, and the knowledge, interests, and pursuits of men in maturer life. Of the large number of men who have little aptitude or taste for literature, there are many who have an aptitude for science, especially for science which deals, not with abstractions, but with external and sensible objects; how many such there are can never be known, as long as the only education given at schools is purely literary; but that such cases are not rare or exceptional can hardly be doubted by any one who has observed either boys or men. Nor would it be an answer, were it true, to say, that such persons are sure to find their vocation, sooner or later. But this is not true. We believe that many pass through life without useful mental employment, and without the wholesome interest of a favourite study, for want of an early introduction to one for which they are really fit. It is not, however, for such cases only, that an early introduction to natural science is desirable. It is desirable, surely, though not necessary, for all educated men. Sir Charles Lyell has remarked on the advantage which the men of literature in Germany enjoy over our own, in the general acquaintance which the former possess with what is passing in the scientific world, an advantage due to the fact that natural science to a greater or less extent is taught in all the German schools. To clergymen and others who pass most of their lives in the country, or who, in country or town, are brought much into contact with the middle and lower classes, an elementary knowledge of the subject, early gained, has its particular uses; and we believe that its value, as a means of opening the mind and disciplining the faculties, is recognized by all who have taken the trouble to acquire it, whether men of business or of leisure. It quickens and cultivates directly the faculty of observation, which in very many persons lies almost dormant through life, the power of accurate and rapid generalization, and the mental habit of method and arrangement; it accustoms young persons to trace the sequence of cause and effect; it familiarises them with a kind of reasoning which interests them, and which they can promptly comprehend, and it is perhaps the best corrective for that indolence which is the vice of half-wakened minds, and which shrinks from any exertion that is not, like an effort of memory, merely mechanical. With sincere respect for the opinions of the eminent Schoolmasters who differ from us in this matter, we are convinced that the introduction of the elements of natural science into the regular course of study is desirable, and we see no sufficient reason to doubt that it is practicable."

We shall hereafter refer to the Recommendations relating to Scientific Instruction made by this Commission.

Report, vol. 1., pp. 32, 33. 11. The Schools Inquiry Commission in their Report remark, as the result of their Inquiries, that the importance of Natural Science as a branch of General Education, "has received a large amount of sanction of the highest kind." "Of the Witnesses," they say, "whom we ourselves examined on this point, almost all who were not Schoolmasters, desired the adoption in schools of some branch of Natural Science, though, as a rule, they did not aim at the deposition of any existing subject."

Report, vol. 1., p. 34. And they continue, "We cannot consider any Scheme of Education complete which omits a subject of such high importance."  
 "We think it established that the study of Natural Science develops better than any other studies the observing faculties, disciplines the intellect by teaching induction as well as deduction; supplies an useful balance to the Studies of Language and Mathematics, and provides much instruction of great value for the occupations of after life."

12. The Regulations relating to Natural Science issued by the Special Commissioners appointed for the Purposes of the Public Schools Act of 1868 are referred to in a subsequent part of this Report.

13. The intention of the Endowed Schools Commissioners is thus expressed in the following extract from a letter addressed by their Chairman to the Chairman of this Commission on the 25th March 1871 :—

"In all these Schools, without exception, whether for boys or girls, we propose to require as a substantial and indispensable part of their course of Instruction, at least one branch of Physical Science; and in a few, intended for the more special encouragement of what may be called *modern* subjects, we suggest, without absolutely requiring, more extensive teaching of Science." Appendix I,  
p. 13.

In accordance with this intention, the Endowed Schools Commissioners have taken steps to render obligatory the teaching of one or more branches of Natural Science in many of the Schemes which they have issued for the future management of the Grammar Schools of King Edward the Sixth, and of other Royal or Private Foundations. When the Trustees of such Endowments, or the Governors appointed under the new Schemes, have desired to build Laboratories for the Practical Instruction of the Pupils of such Schools in Chemistry or in some branches of Experimental Physics, the Endowed Schools Commissioners have, in some cases, sanctioned the appropriation to these objects of funds raised from the *corpus* of the trust estate,

14. Not only has the importance of introducing Science into our School System, as an integral and important part of Education, been urged by the four Commissions, to which reference has been made, but the good effects which have attended its partial introduction have been fully acknowledged by many Schoolmasters of great experience. Mr. Wilson, one of the Assistant Masters at Rugby School, in a paper "On Teaching Geology and Botany as part of a Liberal Education," strongly supports this view :—

"I am quite sure that this is the first business of our profession as schoolmasters, to hold this truth strongly against all comers, that 'humanity,' and nothing else, is to be our object. We must make our teaching bear on this, give our best care to the selection of subjects, and the method of teaching, in order to make this teaching more effective. And when I urge the introduction of the sciences at the head of this paper into our course of education, I wish to make it plain that this is what they ought to be introduced into, and to this they ought to be made to contribute very effectively." Secretary's  
Report :  
Appended  
Paper, No. 1,  
p. 63.

To this end Mr. Wilson proposes that the Elements of certain parts of Science, to which he gives the general name of "Natural History," should be taught to young boys as part of what he aptly terms the "common ground for all," and he has so well described the nature of this common ground that we quote the main parts of his sketch.

"An orrery and globe, and a little astronomy, form the natural beginning. Let the boys make the effort involved in realizing the plan of our solar system, and our earth in space with its atmosphere mantling round it; its kinship to the planets, its relations to sun and moon. These, and some of the common phenomena—day and night, summer and winter, eclipses, and the changes of the moon—form the natural and the old well-established introduction to science. They are still subjects of surpassing interest to every successive generation. They take boys on all their sides—memory, imagination, and reason. They show, as nothing else shows, the connexion of cause and consequence. And there is a genuine and deep satisfaction, a real pleasure of the intellect, which boys attain when they first understand the causes of these common great phenomena. They stand thenceforward on a higher platform. The universe presents to them not a mere wonderland but a reign of law. These are the *littera divinae* written in the universe by the finger of God." Ibid., p. 65

"Then we pass to the great earth itself, and all its activities, the effects of its still remaining internal heat, its volcanoes and earthquakes, the slow oscillations of level, and the great changes slowly taking place in the familiar outline of the continents and islands, and the proofs still visible of past changes. These things must be well thought out by the class, and illustrated and brought home to them by pictures and specimens. The effect of the attraction of the sun and moon in making tides, and their geological and cosmical action, is a matter that can be to some extent grasped, though so difficult in its complete theory; and is far too important and common a phenomenon to pass by without notice. And then come the complicated consequences of solar heat and light. It is with peculiar interest and pleasure that a boy learns the causes of winds and currents, of trade winds and cyclones, of evaporation and rain, and its distribution on the earth. There is a sense of power obtained by finding out that these great and familiar phenomena are subject to laws, and are not primary facts. And all these are matters, towards which it is only necessary to guide the thoughts of the boys, and they can, with very little help, think them out for themselves. I find it rarely necessary to give a regular explanation of anything, except as a kind of *résumé* of the suggestions thrown out by the class, and successively criticised. Fresh information as to fact must of course be given, when it is seen to be wanted, and not before. And this incidentally gives them a much higher respect for knowledge and the value of facts than they had before. The labours of observers, and mathematicians, and collectors are seen by the class in their true light, as contributing to the store of accurate knowledge in regions more or less inaccessible to themselves."

"The consequences of these activities must then be traced out. And these constitute the principles of Geology. To teach them is not hard; a large stock of pictures, photographs, &c., will be found very useful. We take the work of rain and rivers; their solvent and transporting powers, and straightway the ravine and the waterfall, the rich plain, and the whole river valley, with its wondrous system of drainage, are seen to be the consequences of the familiar forces at work all round us. The work of the sea is easily understood, and behold the map of England is looked at with new eyes; there must be a cause for every bay and headland. The formation of marine deposits, the growth of coral, and Darwin's explanations of the form of coral

islands: the ooze of the Atlantic, the work of frost and snow, the glacier and iceberg, the geographical distribution of plants and animals, all are intelligible, and all, if I may so call it, exciting; they excite to further reading and a good deal of thought; they show, moreover, the regions of knowledge; the necessity of chemistry, and meteorology, and astronomy, and zoology is really felt, without being stated in so many words."

After some further illustrations of his method of teaching Geology, Mr. Wilson continues:--

"It may seem to some that the amount of positive knowledge gained is too little; and indeed it is not much, not as much as would be gained by half the time spent in learning and being examined on somebody's advanced text-book. But from the one system the boy emerges hungry for more knowledge, and his own reading will supply his wants; he emerges with a clear understanding how science grows, and what it is, and has a framework in which he can fit all knowledge he subsequently acquires; while from the other he comes out—perhaps some of my hearers know how he comes out."

"I know of no single book which contains all these subjects. The teacher, at any rate, *must* draw his knowledge from many books, and from real, personal knowledge of his subject. Methods of teaching are very important, but the teacher is of far more importance; and no teaching of these or any other subject is likely to be worth much unless the teacher is thoroughly master of his work, has made it his own by viewing it in various lights, and is independent of any text-book, or any order of viewing nature. He cannot be too discursive in his reading or varied in his attainments, and if he is further able to be prosecuting some original work, however humble, in which his pupils can assist him, they will learn more of the true scientific spirit by contagion than they will gather from the most eloquent lectures."

"I do not see any reason for doubting that these subjects are the best for early education, say from the ages of twelve to fourteen. At such an age, chemistry or physics cannot be understood, except in the rarest cases. I know that Faraday expressed an opposite opinion. But Faraday loved the children, and never examined them. These subjects, especially the geological course, as I have explained it, give a solid foundation of familiar facts, which form the basis of subsequent scientific knowledge. And they attract the strongest and finest minds, which is not found to be the case with all branches of science."

"It may be urged that this teaching cannot be *thorough*,—that boys will be brought in contact with chemistry, physics, mechanics, mathematics, at an age when they cannot understand them; and the result will be, to turn them out capable of talking *about* a great many things, and *knowing theories* about a great many things, but without the rigorous training necessary to enable them to judge of these theories."

"This is, of course, partly true. But it is no objection. The logical order of ideas is not the educational order. A boy learns to read, and make out the meaning of a storybook before he learns grammar, which might be said to precede logically; he reasons before he can learn logic; and so he has to learn a thousand things by experience and observation and reading and conversation, which form the material out of which science grows. The teaching is thorough *so far as it goes*, and it is delusive to suppose that the teaching of mechanics or physics can be made exhaustively thorough to a boy. He apprehends only by comparison of one thing with another; and where experiment takes him out of the range of his experience, there his conclusions are not his own, but his teacher's. These subjects, which may be put aside as mere scientific information, have a double value, stimulative and intellectual, that no one who has not tried them can well estimate. They would plainly be incomplete by themselves, they do not admit, taught in this manner, of the careful study of detail, the minute and painstaking work and drudgery, that makes every science so valuable as an instrument of education. But these subjects claim to enter into the schemes of literary and scientific education; to form a common ground between them; to be science to the men of literature and literature to the men of science."

15. Whether the topics of Elementary Scientific Instruction should be taken in the precise order indicated by Mr. Wilson, or in some other, is a point on which we do not express an opinion; but we desire to draw attention to the fact, that it is the opinion of some able and experienced Schoolmasters, and that of previous Commissions, as well as our own, that such Instruction in Elementary Science ought to be given, and that there is no real obstacle to its being given, in the early years of school life.

### III. Discussion of the Difficulties attending the Introduction of the Teaching of Science into Public and Endowed Schools.

16. In spite of this concurrence of authority in favour of the Introduction of Science into Schools, it appears that not one half of the 128 Endowed Schools from which returns have been received have even made an attempt to introduce it; and, of these, as we have already stated, only 13 have a Laboratory, and only 10 give as much as four hours a week to these subjects.

17. The neglect of Recommendations of so weighty and authoritative a character should imply the existence of strong grounds of excuse. The chief of those given for the omission of the Teaching of Science in Schools are—(1.) the Absence of Funds; (2.) the Uncertainty as to the Educational Value of Science, particularly in the case of young Pupils; (3.) the Difficulty of finding Time for a New Study in an already overcrowded Curriculum.

18. The absence of funds, no doubt, places very serious difficulties in the way of some of the smaller Foundations; but experience shows that satisfactory results in Science Teaching may be produced at a very small expense. On this subject we may refer to Mr. Tuckwell's account of the limited means with which it was commenced and carried on with success at Taunton.

19. We think that this account conclusively proves that the apparatus requisite for Elementary Science Teaching can be provided at a comparatively trifling cost; and that, where there is a good Teacher, the makeshift character of the appliances need not prevent efficient Teaching. On the other hand, it is important to remember that the introduction of new subjects of study implies the introduction of Teachers qualified to take charge of them; and that in many of the smaller and more poorly endowed schools to which we are now referring, there is great difficulty in obtaining the funds requisite for the payment of additional or increased salaries. At the same time, it must be regarded as certain that no school which is forced to plead its poverty as an excuse for the neglect of Natural Science, can pretend to complete efficiency, or can adequately meet the Educational Requirements even of its own locality.

20. When the income of a School is small it may not be possible to provide an adequate stipend for an Assistant Master employed only in Scientific Instruction. Moreover, the number of pupils may not be so great as to justify such an appointment. It is, therefore, important that at least one Master should combine, with the qualifications necessary for his success in teaching Literature, such knowledge and skill as may enable him to give Practical Instruction in Natural Science. No doubt this combination of Literary and Scientific Knowledge with Practical Skill in conducting the Instruction of Classes is at present rare, and it is very desirable that a Systematic Preparation for such Teachers should, if provided.

21. With reference to the wealthier Foundations, and the great Proprietary Schools, the want of funds cannot be properly alleged as a reason for not providing appliances proper for the Teaching of Natural Science. Indeed, there is already considerable evidence of improvement in this respect. Laboratories have been built, or are in the course of construction, at Eton, Harrow, and Rugby; and there is reason to hope that the example will be generally followed, as the Special Commissioners appointed for the Purposes of the Public Schools Act of 1868 have included in their Regulations a Clause requiring the Governing Bodies of the nine Public Schools to which their powers extended to provide and maintain Laboratories and Collections of Apparatus and of Specimens. We desire to record our opinion that School Laboratories should be constructed so as to supply accommodation for Practical Work in Physics, as well as in Chemistry. It will be seen from the Secretary's Report that many persons of experience in education have arrived at the conclusion that Chemistry is not so well fitted for the practical instruction of young pupils as Physics. Without attempting to decide this disputed question, we would express our conviction that neither of these forms of practical work ought to be neglected in School Teaching.

22. It is generally admitted that a sound knowledge of the Sciences of Observation and Experiment cannot be acquired from the study of Text Books alone; and that oral teaching, accompanied by appropriate illustrations and experiments, is indispensably necessary. But even such oral teaching has been found by itself to be insufficient; and, in our judgment, no System of Scientific Instruction can be regarded as satisfactory which does not familiarise the learner with the methods of observation and experiment, by making him practise them himself, whether in the field or in the Laboratory.

23. As the organization in a large School of Practical Instruction in Physics has appeared to offer some difficulties, we would refer to the Secretary's Report for an account of the advantages attendant upon the arrangement adopted by Professor Pickering at the Massachusetts Institute of Technology in Boston.

Secretary's  
Report, § 11,  
Appendix,  
pp. 36-43.

24. We regret to observe that in many of the Larger Schools the number of Science Masters is totally inadequate. The Special Commissioners have found it necessary to insist that there should be at least one Science Master for every 200 boys; a provision which appears to point to a still greater deficiency at present. Until this state of things is remedied, no considerable improvement can be expected in the Standard of Scientific Education at present prevailing in English Schools. We fear that the fewness of the Science Masters in the great Public Schools, and the slowness with which their number is allowed to increase must, to a certain extent, be attributed to an inadequate appreciation, on the part of the Authorities of those Institutions, of the importance of the place which Science ought to occupy, and which the country desires it should occupy, in School Education. But we are also disposed to believe that the difficulty of disturbing existing arrangements, and the increased expense entailed by additions to the staff of Masters, are among the principal causes of the delay in remedying an evil of such magnitude. It might seem, at first sight, that the provision of an adequate number of Science Masters ought not to involve any heavy charge upon the income of a



large school; because, in proportion as the time of the pupils is occupied with Natural Science, fewer teachers of other subjects would be required. It has, however, been found in practice that whenever the subjects of instruction in a school become more varied, the whole number of persons employed in teaching has to be increased. But as there is a well-founded impression that the large English Schools have suffered from being insufficiently supplied with Assistant Masters, we cannot regard it as any disadvantage that a more general introduction of Natural Science Teaching would call for an increase in the number of such Assistants.

25. We have alluded to the difficulty of providing for schools, which have slender incomes, Assistant Masters who have both adequate Literary and Scientific Knowledge, and the requisite skill in Class Teaching and Practical Instruction. Even for the great Public Schools much difficulty is experienced in obtaining the services of Science Masters fitted to form part of their staff. The Head Masters naturally look to the Universities to supply them with Assistant Masters; but the number of University Students of Science is still so limited that the supply falls short even of such demand as exists at present. These several considerations support the suggestions recently made by the Head Masters of Public Schools at their Annual Conferences, that means should exist—and, if possible, within the Universities—enabling young men, who intend to devote themselves to the Scholastic Profession, to pass through a Course of special preparation for it, and to obtain a Certificate of the nature and extent of their qualifications. By such means adequate knowledge and practical skill, both in class teaching and in manipulation, would be ensured.

26. With regard to the second objection, it is obvious that all branches of Science do not possess an educational value of the same kind; and we are not prepared to assert that the mere communication to the mind of the pupil of the facts of Science would contribute very materially to the training of his intellectual powers, although it may supply him with much valuable information, and may render him the still more important service of awakening his desire for further knowledge. But the true teaching of Science consists, not merely in imparting the facts of Science, but in habituating the pupil to observe for himself, to reason for himself on what he observes, and to check the conclusions at which he arrives by further observation or experiment. And it may well be doubted whether, in this point of view, any other educational study offers the same advantages for developing and training the mental faculties by means of a great variety of appropriate exercises. In the Lower Forms of our Public Schools, the youth of the scholars must of course be taken into consideration in the nature of the instruction given, but we nevertheless think it of great importance that the introduction of Science into Education should take place at a very early stage. Elementary Science is certainly not more difficult, and to most young persons is more interesting, than Arithmetic or Grammar, and the most eminent men of Science, as well as some most successful Teachers, are of opinion that there is no reason to apprehend any difficulty in this respect. The Evidence which we have received on this point is very strong; and its force is not diminished by the fact that much of it relates to Primary Schools.

Qu. 2781. 27. Sir W. Thomson, Professor of Natural Philosophy in the University of Glasgow, on being asked :—

“ At what age do you think it desirable that the teaching of elementary science in our primary schools should be commenced, in fact, how young do you think a child could, with any profit, commence instruction in elementary science ? ”—

Replied,

“ I think that at 12 or 14 the commencement of teaching in some branches of science would be very advantageous. I scarcely think before 12, but I think that boys of good intelligence might be very advantageously introduced to much of natural science at 12.”

Qu. 2782.

“ Then I am afraid that would almost exclude natural science from the primary schools of the country, because we can hardly hope to keep children there after 14 ?—No; I scarcely like to adhere to any such answer, except in respect to the more abstract branches. For instance, higher mathematics and dynamics may be very advantageously commenced at 12; but I doubt whether there can be much advantage in commencing such subjects before 12. But there is a great deal of general knowledge in natural history, and geography, and chemistry, which I think could be imparted very advantageously indeed to boys of considerably younger age than 12.”

28. Professor Ramsay, Director General of the Geological Survey of the United Kingdom, of the Museum of Practical Geology, and of the Mining Record Office, thus states his opinion regarding the elementary part of Astronomy and Geology :—

Qu. 605.

“ At what age do you think that a boy might advantageously be instructed in the elementary facts of geology ?—I think they might begin at an exceedingly early age, in the same way that all children who have any education at all, for example, know some of the elementary points of astronomy, so certain questions involving geological knowledge might be instilled into them.”

"Would you do that by means of the aid of specimens and plans, and the like, and not merely books?—  
Not merely books, but by the aid of specimens and by the generally better educated state of the whole of the public. It might be part of a household education, quite irrespective of the teaching in schools, if scientific education in the country were placed on a proper footing." Qu. 506.

29. Dr. Rolleston, Linacre Professor of Physiology in the University of Oxford, says :—

"I would certainly cause a boy to begin acquaintance with scientific matters much earlier than that [the age of 16], for the faculty of observation, the power of observing, is in all its vigour long before 16. Long before the faculties of reflection and ratiocination are in anything like ripeness the faculties of observation are well developed. A boy, I should say, at 11, or certainly 12, might be put through certain of the classificatory sciences, or one at least, viz botany, and he might have a training in physics and a training in chemistry, and all boys alike should have some training in these before 16." Qu. 3719.

30. Canon Cromwell, Principal of St. Mark's College, Chelsea, insists on the importance of introducing the Elements of Physical Geography and other parts of Natural Science into Primary Schools :—

"Understanding by primary schools those in which boys are generally under 13 years of age and above seven, I know by experience that the elements of physical geography can be very well taught almost throughout the school. The first step in geography should be made in physical geography, and one advantage possessed by this subject from an educational point of view is this, that almost everything in it can be presented to a child in a concrete form. He may learn something about the principles of heat, about air and water, about natural history, and the action of the elements upon the surface of the globe. He can have illustrations of those things pointed out to him in his own neighbourhood almost, wherever he is. It seems to me that it is the best introduction to any knowledge of physics that might be hereafter required. Wherever the teacher had a special bent for chemistry he might illustrate what he had to say about the laws of physical geography by his knowledge of chemistry. If, again, he were a man who took great interest in natural history or botany, he would dwell more upon those portions of the subject. Physical geography connects itself with almost the whole circle of what are called the physical sciences. I know that children and young men also take great interest in the subject, and what they take great interest in, they learn quickly." \* \* \* \* \* Qu. 7982.

"You think also that a certain amount of information in natural science could be given in elementary schools? —A certain amount of an elementary character, remembering that it must always be given in a concrete shape with plenty of illustrations. For example, experiments can be exhibited to children illustrating the properties of heat, by taking a common bladder and putting it before the fire, and showing how the bladder fills and bursts, or by taking a bar of iron and putting it into the fire and heating it. Such common experiments are things which boys can easily comprehend. In the same manner, I think, they should be familiar with some of the simple machines and instruments, which could be explained to them by ordinary models, and they should know something about the common properties of matter, something about the different forms of attraction—chemical attraction, capillary attraction, and so forth. All this would be useful to boys of almost all classes, whether in town or country." Qu. 7985.

31. Mr. Jarman, Teacher of Science at the Mechanics' Institute, Huddersfield, answered several questions bearing on the subject :—

"If I remember right, in the evidence which you gave before Mr. Samuelson's Committee in the House of Commons, with reference to elementary schools, you expressed an opinion as to its being perfectly possible to teach a certain amount of elementary science in the elementary schools of the country?—Yes, to the upper classes of the school. I tried the plan during the time that I had a school, and I found it to answer very well." Qu. 8922.

"From the age of 11 to 13?—Yes."

"That is a point which you feel no doubt upon whatever?—I feel no doubt upon it whatever." Qu. 8923.

"Did you try it in chemistry?—Yes." Qu. 8924.

"But, I presume, you would consider that there would be no more difficulty in applying it to botany or physiology than in the case of chemistry?—No, I do not." Qu. 8925.

"Do you think that the teaching of one or two such subjects would in any way interfere with the instruction of children in the elementary subjects of reading, writing, and arithmetic?—No, I do not think it would. I think that the pupils would like it very much. As a rule, boys very much like scientific instruction." Qu. 8926.

"It would give them, would it not, a greater interest in their school education, as a whole?—Yes, I think so." Qu. 8927.

"And, in that way, would have a decidedly favourable influence upon their reading and writing?—In two classes that I have at the Huddersfield College, and the Huddersfield Collegiate Institution, the boys who are in the chemistry class I find to be the best boys in the school in other subjects." Qu. 8929.

32. Mr. Shore, Organizing Master of the East Lancashire Union of Evening Schools, expresses a similar opinion :—

"I think that all the great principles of physical geography might undoubtedly be taught to boys in the day school at 10 years of age." Qu. 2276.

33. The Evidence laid before the Public Schools Commission by Dr. Carpenter, Professor Faraday, and Dr. Hooker, is so entirely in harmony with these views that we quote it in part here

34. Dr. Carpenter speaks strongly on the importance of introducing into Education at an early period subjects of a less abstract character than Grammar and Mathematics.

"65. Do you think that the mind, ordinarily speaking, is as apt for the exercise of its faculties upon the subjects of natural science as upon grammar and mathematical subjects, at the early period of life?—I should say more so; that it is more easy to fix a child's attention upon something which it sees, than upon an abstraction." Minutes of Evidence taken by Public

Schools  
Commission,  
Part 2,  
p. 366.

" 66. Do you think that in that point of view, in fact, it is so far a subject better calculated to call out a healthy action of the reasoning powers than the more abstract subjects of grammar and mathematics?—I think it is, at the early period. I think that a lad of from 10 to 12 years of age is better fitted to be led to observe and reason upon what he observes in objective phenomena, than he is to reason upon abstractions. I think that from say 12 years of age, the powers may be healthfully exercised upon abstractions; but as far as I can judge, a child in learning a language learns by rote purely or almost purely up to say 12 years of age, but after that he begins, if he is well taught, to understand the *rationale* (so to speak) of the rules, but it is a mere matter of memory with him up to that time."

35. Professor Faraday thus refers to his own experience :—

Minutes of  
Evidence,  
Part 2,  
p. 378.

" 46 I understand you to say, that you do not feel in a position to define exactly at what age it might be desirable to introduce the physical sciences?—I think one can hardly tell that until after experience for some few years"

" 47. Or whether you would introduce it at an early age concurrently with classical instruction?—I would not undertake to say. All I can say is this, that at my juvenile lectures at Christmas times I have never found a child too young to understand intelligently what I told him; they came to me afterwards with questions which proved their capability."

" 50. If you take a little boy of ordinary intelligence, 11 years old, at Eton, and, say, half his time is devoted to classics and the other half to any branch of physical science, what would you teach him?—I would teach him all those things that come before classics in the programme of the London University—mechanics, hydrostatics, hydraulics, pneumatics, acoustics, and optics. They are very simple, and easily understood when they are looked at with attention by both man and boy. With a candle, a lamp, and a lens or two, an intelligent instructor might teach optics in a very short time, and so with chemistry. I should desire all these. There might be a door by which you could leave out those for which they were inapt."

" 51. You would not be frightened by the hard words?—I do object very much to the too frequent use of hard words or technical phrases either in chemistry or in other subjects. The hard words are not the things. But the result will depend more on the men who are the teachers than on the wording itself. Education should not be stopped by that."

Minutes of  
Evidence,  
Part 2,  
p. 382.

36. The same Commission received from Dr. Hooker an interesting account of the successful attempt made by Professor Henslow to introduce the study of Botany into a village school. Professor Henslow thought that—" It was the most important agent that could be employed for cultivating their faculties of observation and for strengthening their reasoning powers. \* \* \* \* It was also the opinion of some of the Inspectors of Schools who came to visit him, that such children were in general more intelligent than those of other parishes, and they attributed the difference to their observant and reasoning faculties being thus developed."

The ages of the children varied from 8 to 14; the class, which was a voluntary one, mostly consisted of girls; and the children are said to have learnt the subject readily, and to have been exceedingly fond of it.

37. This Evidence leaves no doubt upon our minds that Elementary Scientific Instruction might be given with great advantage from the commencement of the school career.

38. The third of the difficulties most frequently urged is want of Time. While we cannot deny the reality of this difficulty, it seems to us to offer no justification whatever for the total or almost total exclusion from Education of any great branch of Human Knowledge. The difficulty is one which can only be met by carefully economizing time, by employing the best methods of teaching, and by discarding superfluous subjects of study. To meet it by making education one-sided and incomplete, cannot be for the interest of the pupil. Nor does it appear to us impossible to make a fair adjustment between the claims of the different branches of Instruction. The number of hours of study in our Public Schools may be taken at not less than 35 per week, including in the estimate the number of hours on an average employed in preparation. Now, if six hours per week be devoted to Science, and if we suppose six hours also to be given to Mathematics, there would still remain at least 23 hours a week for the study of Language and other subjects.

39. We are not prepared to admit that the classical Scholarship of the Pupil would, by the close of his school career, have suffered in consequence of the subtraction of the 12 hours which we have assigned to Mathematics and Science: since we believe that the influence of Instruction in Natural Science on the development of his intellectual powers might be such as to promote his success in Classical Learning. Be this as it may, it is quite certain that his Education, if confined to one class of subjects, would be an unbalanced one, that his intellectual tastes and powers would have been developed in one direction only, and that so far he would be the worse prepared, whether for the continuance of study, or for the active business of life. We have already expressed the opinion that the Student who has given evidence that he possesses a fair amount of both Literary and Scientific Culture, may with advantage be allowed to choose for himself among the main lines of study pursued at an University. But, while he is still at school, and before he can have given such evidence, we do not think that the same liberty of choice ought to be conceded.

#### IV. Recommendations of the Royal Commission of 1861.

40. The Royal Commissioners of 1861, while advocating Science Teaching, recommend that "Arrangements should be made for allowing boys, after arriving at a certain place in the school, and upon the request of their parents or guardians, to drop some portion of their classical work (for example, Latin Verse and Greek Composition), in order to devote more time to Mathematics, Modern Languages, or Natural Science; or, on the other hand, to discontinue wholly or in part Natural Science, Modern Languages, or Mathematics, in order to give more time to Classics or some other study."

Recommendation XIII.  
Report, p. 53

41. We confess that, in our opinion, such options should be exceptional and confined to the very highest divisions of the schools, as we regard Science, Language, and Mathematics as essential subjects of education up to the age at which boys leave school.

42. The same Commissioners also say :—

"We think it essential that every non-classical subject (except music and drawing), in every part of the school in which it is compulsory, should affect the promotion from one classical form to another, and the place given to each boy in such promotion, as indeed in certain instances is already the case with respect to Mathematics and some other subjects. Thus, if Natural Science is compulsory on all boys in the fourth and fifth (Classical) Forms of a School, each boy's proficiency in Natural Science should contribute, according to a certain scale of marks, to the rise from the fourth form to the fifth, and from the fifth to the form next above it, and should also help to determine the place assigned him, on each promotion, in his new form."

Report, p. 35.

"A scale of marks for this purpose should be settled by the Governing Body, or by the Head Master with the approbation of the Governing Body, and amended, if necessary, from time to time."

"It is essential that the scale should be such as to give substantial weight and encouragement to the non-classical studies."

"The following approximation to a scale is suggested as indicating the relative weight, which, in our opinion, may fairly be assigned to the various subjects."\*

"Classics, with History and Divinity, not less than  $\frac{2}{3}$  nor more than  $\frac{5}{6}$ ; Mathematics, not less than  $\frac{1}{3}$  nor more than  $\frac{2}{3}$ ; Modern Languages, not less than  $\frac{1}{3}$  nor more than  $\frac{2}{3}$ ; Natural Science,  $\frac{1}{3}$ — $\frac{2}{3}$ ; the three non-classical subjects combined  $\frac{1}{3}$ ."

#### V. Regulations issued by the Special Commissioners.

43. The Special Commissioners appointed for the Purposes of the Public Schools Act of 1868 have recently issued Regulations for all the Schools to which that Act applies.

44. The Regulations for Eton, so far as they relate to Mathematics and Natural Science, are as follows :—

"3. In any examination determining the position of a boy (not being one of the senior boys) in the School, or in any report of a general examination, the proportion of the marks to be assigned to Mathematics shall be not less than one-eighth, nor more than one-fourth, as the Governing Body shall think fit.

"4. In any examination determining the position of a boy (not being one of the senior boys) in the School, or in any report of a general examination, the proportion of the marks to be assigned to Natural Science shall be not less than one-tenth, nor more than one-fourth, as the Governing Body shall think fit.

"5. In any examination of senior boys, the proportion of marks to be assigned to the several subjects of study shall be determined by the Head Master, with the approval of the Governing Body.

"6. The Governing Body shall from time to time determine the point in the College list above which the boys shall be reckoned as senior boys for the purposes of these Regulations.

"7. There shall be one Mathematical Master, at the least, for every 100 boys in the school, and there shall be one Science Master, at the least, for every 200 boys learning Natural Science in the School. All such Masters shall rank as Assistant Masters of the School.

"8. Every boy shall learn Natural Science continuously from his entrance into the Remove until he become one of the senior boys in the School, unless his parent or guardian express in writing a desire for his exemption from this Regulation.

"9. The Head Master shall give facilities so far as he shall think practicable to any senior boy, at the request of his parent or guardian, to pursue any particular subject or subjects of study as may be deemed most expedient for him, and to discontinue any other subject or subjects of study for that purpose.

"10. The Governing Body shall, as soon as possible, provide and maintain out of the income of the property of the School, or out of any other means at their disposal for the educational purposes of the School, laboratories, and collections of apparatus, and of specimens.

"12. Any boy entering the School above the age of 12 shall have the opportunity of showing acquaintance with Botany, Physical Geography, or some other branch of Natural Science, and with Arithmetic, or Mathematics, in the entrance examination for the School.

"13. Any boy in the School above the age of 12 who may evince an aptitude for Natural Science, shall have facilities for that study."

\* "In this . . . scale of marks . . . it is assumed that all the branches of the course are being pursued together. Some variation would be necessary in applying the scale to parts of a school in which this was not done."

45. The Regulations for the other Schools to which the Powers of the Special Commissioners extended are of a similar character, and, as will be seen, the Teaching of Science is left open as regards the more juvenile part of the School, not being compulsory until boys reach a part of the School which they usually attain at about the age of 13.

### Conclusions and Recommendations.

46. On a review of the present state of the Public and Endowed Schools, it appears to us that though some progress has no doubt been achieved, and though there are some exceptional cases of great improvement, still no adequate effort has been made to supply the deficiency of Scientific Instruction pointed out by the Commissioners of 1861 and 1864. We are compelled, therefore, to record our opinion that the Present State of Scientific Instruction in our Schools is extremely unsatisfactory. The omission from a Liberal Education of a great branch of Intellectual Culture is of itself a matter for serious regret; and, considering the increasing importance of Science to the Material Interests of the Country, we cannot but regard its almost total exclusion from the training of the upper and middle classes as little less than a national misfortune.

47. While appreciating the reasons which may have induced the Special Commissioners not to insist, in Regulations which have the force of a Statute, on the introduction of Science in the junior parts of the Schools, we desire to express our own opinion that Scientific Instruction ought to commence from the beginning of the school career.

48. Moreover, while we are sensible that much discretion must be left to the Governing Bodies of Schools, and are, therefore, not surprised at the latitude allowed by the Special Commissioners, we think that the Governing Bodies would do well to adopt not the minimum of one-tenth of the marks, but a larger proportion, say one-sixth.

49. We, therefore, Recommend,

Para. 41.

1. That in all Public and Endowed Schools, a substantial portion of the time allotted to study, should, throughout the School Course (but subject to the exceptional options to which we have before referred), be devoted to Natural Science; and we are of opinion that not less than six hours a week on the average should be appropriated for the purpose.

2. That in all General School Examinations not less than one-sixth of the marks be allotted to Natural Science.

3. That in any Leaving Examination, the same proportion should be maintained.

All of which we humbly beg leave to submit for Your Majesty's gracious consideration.

(Signed) DEVONSHIRE.  
 LANSDOWNE.  
 JOHN LUBBOCK.  
 JAMES P. KAY-SHUTTLEWORTH.  
 BERNHARD SAMUELSON.  
 W. SHARPEY.  
 THOMAS H. HUXLEY.  
 HENRY J. S. SMITH.

In signing this Report, I feel compelled to say that I regard the first Recommendation as too inelastic. While fully admitting that Natural Science ought to form a substantial part of a liberal education, I am not prepared to recommend that in *all* Schools the study of Natural Science should be carried on throughout the School course, but wish a wider discretion to be left to the Governing Bodies, or Head Masters, as to the degree to which what has been called the "stratification" of studies should be carried out.

G. G. STOKES.

J. NORMAN LOCKYER,  
*Secretary.*

June 18th, 1875.

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**APPENDICES.**

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## APPENDIX TO SIXTH REPORT.

### APPENDIX I.

#### LETTER from the ENDOWED SCHOOLS COMMISSION.

" 2, Victoria Street, S W.,  
25th March 1871  
" MY LORD DUKE,  
" I YOUR Grace may, perhaps, think it convenient that the substance of what passed at the interview which we had the honour to hold with your Grace and some of your Colleagues on the 6th inst., should be recorded for further use and reference: and I, therefore, proceed to make a brief statement of the principles upon which we are acting in preparing schemes for the better management and application of educational endowments, so far as scientific instruction is concerned.

" 2. Our schemes may broadly be divided into those which regulate schools giving elementary instruction only, and those for schools giving higher instruction.

" I speak first of this latter class. It contains many schools of very various character, varying from what are little above the elementary schools, to others which are just subordinate to the Universities. In all these schools, without exception, whether for boys or girls, we propose to require, as a substantial and indispensable part of their course of instruction, at least one branch of physical science, and in a few, intended for the more special encouragement of what may be called *modern* subjects, we suggest, without absolutely requiring, more extensive teaching of science. We are prepared, also, in particular cases, to recommend the establishment of schools of a more specifically scientific or technical character, provided that either the endowments to be applied to this purpose are not restricted by their present trusts to particular localities, or such a school appears likely to be regarded by the locality as more beneficial than one of more general instruction.

" 3. Our schemes always provide for the payment of school fees by the majority of the scholars, and the grant of free, or half free, places to a certain percentage, selected by competition either in the school work, or in a special examination, or in both.

" Wherever the endowment is sufficient, we think that further help to boys of merit and ability should be provided in the shape of exhibitions, tenable at some higher school, or at the University, or at some other place of liberal or professional study. In schools immediately above the primary schools, and especially in populous places, we very frequently restrict the competition for a certain number of the free places to scholars from the primary schools of the district, and in these cases, particularly, we endeavour to provide for further assistance being given to meritorious scholars, so as to enable boys of humble means to continue longer at school than could otherwise be expected.

" 4. We do not as a general rule go further into particulars in the scheme. It appears to us wisest to constitute the best governing bodies that we can, and then trust to their intelligence and conscientiousness to carry the scheme into effect, subject to the ordinary tribunals. It is, no doubt, competent to us to apportion the exhibitions and other prizes which the endowment will bear between the several subjects of study, and to specify the precise weight which shall be assigned to science, or any other subject, in estimating the result of a competition, and where the number of exhibitions or free places to be provided by an endowment are considerable, we may very probably sometimes adopt this course. But, in the main, we think it safer to put no fetters on the governing body which may prevent their adjusting the details to suit the local circumstances, so as to work most effectively from time to time on the varying energies of the school.

" 5. We have it now under serious consideration, whether, considering the great benefit which has been devised for elementary instruction from the establishment of training colleges for teachers, we may not most materially assist secondary education by providing some analogous institution for those who are to be teachers in secondary schools. If we should eventually decide upon such a course, we should probably find instruction in science teaching to be one of the most promising, as it is one of the most neglected subjects of special preparation.

" 6. I turn now to the case of schools for elementary instruction. Endowments for such purposes are included within our jurisdiction, just as much as endowments for

higher instruction, or attached to higher schools, with the exception of such as belong to schools which, at the date of the passing of the Endowed Schools' Act (2nd of August 1869), were in receipt of an annual Parliamentary Grant. But the action of the Education Department influences elementary schools so powerfully and so beneficially, and is so likely to attract nearly all schools of the class within its range, that we think it clear that we must deal with endowments applicable to such schools on somewhat different principles from those on which we proceed in the case of others. The Department takes minute cognizance of these schools, inspects them regularly, virtually prescribes their course of study, and the character and qualification of their teachers. We cannot, therefore, wisely prescribe in these schools the teaching of any particular subject, as, for instance, science, but we may, after full consideration of the new code lately issued by the Education Department, see our way to securing a beneficial application of endowments, either by establishing a higher department in the elementary school, in which science should be taught, or by providing teachers of science in common for several schools in a district, or by science exhibitions or prizes, or by giving funds for the supply of proper instruments and apparatus. It certainly seems that no fitter use can be now found, whether for endowments which have through the action of the Legislature ceased to be needed for ordinary elementary teaching, or for non-educational endowments converted under section 30 of the Endowed Schools' Act to educational purposes, than the better promotion of all such knowledge as bears directly upon the industrial occupations of the people, but is not adequately encouraged by other means.

" 7. I have spoken above of the large discretion which we purpose giving to the governing bodies created by our schemes. Their constitution is one of the most difficult, as it is one of the most important parts of our work. The scheme prescribes, within certain fixed limits, the general character of the school which is to be administered, and the general purpose to which an endowment is to be applied. The constitution of the governing body is framed with reference to the character of the school, and we then leave the duty of selecting the governors to various constituencies without restricting their discretion, so as to secure any special representative of science, or of any other branch of instruction. The details of the instruction we leave to the control of the head master.

" 8. Your Grace will see from the above account that our schemes, broadly speaking, do little more than decide who shall apply the endowments, and what objects shall be kept in view in their application. But the future success of the schemes will depend on the manner in which they are worked. And when new subjects are being introduced into the school course, it is especially desirable that accurate information should be easily obtainable as to the best methods and appliances for working them. This information is desirable, not only for the governors, that they may adopt and provide them, but also for us, that we may give the governors the requisite powers. It will give us much greater confidence in prescribing the teaching of science, and give us much greater hopes of conciliating general support to our proposals, if the proposals are supported, and the best means of executing them defined and explained by the high authority of your Grace's Commission.

" 9. I venture briefly to specify some of the points which seem to us especially to require illustration, and which it may, perhaps, be within the scope of your Grace's Commission to consider. They require to be considered in reference both to the several grades of schools, viz., those in which the scholars are intended to complete their education by the age of 15, those in which they are intended to continue till 17, and those in which they do not complete their education before the age of 19, or thereabouts; and, also, in some cases, to the varying circumstances of town and country. These points are:—

- " (a.) The relative educational value of the different branches of science
- " (b.) The age at which children are best fitted to begin such studies.



- " (c.) The amount of time which, on a fair view of the time at the disposal of the several schools, may be fairly claimed for physical science; and what subjects now forming part of the school course might be displaced with least loss, in order to make room for the new studies. The Commissioners are of opinion that the subject which in many schools might give way with least disadvantage is Greek; but the matter is one eminently deserving attentive consideration
- " (d.) The best methods of teaching science, and the appliances necessary for its effectual development, with the size and cost of laboratories, instruments, models, books, maps, and the like, suitable for larger and more expensive, as well as for rural and poor schools
- " (e.) The present, and probable future sources of supply and cost of well-qualified teachers; and the expediency of establishing institutions to train such teachers, whether separate or as branches of general training colleges for teachers above those of elementary schools; or, again, as appendages to large schools in which science is taught.
- " (f.) The need of encouragement, subsequent to school life, for the study of science, either by way of bare examinations, or of scholarships at the Universities or elsewhere, or of admission to public posts, e.g., through the Indian and Home Civil and Military Service Examinations.
- " (g.) The need of special institutions, such as Technical Colleges, corresponding to Theological Colleges for the clergy, or Woolwich and Sandhurst for the army, for the prosecution of scientific studies after school.
- " I have the honour to be,  
" My Lord Duke,  
" Your Grace's obedient servant,  
" LYTTLETON.  
" His Grace the Duke of Devonshire.  
" &c. &c. &c."

## APPENDIX II.

## SECRETARY'S REPORT ON THE TEACHING OF SCIENCE IN CERTAIN PUBLIC AND FIRST-GRADE SCHOOLS; TOGETHER WITH APPENDED PAPERS.

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## INTRODUCTION.

## MY LORD DUKE,

In submitting to your Grace the Report on Science Teaching in Schools, which I have prepared in accordance with the instructions of the Commission, I beg leave, in the first place, to state the manner in which the information required has been obtained.

It will be within the recollection of the Commissioners that prior to the date on which I was instructed to make my inquiry, a letter had been sent to the Head Masters of certain of the Schools, asking them to furnish a statement showing to what extent Scientific Instruction had been introduced into them, how many pupils had availed themselves of it, and with what effect, in each year, since its introduction. Although a considerable amount of valuable information was received in reply to that circular letter, the amount of information was not at all constant for each School; and it struck me as quite possible that if I limited myself to a mere inspection of the Schools, without any common programme, the information that I should obtain by merely visiting the Schools might be as unequal as that furnished by the replies to the statement in question.

In order, therefore, to obviate this possible objection, I prepared a list of queries dealing with the questions which I imagined the Commissioners might consider to be of the greatest importance, having in view the letter from the Chairman of the Endowed Schools' Commission, dated the 25th of March 1871; and before acting upon those queries, I fortified my opinion by consulting Professor Huxley, one of Her Majesty's Commissioners, and Mr. Fitch, one of the Assistant Commissioners of the Endowed Schools' Commission. They were good enough, not only to approve my mode of action, but to add largely to the queries. It was ultimately decided that these queries should be sent to the Schools already named with a covering letter. I append a copy of the covering letter and of the queries.

" Aid to Science Commission,  
6, Old Palace Yard, London, S.W.,  
Sept. 27, 1872.

" SIR, " I AM directed by the Duke of Devonshire, the Chairman of this Commission, to state that the Commis-

sioners are extremely anxious to obtain the fullest information respecting Science teaching in the public and first-grade schools, and the Commissioners will, therefore, feel greatly obliged if, in addition to the information which you have already been good enough to furnish, you will kindly favour them by answering, as far as you may be able, the several questions in the accompanying Schedule

"I am to add, that as the Commissioners are desirous of obtaining information from schools differing in organisation, the questions in the accompanying Schedule are designed to cover the work of a good many schools. It is not, therefore, expected that answers will be given to any questions but those which may happen to apply to your school.

"I am further to say that I have been requested by His Grace to confer with you personally, to explain the precise objects the Commissioners have in view, and the kind of information which will be most valuable to them, if you consider such a course desirable, in which case I shall be obliged if you will inform me on what day it will be most convenient to you that I should visit your school

"I have the honour to be, Sir,  
Your obedient servant,  
J. NORMAN LOCKYER,  
Secretary."

"SCHEDULE of PARTICULARS on which Information is desired by the Royal Commission on Scientific Instruction and the Advancement of Science

"Name of School or College, \_\_\_\_\_

*General Arrangements.*

- "I How is the school classified?  
"II. Is Science a necessary part of the school course, or is it taught only in special forms or departments?  
"III. Copy of time table  
"IV Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately)  
"V. Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes.  
"VI Amount of knowledge required before the study of Science is commenced.  
"VII Is any alternative or choice of subjects offered?  
"What departments of Science are preferred?  
" (a) By parents?  
" (b) By the boys?  
"VIII What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?  
"IX. What weight is assigned to scientific attainments in determining a boy's position in the school?

*Methods of Teaching*

- "X. What proportions of the lessons take the form respectively of—  
" (a) Oral teaching and demonstration?  
" (b) Book work?  
" (c) Practical work?  
"XI. Which form of lesson is found to be most effective?  
"XII. How are text-books used? e.g., is book-work supplementary or preparatory to the oral lesson?  
"XIII. Is the use of note-books encouraged (a) during or (b) after the lesson, and to what extent?  
"XIV. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?  
"XV Describe any method of teaching some special branch of Science which has been found successful in your school.

*Instruments of Teaching.*

- "XVI. What special provision (e.g., laboratory, lecture-room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?  
" (Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

"XVII. Number of assistants and curators, and annual cost.

"XVIII' What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c?

"XIX. Is there a workshop? and if so, how, and for what particular purpose is it used?

"XX. What text-books are in use? distinguishing between those for the junior and senior classes?

"XXI To what books of reference, other than ordinary school books, have the scholars access?

"XXII Is there any Scientific Society or Club in connexion with the School? and if so, who compose it, how is it worked, and what is its influence on the boys?

*Tests of Progress.*

- XXIII How often is the work tested?  
"XXIV In what way? e.g., by examination of note-books, or by oral or written questions?  
"XXV By whom? by the teachers of the subjects, or by an independent examiner?

*Teachers.*

- "XXVI. Is there any difficulty in procuring competent Science Masters?  
"XXVII Where are the best obtained? have they been specially trained for the work, and, if so, in what does such training consist?  
"XXVIII. What evidence of scientific qualification tendered by candidates is found to be of most value?

"XXIX. Can you state any results of Science teaching in the school? Such as—

- " (a) Success, professional or otherwise, of individual scholars?  
" (b) Influence upon the general studies and intellectual life of the school?

"XXX Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful Students of Science in the School?

"XXXI What improvements, do you think, could be effected in the teaching of Science in your own School?

"XXXII What are the principal obstacles to the teaching of Science in your own School?

"XXXIII How could the Universities best assist Science teaching in Schools?

"XXXIV Can you suggest any way in which Government could assist Science teaching in Schools, as, for example, by inspection?

"XXXV. Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

"Head Master."

"Date \_\_\_\_\_"

In many cases the answers were not given until I had visited the school personally and stated verbally to the Head Master and the Science Master, in greater detail than was possible in the queries, the precise information required by the Commissioners and the object for which that information was sought.

In the various sections which follow, I have brought together, for the convenience of the Commissioners, the information thus obtained, that is, obtained both by inspection and by the printed replies to the questions. I have introduced my own opinions as little as possible, and I make no claim for originality in the Report: my only effort has been to place the available information before the Commission in the most authentic and convenient form. I have, however, referred at greater length to some of the points raised, and in order to strengthen the views which I have expressed, I have added, as Appendices to the Report, certain documents which support them.

J. NORMAN LOCKYER.

## § 1.—ON THE GENERAL ARRANGEMENTS OF THE SCHOOLS.

It is important, for a clear understanding of what follows, to give, at the outset an idea of the organization adopted for teaching purposes in the various schools. This is not only necessary in order to analyse exactly the various time tables, and to determine the exact place of science in the curriculum, but I think it will be interesting to the Commissioners to see the various groupings adopted: it may be, also, that some light may thus be thrown on the question of "Modern Schools."

The schools may be arranged in the following groups.  
 I. Schools with only one main line, and that *classical*  
 II. Schools with only one main line, in which *general fitness* determines place  
 III. Schools with a Modern Side  
 IV. Other schools.

## I.—SCHOOLS WITH ONLY ONE MAIN LINE, AND THAT CLASSICAL.

*Eton College*

The normal Forms are the VIth (the highest), the Vth, the Remove, the IVth, and the IIIrd; but these Forms are, in some cases, very large, e.g. the Vth contains about 490 boys. The VIth and Vth Forms together are, therefore, split up into 14 divisions, each under a different classical master. These divisions are arranged in groups, called A. B. C. D.

The A group comprises divisions	-	1, 2, 3
B. "	"	4, 5, 6.
C. "	"	7, 8, 9, 10
D "	"	11, 12, 13, 14

For mathematics and science (and in some cases for French), the different groups are divided afresh, on a different principle, among the mathematical staff (or the French staff). A whole group, e.g. B. or C. goes to mathematics together, and the mathematical masters arrange them, according to their mathematical proficiency, in different classes. ten mathematical classes can go on simultaneously.

A similar redistribution, but not so complete, is made for science-teaching.

The Remove and IVth form are similarly arranged, but they have no science-teaching.

Science is a necessary part of the school course from division 4 to 9 inclusive.

It is an alternative subject with Modern Languages, Modern History, Extra Classics, or Extra Mathematics, in divisions 1, 2, 3.

*Rugby School.*

At Rugby, the whole school is divided into—  
 Sixth Form and Upper School.  
 Middle School  
 Lower School

This is a *classical* division, and a boy's position in the school, therefore, depends upon classics.

Each of these main divisions has its own separate classification into sets for Mathematics, Modern Languages, and Natural Science, except the lower school, in which Natural Science is not taught.

There are three Natural Science sets in the 6th Form and Upper School, and seven in the Middle School.

Natural Science forms a necessary part of the course in the Middle School; in the Sixth Form and Upper School, the choice is allowed between Science and German.

*St. Peter's College, Westminster.*

At Westminster the school is classified, according to the attainments of the boys in classical and general learning, into the following forms.

	Boys,
VIth Form	- 20
Shell	- 25
Vth Form, Upper	- 25
Under	- 25
Remove	- 25
IVth Form, Upper	- 23
Under	- 25
Under School	- 20

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For mathematics it is again classed into six divisions, according to proficiency in that study; for French or German into groups of about 50 boys each, subdivided afresh into four or three classes according to proficiency; and for natural science the boys of the three highest divisions of the school, about 70 in number, and some 30 of the lower forms have been taken and classified afresh.

Science is necessary, under the new regulations, for all boys old enough to profit by it and capable of following the teaching. There is a power of exemption in special cases vested in the Head Master, who must report all such exemptions annually to the Governing Body.

*Charterhouse School.*

At Charterhouse we find—

6th	} Upper school.
Upper 5th	
Under 5th	
Upper 4th	} Under school.
Under 4th	
Upper Shell	
Upper Shell	
Upper 3rd	
Under 3rd	
2nd	
1st	

Science forms a part of the obligatory school course from the sixth form to the under third inclusive.

## II.—SCHOOLS WITH ONLY ONE MAIN LINE, IN WHICH GENERAL FITNESS DETERMINES PLACE.

*City of London School.*

The general arrangements of the City of London School are as follows:—

The school is divided for general purposes into Forms and Classes, and these are grouped into divisions for Science purposes

6th form	-	1st division.
5th ditto	-	
4th class	-	2nd division.
Latin class	-	
3rd class	-	3rd division.
2nd class	-	
1st class	-	4th division.
Grammar class	-	
1st junior class	-	5th division.
2nd junior class	-	
3rd junior class	-	6th division.
4th junior class	-	

Science is a necessary part of the school course.

*Dulwich College.*

The school is divided into three Sections (the Junior Section, the Senior Section, and the Sixth Form), within each of which an independent classification is made for each subject or group of subjects in which instruction is given.

Under this System all boys alike receive instruction in those subjects which are regarded as essential to a liberal education, while the opportunity is given of studying, under a distinct classification, such additional special subjects as may be thought desirable, in each case, with a view to the boy's intended profession or pursuit. Every boy is classed in each subject in which he receives instruction strictly in accordance with his actual proficiency in that subject.

The subjects of instruction are grouped as follows. —

In the Junior Section—

1. Form work, including English, Latin, and French.
2. Arithmetic.
3. Drawing.

In the Senior Section and Sixth Form—

1. Form work, including English, Latin, and French.
2. Mathematics.
3. Greek
4. German
5. Physical science
6. Drawing

Instruction in Science is open to all boys in the Senior Section and in the Sixth Form, but is not compulsory, except so far that all boys not learning Greek and the higher Classics are required to take up either Physics or Geology. The Chemistry Classes are held at such times as to be open to all boys in the Sixth Form and the Senior Section of the School, whether they belong to the classes for Physics or Geology, or not.

*University College School.*

A boy's general standing in this school is defined by Forms, the "Form" or mean position of each boy is determined by calculating the average rank of all his classes.

The work is done in "Classes," which rank from Upper Sixth, Sixth, and Lower Sixth, to Upper First, First, and Lower First.

Boys are examined at entry and classified, with a view to their requirements, in each subject separately according to individual proficiency. Thus, the same boy may be in a high class in one subject and in a low one in another.

Each boy, in fact, has his own programme of work, which is not necessarily identical with that of any other boy.

The revision of all classes, and, therefore, of form position, by promotion or degradation at the end of the session is universal. Each step, however, must be earned, that is, a boy must satisfy his master that he can and will follow the work of the rank of the class to which he is advanced.

Individual cases of promotion and degradation are of almost daily occurrence throughout the year, except during the last month of each term, but this is the only limitation to the practice of *ad libitum* revision.

Under this system it is claimed that a boy is not, as in many public schools, kept for a long time in any class which is either too high or too low for him, but may, at any time, be removed from a class which experience has shown is not suitable for him to one adapted as closely as possible to his actual requirements. In this way the opposite evils of disheartening a boy or of making him careless are equally avoided, and his interest in every part of his work is constantly maintained.

Taunton College School.

In Taunton College School we have also an example of a school arranged into upper, middle, and lower (each compartment being subdivided), the principle of classification being uniform, that is, each boy is placed according to his general fitness, and his marks, in all the subjects taught, including, of course, Science, determine his position in his form, further, there is no different arrangement of classes for different subjects.

Science is necessary for all boys in the Upper and Middle Schools.

III—SCHOOLS WITH A MODERN SIDE

At Harrow, Clifton, Marlborough, Wellington, Cheltenham, Rossall, and Christ's Hospital, we find a well-defined, and so styled "Modern Side."

But in the manner in which this Modern Side is regulated we find wide differences.

An important distinction may be drawn between those schools in which a boy, by studying the modern subjects, can rise to the 6th Form, or a 6th Form, and those in which he cannot.

Harrow School.

At Harrow the school consists of two sides. (1.) The Classical side, and the Modern Side, established in September 1869. The Forms are as follows:

Classical Side		Modern Side.	
The Monitors and VI 1	- - 35 boys.	VIth	- - 6 boys.
VI 2	- - 31 "	Upper Vth	- - 9 "
First Vth	- - 35 "	Lower Vth	- - 12 "
Second Vth	- - 32 "	Modern Remove	- - 10 "
Third V.	- - 33 "	Upper Shell	- - 11 "
Upper Remove	- - 33 "	Lower Shell	- - 4 "
Lower Remove	a 34 } β 29 }		
Upper Shell	- a 32 } β 33 }		
Middle Shell	- a 32 } β 31 }		
Lower Shell	- - 33 "		
First IVth	- - 33 "		
Second IV.	- - 32 "		
Third IV.	- - 17 "		

Science is taught to all boys on the Modern Side, and to boys in the Vth Forms and Upper Remove on the Classical Side.

Wellington College.

At Wellington College, we have two schools side by side, as shown in the accompanying scheme, the "Classical School," and the "Mathematical" or "Modern School." These are quite parallel and equal in position and status. The Mathematical School contains rather more than one-third of the whole school, or nearly two-fifths, excluding in the Lower School.

Classical School.	Mathematical or Modern School.
Sixth Form	Sixth Form
Upper School	Upper School.
Middle School	Middle School.
Lower School	

It will be observed that there is a sixth form on each side, and the Prefects of the schools may be indifferently in each school. Boys are not allowed to enter the Modern School unless they are distinctly qualified to do so. The masters are judges as to this. Boys may be transferred from one school to the other at any point of either school; and thus, I am assured by the Head Master, is frequently done, so that there is, so to speak, a complete intermixture of the two divisions. Those whose classical work is important to their future (or who will, *e.g.*, make classics serviceable in examinations, as at Woolwich), but wish to end their work at school with a mathematical training, frequently enter the Mathematical School from the sixth or fifth. Conversely, good scholars in the Modern School have some classical lessons with the classical sixth.

For modern languages, mathematics, and science, the forms are rearranged into sets as under—

Classical	Mathematical or Modern.
Sixth into	Sixth and Upper School into
- 2 mathematical - sets.	{ 4 mathematical - sets.
- 2 German - "	{ 3 science - "
- 1 science - "	{ 1 Greek - "
Upper School into	Middle School
(3 forms) - 4 mathematical - "	{ 3 mathematical - "
- 4 modern language - "	(3 forms)
Middle School into	[Modern languages being the basis of form division, but promotions made by all subjects conjointly.]
(4 forms) - 5 mathematical - "	
- 5 modern language - "	
Lower School into	
(2 small forms) - 3 mathematical - sets.	
- 2 modern language - "	

Science is necessary on the Classical Side in the sixth (unless Drawing be preferred); on the Modern Side in all forms but the lowest (unless Greek be preferred). There is also a voluntary class in Practical Chemistry.

Rossall School.

At Rossall, also, we find a Modern School side by side with a Classical one, and almost, if not quite, on an equal

footing with it, a severe competition existing between the schools in the results of the teaching of the subjects common to both, the same subject being dealt with by different teachers. The difference between the two schools consists in replacing Greek and drawing in the Classical school by higher Mathematics, English, Chemistry, and Book-keeping in the Modern one.

The divisions in these schools are as follow:—

	<u>Classical.</u>		<u>Modern</u>	
Monitors	- { Upper. Lower.			
Probationers	- { Upper. Lower.			
V. Form	- { Upper } -	A Upper,		
IV. Form	- - -	A Lower.		
III. Form	- - -	B Upper.		
II. Form	- - -	B Lower,		
I. Form	- { Upper. Lower			
Lower School	{ Upper Remove. Lower Remove.			

Science is a necessary part of the school course in the Modern Department, but is open to volunteers from the Classical Side

*Winchester College.*

At Winchester College the main division is into four Blocks, called—

- (A) Sixth Book of 60 (in round numbers)
- (B) Senior Part V of 110 " "
- (C) Middle Part V. of 150 " "
- (D) Junior Part V of 60 " "

Besides these there is a Modern Class, ranking with B. There have been for some time one or two Prefects at a time, belonging to the Modern Class, some of whom have taken part with the other Sixth Book boys in their lessons in the subjects which they did in common.

The blocks are subdivided for the several subjects of study, as follows, into the following number of classes:—

	Classics	Mathematics	Science.	Modern Languages.
Block A into	2	6	1	3
B -	4	7	4	4
C -	5	10	—	6
D -	2	4	—	2

Science is taught to boys in the Upper Sixth Book who have evinced special capacity for it, or who desire it themselves, or whose parents wish it, and to all boys in the Lower Sixth Book, in Senior Part V., and in the Modern Class.

*King's College School*

The school is classified into—

- A. Classical Department.
- B. Modern Department
- C. Preparatory or Lower School.

The following is the distribution of the classes:—

<u>Classical Side.</u>	<u>Modern Side.</u>
Upper Sixth	* Upper Sixth
Lower Sixth	* Lower Sixth
Upper Fifth	* Upper Fifth
* Senior Matriculation Class	* Middle Fifth
* Junior Matriculation Class	
Lower Fifth.	* Lower Fifth
* Fourth.	* Upper Fourth.
	* Lower Fourth.
* Remove.	* Upper Remove
	* Lower Remove.

Science Class.

Commercial Class

Lower School

\* Third

Upper Second.

Lower Second

\* Upper First.

— Middle First †

Lower First

The classes marked \* attend lectures on science and take up class books on science.

† Note.—“Since the date of the Report, King's College School, the Head Master states, “has considerably increased, the nomenclature of the Classes has been altered, a Middle School has been added, the teaching of Science has been still further extended, and additional Science Prizes have been introduced.” October 22, 1873.

Science is a necessary part of the school course—

- (1) In the matriculation, fourth, and remove classes of the classical division
- (2) In the whole of the Modern Department, excepting the commercial and special classes.
- (3) In the Third and Upper First classes of the lower school.
  - (a.) The Elementary Physical Class is attended by the Fourth and Remove (A), the Upper and Lower Fourth, Upper and Lower Remove (B), the Third and Upper First (C).
  - (b) The Chemical Class is attended by the Matriculation Class (A), and Upper and Middle Mathematical Classes (B), and by a few boys who join for the Practical Chemistry
  - (c) The Advanced Physical Class is attended by the First, Fifth, Upper and Lower Fourth Matriculation Classes (B).

*Clifton College.*

At Clifton, also, there is a well-developed Modern Side, the divisions of which are arranged according to proficiency in Science:—

<u>Classical (229 Boys).</u>		<u>Modern (110 Boys).</u>
Sixth Form.		
Fifth Form.	{ First Division. Second Division.	First Division.
Fourth Form.	{ First Division. Second Division.	Second Division.
Third Form	{ Third Division. Fourth Division.	Third Division.
Junior School—114 Boys—		Junior School.

Science is taught as an alternative for German in the Sixth and Fifth, that is, the four highest forms of the Classical Side. In the remaining forms of the Classical side, and throughout the Modern Side, as also in the two highest forms of the Junior School, it is taught as a matter of course to all boys without exception. In the lowest three forms of the Junior School, consisting of boys between 10 and 12 years of age, Science is not taught. In the Sixth and Fifth forms, both Classical and Modern, boys who show special taste for Science, or who are likely to require it for professional purposes, or for some competitive examination, are also taught in special classes so arranged as to form alternatives for some other parts of the school routine. There are also voluntary classes doing practical work in the Chemical Laboratory, Botany, Geology, Physical Geography, Zoology, and Physiology

It is specially to be remarked that the divisions of the Upper Forms on the Classical Side represent proficiency in Science.

This curious fact, perhaps, arises from the other one in this school. There are special Science Classes for the Sixth and Fifth Forms, besides Voluntary Classes open to the whole school; which, in the case of Chemistry, are taken more advantage of by the Classical boys than by those on the Modern Side. An idea of the arrangement of these Voluntary Classes may be gathered from the following extract from the Report:—

“(a.) Voluntary Classes:—

“(1) Boys working in the chemical laboratory are obliged to attend not less than three hours every week, many go much more than that. The hours of laboratory work are generally taken from what in our terminology is called ‘out-of-school hours,’ designated in the question as playtime.

“(2) The remaining voluntary classes mentioned under question 2 generally meet once a week. In the case of Botany and Geology, the lessons are supplemented by excursions from time to time on half-holidays. In all the various classes the boys are expected to keep note-books, and to give some time to the study out of school, either as preparation for the lesson or in the way of reading afterwards. It should also be added, that of Voluntary Botany, Geology, and Physical/Geography Classes, it seldom happens that more than two are going on during the same term; that the Zoology and Physiology Classes are confined to a small number of the senior boys, and that none of these voluntary classes involve any extra payment excepting the work in the chemical laboratory.”

*Marlborough College.*

The arrangements at Marlborough are as follows:—  
There are three divisions of the school, the Upper, the Lower, and the Modern School. The lower school contains all those junior boys whose attainments do not enable them to win a place in the upper school. The modern school is mainly composed of boys intended for the army and navy, for Woolwich, for the Engineering College, for the Indian Civil Service, and for business.

These are arranged as follows:—

<i>Classical</i>	<i>Modern.</i>
Sixth.	
Upper Fifth.	Upper Division.
Middle and Lower Fifth	Middle Division A.
Upper Shell.	Middle Division B.
Upper Fourth	Lower Division
Middle and Lower Fourth	
<i>Lower School.</i>	
Upper Third	
Lower Shell.	
Lower Third.	
Upper Second	

There are two voluntary science forms from the Classical Side, consisting of boys from the Middle and two Lower Fifths, and from the Upper Shell and the two Upper Fourths—

Two hours a week of science work forms a necessary part of the school work of the upper and two middle divisions of the modern school (about 80 boys), and one hour a week is necessary in the case of the upper shell, upper fourth A, and upper fourth B. (about 75 boys in all). Otherwise, certain forms are grouped together for science purposes: thus, about 10 boys from each of the three fifths (lower fifth A and B, and middle fifth), with five from the upper fifth, and four from the sixth form for the upper voluntary science form of 43 boys. Again, about 10 boys from each

of the upper shell, upper fourth A form, and upper fourth B form, form the lower voluntary science form of 31 boys. Each of those forms are voluntary; there are three alternative subjects

*Cheltenham College*

At Cheltenham College there are three departments, viz., the classical, the military and civil, and the junior (boys under 13 years of age)

In the Classical Department science is taught as an alternative with German to boys in the four highest of the nine classes; and to select boys in first class a second scientific subject is also taught as alternative with French. Boys in the Latin class (no Greek) also are taught science. Total number learning science, 86.

In the Military and Civil Department, science is a necessary part of the school course for all boys in the four highest of the nine classes. Total number learning science, 128.

There is perfect equality between the Classical and Military Departments. The Prefects are taken from each Department equally, i.e., every boy in any division of the first or highest class of either department becomes a Prefect at 17 years of age, or at 16, if he is in the highest division of the First Class of either Department. Marks are given for work in sciences as for other work; and Promotion is made on the total of marks including marks for science.

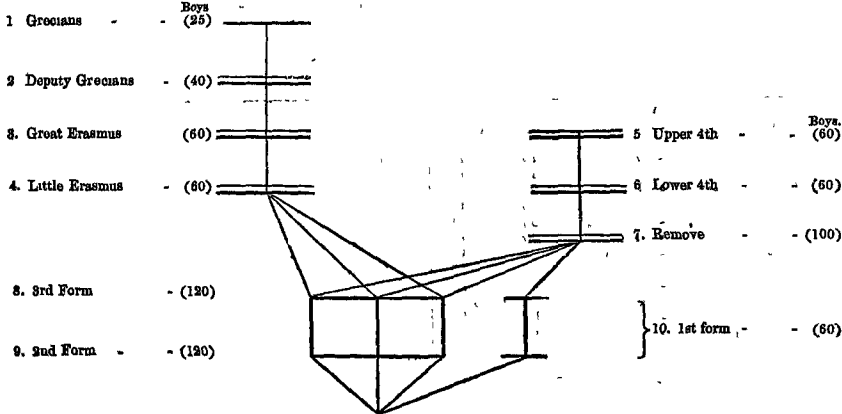
There is a Natural History Society with evening meetings in winter, and excursions (chiefly botanical) in summer.

*Christ's Hospital*

The classification adopted at Christ's Hospital is somewhat peculiar.

In the "Grammar School" or language department, every boy (with the exception of the 50 Naval Boys) passes at least half his school hours, besides this, there are the Mathematical and Commercial Schools and a Naval School.

The accompanying diagram will show the arrangement adopted in the Grammar School, and it will be seen that part of it is, in effect, a Modern School.



11. Hertford School (400)

The horizontal lines denote the several classes. The classes 8, 9, are under three parallel masters. 10 is composed of backward boys, who are older than the average age on coming from Hertford.

Boys pass from 8, 9, into 1-4 as soon as they are fit, but boys who reach the age of 13½ before they are qualified for 4, are draughted from 8, 9, into 7, as are also all boys from 10 on reaching the age of 13½.

The classes 1-4 are intended to fit boys for professional life, 5-7 for commercial life.

Classes 1, 2, spend 9 hours a week, and 3, 5, an average of 6½ hours in the Mathematical School.

Classes 3, 5, give an average of 5 hours a week, and 4-10 half their school hours, minus a short time given to drawing, in the Commercial School (for arithmetic, writing, reading, geography, &c.)

In the Naval School some 50 boys are prepared for sea.

Science is a necessary part of the school course for Classes 1, 2, 3, and 5, and very elementary lessons in Natural Philosophy are given to the boys of Class 10, with the view of stimulating their powers of observation.

IV.—OTHER SCHOOLS

*Manchester Grammar School.*

The arrangements adopted at the Manchester Grammar School will be gathered from the following scheme, in which the Forms are numbered from the 6th downwards.—

FORMS.

Classical.	Science.	Mathematics.	Modern Languages.
6th	6th	6th	
Transitus	Transitus		
Upper 5th			
Lower 5th	5th		
" 4th			
Remove	Remove		Remove
" 4th			French 3rd
" 3rd			" 2nd
" 2nd			" U
Upper 1st			" M.
Lower 1st			" L.

For the purpose of mathematical teaching all the forms below the Three Sixths, Science, Classical, and Mathematical are re-distributed into three groups each consisting of five sets.

In the Science and Mathematical forms the boy has his choice between the study of classics and modern languages.

In addition to constituting the principal part of the teaching of the four Science forms, Science is an essential part of the teaching of the Mathematical Sixth. There are, besides, optional classes for the teaching of Mechanics, Elementary Chemistry, and Physical Geography, drawn from all parts of the school.

## § 2.—SUMMARY OF THE NUMBER AND AVERAGE AGE OF BOYS LEARNING EACH OF THE VARIOUS SUBJECTS IN THE NATURAL SCIENCE CLASSES.

ETON COLLEGE.			
	Optics.	Chemistry	Hydrostatics.
Number of boys	5	64	22
Average age	17-18	15-18	16

[The above refers to Mr Madan's present classes.]

Divisions I.—III	8 classes in Chemistry 1 class in Physical Geography.
IVth division, Chemistry.	6 classes in Physical Geography
Divisions V.—XIV formed until last schooltime	3 classes in Astronomy 3 classes in Mechanics and Hydrostatics.
Last schooltime	1 class in Heat
Divisions V.—VIII formed	2 classes in Physical Geography 3 classes in Mechanics.

Divisions IX.—XIV had no Physical Science  
Other boys are learning physical geography, or elementary astronomy, or mechanics, in the Science hours. See Mr Dalton's answer

Their ages range from 18 to 13.

### HARROW SCHOOL.

At Harrow the boys on the Modern Side have been taught in two divisions, each consisting of about 26. In future they will be divided into three divisions. The boys on the Classical Side are at present taught in four divisions, each consisting of about 32 boys.

### RUGBY SCHOOL.

At Rugby School the number of boys and average age in each set are given below:—

Sixth Form and Upper School.		
	Number of Boys.	Average Age.
1st set, Heat and Optics	22	17½
2nd set, Electricity	17	16½
3rd set, Chemistry	50	16½
Middle School.		
4th set, 1st Physics	20	16½
5th set, 2nd Physics	51	16½
6th set, 1st Geology	84	16½
7th set, 2nd Geology	24	16½
8th set, 1st Botany	22	16½
9th set, 2nd	84	14½
10th set, 3rd	80	15½

### CLIFTON COLLEGE.

Classical Side.				Modern Side.			
		Boys.	Average age.			Boys.	Average age.
VI and V.	1st division	19	16	Modern Side	1st division	31	16
"	2d "	12	16	"	2d "	36	16½
IV and III	1st "	24	14½	"	3d "	43	14½
"	2d "	43	14½				
"	3rd "	33	14				
"	4th "	30	13				
Zoology	average No.	4	17				
Physiology	"	4	17				
Chemical laboratory	two divisions	40	18 to 16				
Botany class (voluntary)	average No.	12	15 to 16				
Geology	"	11	15 to 16				
Physical Geography	"	10	15 to 16				

Junior School, one division, 54 boys, average age, 12.

### MARLBOROUGH COLLEGE.

At Marlborough College, the age of those boys who study science varies between 13 and 19, the average age being, perhaps, 16. The actual number of boys who do science is at this time 202, of these 47 do only one subject a week (1 hour chemistry), 155 do two subjects a week (1 hour chemistry, and 1 hour electricity), while the Woolwich class, numbering 17, do three subjects a week.

### WINCHESTER COLLEGE.

- Mechanics and hydrostatics, sixth book. No., 12. Age, 17.
- Geology No., 30. Age, 17.
- Physical geography. { No., 40. Age, 16.
- Physical geography. { No., 40. Age, 16.

### ST PETER'S COLLEGE, WESTMINSTER.

- 62 Natural Science—Hydrostatics, A. 3 classes—average age, seniors, 17; juniors, 16 or less  
27 Natural Science—Physical Geography, B. 2 classes—average ages 16, 15, or less.

### CHELTHENHAM COLLEGE.

In the Classical Department.				In the Military Department.			
		Boys.	Average age.			Boys.	Average age.
Class I.	Electricity	6	18 years 1 month.	Class I.	Chemistry	39	17 years 0 months
	Chemistry	6	" 0 "		Electricity		
	Botany	20	" 8 "	" II.	Geology	30	16 " 2 "
	Chemistry	18	" 9 "		Light		
	Botany	8	" 6 "	" III.	Heat	29	16 " 3 "
	Chemistry	12	" 6 "		Elementary		
Latin Class.	Chemistry	16	" 2 "		Physics	29	16 " 1 "

WELLINGTON COLLEGE

Classical sixth (average age)	-	17.057	yrs. m.
Mathematical school, 1st and 2nd set, 24 boys,			
average age	-	16	11
Mathematical school, 3rd set, 26 boys, average age		15	11
" 4th " (once a week only) "		15	4

CHARTERHOUSE SCHOOL

	No. of boys.	Age	} Upper School.
6th Form	12	17	
Upper 5th "	12	16	
Under 5th "	20	16	
Upper 4th "	19	14	
Under 4th "	15	14	
Upper Shell "	14	13	
Under Shell "	15	13	
Upper 3rd	18	12	
Under 3rd	21	12	

CHRIST'S HOSPITAL.

Range of age of 1 Grecians	-	25 boys	-	16-19.
" 2 Deputy Grecians		40	-	14-16
" 3, 5, "		120	-	14½-16.
" 4, 6, "		120	-	12½-14½.

CITY OF LONDON SCHOOL

	No. of boys.	Average age
1st division { 6th form	27	17
5th "	24	15½
2nd division { 4th class	36	15
Latin class	50	14½
3rd division { 3rd class	61	14½
2nd class	64	13½
1st class	85	13½
4th division { Grammar class	97	13½
1st junior class	70	13 nearly
5th division { 2nd junior class	57	12½
3rd junior class	49	10½
6th division { 4th junior class	47	10½

TAUNTON COLLEGE SCHOOL

Advanced chemistry, 20 boys of about 16 years old	do
Botany, do	do
Elementary chemistry, 50 boys of about 14 years old	do
Mechanics, do	do

KING'S COLLEGE SCHOOL.

- (1) Advanced class of natural philosophy Number of boys, 35 Average age, 16.
- (2) Chemistry class No. of boys, 54 Average age just under 16.
- (3) Elementary class in physics. No. of boys, 160. Average age slightly under 16.

MANCHESTER GRAMMAR SCHOOL.

	No. of boys	Average age.
Mathematical Sixth	15	17½
Science Sixth	20	16½
Science Transitus	30	15½
Science Fifth	30	15
Science Remove	40	14

DULWICH COLLEGE

Chemistry, 1st class	-	24 boys.	Average age 15½
" 2nd class	-	23	13½
Practical chemistry, 1st class	-	34	15½
" 2nd class	-	18	13½
Electricity and magnetism	-	62	14½
Geology	-	24	14½
Physical Geography	-	13	14½

The Master of Dulwich College remarks, with regard to this return — "I have stated the actual average age, but the return in this respect is illusory, since the recent increase of the school (from 130 to 500 boys), and the excess, in consequence of young boys lately admitted, reduces the average of age below its normal amount"

UNIVERSITY COLLEGE SCHOOL

Michaelmas Term, 1872

	No. of boys.	Average age
		Years Months
Upper Sixth, Applied Mathematics	10	16 1
Upper Sixth, Chemistry, theoretical and practical	18	15 11
Sixth, Natural Philosophy	47	15 6
Upper Fifth, Chemistry and Chemical Physics	57	15 3
Fifth, Chemistry	30	15 4
Fifth, Astronomy	21	15 2

(The average age is computed from the beginning of the Sessional Course)

§ 8.—HOURS PER WEEK GIVEN TO SCIENCE IN THE SEVERAL COLLEGES AND SCHOOLS.

College or School	Class Work in School Hours.	Practical Work.	Preparation.
IRON COLLEGE	A Divisions, four hours to Alternative Subjects, Science, History, &c. &c. B Divisions, two hours to Science C Divisions, the same as B., except that there is also a Geography lesson	There is voluntary work in the laboratory during play hours	Exercises are done out of school.
RUGBY SCHOOL	Two lessons in each subject of one hour's duration each.	Actual dissection of specimens by each boy is a regular part of each botanical lesson In the chemical laboratory all the work is practical	The amount and kind of preparation required differs in different "sets"
CLIFTON COLLEGE	Classical Side: VI. & V. also the upper and lower IV and III each division two lectures every week Modern Side first, second, third, and fourth Divisions each division four lectures every week Junior School in one division, one lecture every week Special Science Classes, consisting of boys in the VI and V forms, seven or eight hours every week in addition to the lectures mentioned above.	Boys working in the chemical laboratory are obliged to attend three hours every week, generally taken from "out-of-school hours." A few boys do some work in the small physical laboratory with the physical master	In all the various classes the boys are expected to keep note-books, and to give some time to the study out of school, either as preparation for the lesson, or in the way of reading afterwards
MARLBOROUGH COLLEGE	Modern school, middle division A., one hour to chemistry and one hour to electricity, middle division B., two hours to chemistry, Upper Shell Form, one hour to chemistry. Lower Voluntary Form, consisting of about 10 boys from the Upper Shell, and from each of the two upper fourths (A. & B.), one hour to electricity.		



Hours per Week given to Science in the several Colleges and Schools—*continued.*

College or School.	Class Work in School Hours.	Practical Work.	Preparation.
MARLBOROUGH COLLEGE— <i>cont.</i>	<i>Upper Division (Modern School)</i> one hour to chemistry, and one hour to electricity <i>Upper Fourth A., and Upper Fourth B.,</i> one hour to chemistry. <i>Upper Voluntary Form,</i> chiefly from the middle and two lower fifths, one hour to electricity, and one hour to chemistry		
WINCHESTER COLLEGE.	<i>Sixth Book and Senior Part V.,</i> two hours to Natural Science <i>Modern Class,</i> two hours.	- - -	The work for science out of school consists of this:—Note-books are kept by the boys, and looked over carefully by the Master once a week; and the boys have some book (in most subjects), also, which they are requested to study out of school.
ST PETER'S COLLEGE, WESTMINSTER.	<i>Senior class,</i> two hours; <i>Junior class,</i> one hour.	- - -	At least two hours a day of additional work in preparation is given by industrious boys, and one hour enforced from all.
CRUELINGHAM COLLEGE.	<i>Classical Department, Class I A B.</i> Two hours and a quarter to botany, and the same to chemistry, one hour and three quarters to electricity <i>Class II A.</i> One hour and three-quarters to chemistry <i>Class II B.</i> : One hour to chemistry. <i>Class III.</i> One hour and three-quarters to botany, one hour and three-quarters to chemistry <i>Military and Civil Department, Class I A.</i> Four hours and three-quarters to Natural Science <i>Class I B,</i> and <i>Class I C</i> Two hours to Natural Science <i>Class II A.</i> Two hours to Natural Science. <i>Class II B.</i> One hour and three-quarters to Natural Science. <i>Class III A.,</i> and <i>Class III B.</i> One hour and three-quarters to Natural Science <i>Class IV A</i> and <i>B.</i> Two hours and a quarter to Natural Science	Seven hours to chemistry. Six boys in the classical department are taken, two at a time, three evenings weekly, two hours each time In Botany, great stress is laid on actual dissection and classification <i>Military Department</i> About half the time with the highest classes is given to practical work. With the lower classes, about half the time is given, when the subject allows, to experimental demonstration.	In all departments of the college much time is given out of school hours to preparation of work of every kind. All boys are in school 28 hours a week. Hard working boys in the upper classes would give 25 to 30 hours a week to preparation out of school. The idler boarder in the lowest class must give 18 hours a week, in the evenings, to preparation under supervision in large room. Elder boys work in their own study without supervision
WELLINGTON COLLEGE	<i>Classical Sixth.</i> One hour to science, or two hours by those who do not learn drawing <i>Mathematical Sixth.</i> Three hours to science (or Greek) <i>Upper School,</i> three hours (or Greek). <i>Middle School</i> (two of the three forms), one hour	About two-thirds of the first division two hours to Electrical Measurements (the subject at present), for five or six consecutive weeks in the year four boys are taken together. In the voluntary chemical class, 10 boys in two sets. Each set works one hour and a half in the laboratory	In <i>Modern School,</i> two hours to the reproduction of lectures, or the working of examples in <i>Classical School,</i> one hour to the same.
ROSSALL SCHOOL		Five or six boys work at practical chemistry in the laboratory, two hours and half.	No time is devoted to preparation out of school.
CHARTERHOUSE SCHOOL.	Two hours		
CHRIST'S HOSPITAL	<i>Classical School, Class III, Upper Half</i> two hours to chemistry, <i>Class III, Lower Half,</i> one hour to Natural Philosophy <i>Modern School, Class V., Upper Half</i> Two hours to chemistry, <i>Lower Half</i> one hour to Natural Philosophy The time given to Natural Science is outside the regular school hours as a matter of fact, every boy in the senior part of the school has to give one or two hours a week more than the general school hours to some subject or other. All junior boys have about 26 hours a week in school; all senior boys from 27 to 29 hours	Sometimes replaces class work See Prof. Russell's Report, in APPENDIX VI.	
CITY OF LONDON SCHOOL.	<i>First, second, third and fourth divisions,</i> a lecture, of an hour's duration, once a week <i>Fifth and sixth divisions,</i> a lecture, lasting an hour and a quarter, once a week. An occasional lesson, of one hour's duration, is given in the Lower School.	Practical chemistry, two hours. The half holiday is utilised for the practical work.	A few boys in each division avail themselves of the half hours (12 to 12.30 and 3 to 3.30), for trying some of the experiments shown at the lectures. Boys are also helped (during play time) to prepare for the various science examinations at South Kensington, &c. The science exercises have to be prepared some time during the week.

Hours per Week given to Science in the several Colleges and Schools—*continued.*

College or School	Class Work in School Hours.	Practical Work.	Preparation
TAUNTON COLLEGE SCHOOL	In the Upper School, three hours to chemistry, and two hours to botany In the Middle School, two hours to chemistry, and two hours to mechanics	Two thirds of the time devoted to class work is devoted to practical chemistry. In botany one half the time is given to dissections, schedule writing, and classification.	
KING'S COLLEGE SCHOOL	One lecture to each class—one hour and a quarter for the higher classes, three-quarters of an hour for the elementary classes In the <i>Chemistry Class</i> , lecture and demonstration, one hour.	Twenty boys do practical Chemistry two hours One special boy does considerably more A few boys go into the physical laboratory	
UNIVERSITY COLLEGE SCHOOL	Lower fifth form, one hour and a half to chemistry and physics Upper fifth form, one hour and a half to chemistry, and one hour and a half to chemical physics Upper sixth form, one hour and a half to chemistry	Upper sixth form, one hour and a half to practical chemistry. In the New Laboratory, boys can work for a longer time than this; some are working for more than six hours.	
MANCHESTER GRAMMAR SCHOOL	In the Mathematical Vith, four hours and a half to physics. In the Science Vith, five hours and a quarter to physics, and six hours and three quarters to chemistry In the Science Transitus, one hour and a half to physics, and six hours and three quarters to chemistry. In the Science Vth, three hours and a half to physics, and five hours and a quarter to chemistry In the Science Remove, four hours and a half to physics, and three hours to chemistry	The Science Vith, and Science Transitus receive instruction in practical chemistry four hours per week, exclusive of the usual school hours	
DULWICH COLLEGE	<i>Sixth Form science students</i> during school, four hours. <i>Additional branch of science</i> , four hours. <i>Senior section</i> during school, three hours and a half <i>Additional branch of science</i> , two hours	One hour, for advanced pupils, two hours	The more advanced pupils, two hours for chemistry, and one hour and a half for physics

## § 4.—SUBJECTS TAUGHT TO JUNIOR AND SENIOR STUDENTS.

At Eton, the subjects are Chemistry, Heat, and Physical Geography. Mr Madan points out that Heat, treated in a very simple way, is very attractive to the younger boys. For the senior boys the subjects are Chemistry and Physical Geography; for the juniors, Physical Geography, Astronomy, Mechanics, Hydrostatics, and Heat.

At Harrow, Experimental Physics is the only subject which has been taught in school. A few boys receive instruction in Comparative Anatomy and Physiology during the half holidays, and other times which they can arrange with the teacher.

At Rugby, in the Middle School, and, therefore, with younger boys, the teaching of physics has been found to be less satisfactory than in the Upper School. The subjects that have been tried are hydrostatics and pneumatics, with the elements of heat, but, although most of the boys have shown considerable interest in the *facts and experimental illustrations*, the *power of grasping the principles* and applying their knowledge to easy problems has been acquired comparatively by few. At present the greater number of boys in the Middle School are learning either botany, geology, or elementary physics. In the Sixth Form and Upper School, chemistry and physics are the only subjects taught, with the exception of a short course of physiology. Under physics is at present included heat, magnetism and electricity, and geometrical optics treated experimentally. The experience of the masters goes to show that physics can be taught successfully to a larger proportion of boys than chemistry. Indeed, it would seem that a boy requires an almost special turn of mind to grapple successfully with the ideas involved in chemical affinities and reactions. It is hoped by the masters that, in time, better arrangements

may be made for carrying on the instruction in the Natural History side of Science after a boy has reached the Upper School.

At Chifton College the younger boys are taught elementary physics, physical geography, or botany, the subjects being taken in turn. The elder boys learn chemistry and physics. The Head Master says, "So far as I have been able to arrive at any definite opinion, I consider this to be the best arrangement of subjects from a purely educational point of view, provided that it is supplemented, as with us, by an elastic system of voluntary classes, to facilitate the development of individual tastes. I consider that every branch of scientific teaching which we have tried has been fairly successful, quite as much so as could have been expected in the case of new studies. More particularly, I should speak of chemistry and physics as having proved a valuable addition to our school work in the middle and upper parts of the school, whilst the same may be said of botany, physical geography, and elementary physics among the younger boys, and of geology as taught to a voluntary class."

At Dulwich College a continuous course of instruction is given in chemistry. Instruction is given in each Term in two or more additional branches of Science—heat, electricity, magnetism, geology. The younger boys generally begin their Science Studies with Physics, but a considerable proportion of them join at the same time the Elementary Chemistry Class. The Master of the College says, "I am decidedly of opinion that chemistry possesses the greatest educational value."

At Marlborough College, physics and chemistry receive most attention. The Head Master observes "I cannot say what branch of science has the greatest educational value I should think, as matter of individual opinion (not of experience), the following subjects would be most valuable:—

a For young boys.

Elementary botany.  
" chemistry.  
" mechanics, pneumatics, hydrostatics,  
and hydraulics

b For boys between the middle fourth and the fifth

Elementary heat  
" electricity  
" magnetism  
" sound  
" light.  
" chemistry.

c For boys in and above the fifth.

Mechanics, electricity, magnetism, heat, chemistry.  
Elementary astronomy  
Elementary physiology.

" Series of lectures have from time to time been given by different masters on geology, animal physiology, botany, &c., with satisfactory results in increasing the stock of knowledge possessed by a good many boys, and giving a marked stimulus to a few."

At Winchester College the subject which receives most attention is the surface of the earth, there being always a class in geology, in summer there are several classes in botany. Other branches of physics are taken in a cycle. The Head Master does not think there is any special educational value in the lessons different from what is derived from lessons in other subjects given in the same way. The geological and botanical courses, which cause actual acquaintance with specimens, are the only ones that seem special. Physical Geography has been successfully taught. The Experimental Courses in Physics interest a good many boys, and give them new ideas. Electricity seems to be the best subject; Chemistry, as taught in courses of lectures, does not seem to answer."

At St Peter's College, Westminster, applied physics is the only branch which has as yet been attempted. "A course of lectures on Heat seemed to answer best for the classes generally, but the subject of Electricity was more interesting to a few of the best pupils."

At Cheltenham College the subjects chosen are practically determined by the examinations for which the boys are preparing, e.g. in the Classical Department for scholarships at the Universities and for the Indian Civil Service. In the Military Department the boys are first taught the chief facts and principles of physical science. Chemistry is not taught till a boy reaches the first class, and then it is studied theoretically and practically. In this class, chemistry and heat are alternative subjects, with magnetism and electricity, or with geology and physical geography. "From a purely educational point of view," the Principal considers "Physical Geography, from its aptitude for varied and familiar illustration from History—and Botany, from its power of developing observation in the country walks of every day—the best subjects for young boys. "Afterwards, severer and more strictly scientific subjects."

At Wellington College, in the *Classical Sixth*, an elementary course, lasting about two years and a half, comprising Mechanics, Astronomy, Heat, Steam, the first principles of Chemistry, and Electricity. In the *Modern School*, in the lower classes, Physical Geography, Heat, and Elementary Chemistry, in the upper classes, chiefly Electricity and Magnetism (for Woolwich), also, occasionally, Light and Heat. In the *highest Mathematical set of the Modern School*, Mathematics and Hydrostatics.

At Rossall School, chemistry has been always held to be the chief subject in Natural Science. The Head Master states that "as, according to his experience, Natural Science in schools, as an instrument of education, can only be useful in developing the observation and not the memory, much less the judgment, I am inclined to think that the branches that can be best illustrated by specimens and experiments must really have the greatest educational value. If science is to be taught as an accomplishment, like conversational French, for practical use, then probably chemistry and geology are the most important." He continues, "Geology, to a select class of

"volunteers, has been very fairly taught during the last quarter by lectures once a week illustrated by diagrams."

At Charterhouse School, as yet, only botany and chemistry have been attempted. Botany was taught in the summer quarter, but it was not a popular subject. Theoretical chemistry, the subject for the winter quarter, is popular with most of the boys. Practical chemistry cannot be taught at this school till the laboratory is completed.

At Christ's Hospital the classes of chemistry and natural philosophy have been barely two years at work, and it is hardly possible to judge with what success at present. A very high educational value is attached at this school to the training in mathematical sciences given in Classes I. and II. Every boy in Classes III.–VI. gives at least one hour a week during half a year to Natural Philosophy (oral lectures with apparatus and experiments), as an introduction to the chemistry class, in which he stays at least half a year. Those who show any special aptitude are allowed to continue chemistry, and promoted to the practical class. Further, the boys in III. and V. learn elementary mechanics in the Mathematical School as soon as they are qualified by their mathematical knowledge. In Classes I. and II. Mathematical science (statics, dynamics, hydrostatics, optics, astronomy), is studied in preparation for the Universities, and carried to a high point. The boys in Class X. give one hour a week to very elementary Natural Philosophy (oral lecture with experiments).

At the City of London School most attention is given to chemistry in the lower school, and to chemistry and physics in the higher school.

At Taunton College School, the most popular subjects are chemistry and botany. The Head Master says that he believes this "is due to the special enthusiasm displayed in teaching these subjects, not to any interest inherent in the subjects. The most zealous and effective teacher will make his own subject the most popular, or, teaching several subjects, the subject which he loves best."

At University College School, the subjects taught are: Physical Geography; Chemistry, theoretical and practical; Chemical Physics, Natural Philosophy; Astronomy; Applied Mathematics.

At King's College School chemistry and natural philosophy are the subjects which receive most attention.

At the Grammar School, Manchester, physics and chemistry receive an equal degree of attention. At this school it is found that beginners appear to derive most profit from acoustics, and the more advanced students from optics and chemistry, electricity and heat occupying an intermediate position.

That physics, rather than chemistry, will be found the best subject for boys to begin with, appears to be borne out by the following return (furnished by the Natural Science Master) of the averages of marks obtained at the last examination at Marlborough College. Max = 100—

Upper voluntary (from the fifth)	Electricity	59.14
	Chemistry	35.55
Upper shell	"	31.48
" fourths (A)	"	29.31
" (B)	"	26.16
Lower voluntary (from three preceding forms)	Electricity	42.03
	"	49.49
Upper division Modern School	Chemistry	26.97
	Electricity	48.68
Middle division	Chemistry	17.90
	Electricity	24.41
Lower division	Properties of Matter	35.05
Woolwich class	Heat	36.07

Further important evidence in support of this view comes from the Head Master of Christ's Hospital. He says, "My experience is but short, but I have found already that the plan often adopted of teaching chemistry as the first subject, is not satisfactory. I attended an admirable course of lectures given by the late Dr Mathiessen to a class of our boys, who had had no previous scientific instruction in Natural Science. It was obvious that most of it was lost upon them for want of familiarity with simple scientific notions; and we found it necessary to institute the Natural Philosophy class as an introduction to the Chemistry class." In this remark, the Head Master of King's College School fully concurs.

§ 5.—TEXT BOOKS IN USE AT THE SEVERAL COLLEGES AND SCHOOLS.

College or School.	Acoustics.	Astronomy.	Botany	Chemistry	Geology	Heat.	Hydrostatics.
Eton College -	-	Lockyer's Astronomy (b)	-	Wilson's Chemistry (b), Chambers's Course (b), Harcourt and Madan's Practical Chemistry (b), Fownes' Chemistry (a), Fresenius's Qualitative Analysis (a).	Lyell's Elements and Principles, in the small select class.	Tyndall on Heat, in the small select class.	-
Harrow School	Tyndall on Sound (Modern Side).	Lockyer's Astronomy (Modern Side)	-	-	-	Maxwell on Heat (Modern Side)	-
Rugby School -	-	Lockyer's Astronomy (b)	Oliver's Elementary Botany (b); Asa Gray's Class Book of Botany, and Bentham's British Flora (a).	Roscoe's Chemistry (a); Harcourt and Madan's Practical Chemistry, and Fresenius's Qualitative Analysis (c)	Jukes' School Manual of Geology (b)	Deschanel's Natural Philosophy (a)	-
Clifton College	-	-	Oliver's Botany, Balfour's Outlines	Roscoe is at present the book generally used, but this is about to be replaced gradually by Miller's Text-book of Inorganic Chemistry Cooke's First Principles of Chemical Philosophy, for special classes Miller's Elements of Chemistry, for the Lower Divisions Harcourt and Madan's Practical Chemistry, with MS notes, tables, &c., supplied by the master in the laboratory	Page's Small Handbook. Jukes and Geikie.	-	-
Marlborough College -	-	-	-	W. A. Miller's Elementary Chemistry (a) Roscoe's Elementary Chemistry Frumer (b).	-	Tyndall on Heat as a Mode of Motion (d)	-
Winchester College -	-	Lockyer's Astronomy.	Oliver's Botany.	-	Page's Geology, Jukes' Geology	Tyndall on Heat.	-
St Peter's College, Westminster.	-	-	-	-	-	Balfour Stewart on Heat (a.)	-
Wellington College.	-	-	-	Barff's Chemistry (a & b)	-	Orme on Heat (a & b.), Ganot's Physics (a)	Besant's Hydrostatics (a)

(a) Senior boys (b) Junior boys (c) Laboratory practice. (d) Special pupils.

continued

College or School.	Magnetism and Electricity.	Mechanics	Optics	Physical Geography	Physics, generally.	Physiology	Zoology
Eton College	-	-	-	Keith Johnston's Physical Atlas for Schools (for all boys) In the small select class, individual boys have used Mrs Somerville's Physical Geography; Herschel's Physical Geography	Balfour Stewart's Elementary Physics (b); Ganot's Physics (a).	-	-
Harrow School	-	-	-	-	Deschanel's Physics (Modern Side)	-	-
Rugby School	Ganot's Physics, for Electricity and Magnetism (a)	-	Airy's Geometrical Optics (a).	-	Balfour Stewart's Physics (b).	-	-
Clifton College	Deschanel's Electricity.	Todhunter's Mechanics, in the upper class.	-	-	Deschanel's Natural Philosophy, in the upper class. Balfour Stewart's Physics, in the lower class; do. do. Primer, for the youngest boys	Kirke. Rolleston's Forms of Animal Life	Nicholson's Manual.
Marlborough College	Deschanel's Electricity and Magnetism.	-	-	Hughes's Physical Geography	Privet-Deschanel's Natural Philosophy, (a). E. Stewart's Elementary Physics Primer (b). Ganot's Smaller Physics (d)	Huxley's Elementary Physiology (d).	-
Winchester College	-	-	-	-	Ganot's Physics, Balfour Stewart's Physics.	-	-
St. Peter's College, Westminster.	Ferguson on Electricity (a). Gleig's series, Tate's Electricity (b); do. do. Magnetism, &c. (b)	-	-	Ansted's and Hughes' Physical Geography (a).	-	-	-
Wellington College	Deschanel's Electricity (Everett); Ferguson's Electricity (both by the seniors chiefly)	Goodwin's Statics and Dynamics (a), Todhunter's Elementary Mechanics (a)	Herschel's Familiar Lectures (a), Ganot's Physics (a)	-	-	-	-

(a) Senior boys. (b) Junior boys. (c) Laboratory practice. (d) Special pupils

continued.

College or School.	Acoustics.	Astronomy	Botany	Chemistry	Geology	Heat.	Hydrostatics.
Cheltenham College	-	-	Classical department— Balfour's Elements of Botany (b), Bal- four's Manual of Botany (a).	Classical department—Roscoe's Element- ary Chemistry (b), Harcourt and Madan's Practical Chemistry (a) Military department.—Roscoe's Lessons in Elementary Chemistry (b), Fre- senus's Qualitative Analysis, Laveing's Tables (a).	Military department — Jukes' School Manual of Geology (b), Lyell's Elements and Principles (a).	Balfour Stewart on Heat (b), Deschanel's Natural Philosophy (a); Ganot's Physics (a).	—
Rosall School	-	-	-	Roscoe's Chemistry, Gill's Chemistry for Schools	Page's Geology	—	—
Charterhouse School	-	-	Oliver's First Lessons in Elementary Botany (a & b).	Roscoe's Chemistry (a), Barff's Intro- duction (b)	—	—	—
Christ's Hospital School	Tyndall on Sound (a)	Godfrey's Astronomy (a)	-	Barff's Manual of Chemistry (b), (Roscoe and Gill occasionally) (b)	-	Maxwell on Heat (a), Tyndall on Heat (a)	Besant's Hydrostatics (a), Hamblin Smith's Hydrostatics (b), Galbraith and Haugh- ton's Hydrostatics and Mechanics (b)
City of London School	Lee's Acoustics	-	Oliver's Botany (a).	Jarman's Qualitative Analysis (a), Fownes' Chemistry (a), Miller's Chemistry (a); Hall's Chemistry (b), Buckmaster's Chemistry (Inorganic) (b)	Lyell's Geology (a)	Tate's Heat, &c (a), Lee's Light and Heat.	-
Dulwich College	-	-	-	1st Class — Miller's Inorganic Chemistry (a), Gill's Chemistry for Schools (a), Harcourt and Madan's Practical Che- mistry (a), Fresenius's Qualitative Analysis (a) 2nd Class — Roscoe's Chemistry (" Science Primer") (b)	1st Class — Jukes' Student's Manual of Geology (a) 2nd Class — Page's In- troductory Text Book (b), Jukes' School Manual of Geology (b)	—	Besant's Hydrostatics.
Tannton College School	-	-	Oliver's Botany (a), Lindley's Descriptive Botany (a).	Roscoe's Chemistry (a).	—	—	-
King's College School	-	-	-	Miller's Introductory Text Book. Roscoe's Chemistry Class Book. Gill's Chemistry for Schools (a).	-	-	Besant's Hydrostatics.
University College School.	-	-	-	-	-	Orme's Science of Heat (a).	(None)
Manchester Grammar School.	Tyndall on Sound (a); Lee's Acoustics, &c (b)	-	-	Roscoe's Chemistry (a & b); Bloxam's Metallurgy (a), Fownes' Chemistry (a).	-	Balfour Stewart's Treatise on Heat (a).	-

(a) Senior boys (b) Junior boys. (c) Laboratory practice. (d) Special pupils

continued.

College or School	Magnetism and Electricity	Mechanics.	Optics	Physical Geography	Physics, generally	Physiology	Zoology
Cheltenham College	Classical and Military departments — Deschanel's Electricity (b), Ferguson's Electricity (a), Ganot's Physics (a), Tyndall's Notes (a)	Military Department: Deschanel (a), Ganot (a), Tyndall (a), Balfour Stewart (b)	-	-	Classical Department — Balfour Stewart's Elementary Physics (b). Military department. — Balfour Stewart's Elementary Physics (b); Ganot's Physics (Atkinson), (a)	-	-
Rossall School	-	-	-	-	-	-	-
Charterhouse School	-	-	-	-	-	-	-
Christ's Hospital School	-	Todhunter's Elementary Mechanics (a), Parkinson's ditto (a), Todhunter's Analytical Statics (a)	Parkinson's Optics (a)	-	Deschanel's <i>Traité de Physique</i> (a), Balfour Stewart's <i>Lessons in Elementary Physics</i> , Balfour Stewart's <i>Science Primer</i> (b)	-	-
City of London School	Ferguson's Electricity (b)	-	-	In a small class Ansted, Herschel, Skertchley, Ramsay	Balfour Stewart's Elementary Physics (a), Ganot's Physics (a), Brook's Natural Philosophy (a), Lardner's Handbook of Natural Philosophy (4 vols), (a)	Carpenter's Animal Physiology (a), Carpenter's Vegetable Physiology (a); Huxley's Physiology.	-
Dulwich College	Deschanel's Electricity and Magnetism.	Todhunter's Mechanics	-	Hughes's Physical Geography, Maury's Physical Geography of the Sea, Student's Manual of Modern Geography.	Balfour Stewart's Elementary Physics (a), Deschanel's Natural Philosophy (a).	-	-
Taunton College School	-	Twisden's Practical Mechanics (a).	-	-	Newth's Natural Philosophy and Mechanics (a).	Huxley's Physiology (a)	-
King's College School	Ferguson's Electricity.	Parkinson's Mechanics. Todhunter's Mechanics.	-	-	Ganot's Physics	-	-
University College School.	(None)	(None)	(None)	Page's Physical Geography	-	-	-
Manchester Grammar School.	Ferguson's Electricity; Jenkin's Magnetism and Electricity (a).	Todhunter's Mechanics; Goodwin's Statics	Ganot's Physics, Deschanel's Light; Tyndall's Notes on Light	Ansted's Physical Geography (a), Macturk's Physical Geography (b)	Balfour Stewart's <i>Lessons on Elementary Physics</i> (b), Ganot's <i>Physics</i> by Atkinson (a); Deschanel's <i>Natural Philosophy</i> by Everett (a).	-	-

(a.) Senior boys (b) Junior boys (c) Laboratory practice. (d) Special pupils.

§ 6.—WEIGHT ASSIGNED TO SCIENTIFIC ATTAINMENTS IN DETERMINING A BOY'S POSITION IN THE SCHOOL.

At St Peter's College, Westminster, the weight assigned is very small.

At Christ's Hospital, the Head Master states, "the highest position in the school, which brings the most substantial rewards, is that of Grecian. A boy who, in Classes 2 and 3, shows a marked aptitude for science, is encouraged to pursue it, and if his progress continues satisfactory, is made Grecian, even though he may make little progress in classics. Two boys have thus been recently elected at Cooper's Hill College, who had been kept till 18 as Grecians by reason of their aptitude for science and mathematics; one boy has just been elected to a Physical Science Exhibition at Oxford, and he has had an Exhibition granted to him by the Governors almost entirely by reason of his proficiency in science. It is my hope," the Head Master continues, "that we shall have a succession of similar cases, so that it is not strictly accurate to say that the weight assigned to scientific attainments in determining a boy's position in the school is *practically nil*."

At Charterhouse School it is considered that the amount of acquirement would not at present justify any weight being assigned to scientific attainments for determining the position in the school, but as advance is made, this, it is stated, will be remedied.

At King's College School no weight is assigned in determining a boy's position in the school, but his marks for science are added to his class marks to obtain a prize.

At the City of London School, the weight assigned to scientific attainments in determining promotion and in awarding scholarships is one third of that assigned to Mathematics or to Classics.

At Rugby School, the proportion of the marks for different subjects, both for terms' work and examination, is given below.

Upper School		Terms' mark.	Exam. mark.
Classics and English	-	39	33
Mathematics	-	6	6
German or Natural Science	-	3	3
French	-	2	2
Middle School.			
Classics and English	-	36	33
Mathematics	-	6	5
Natural Science	-	4	2
French and German	-	4	3

In the higher part of the school, a boy who shows ability may be allowed to drop verses, together with a certain amount of general classical work, and devote the extra time to mathematics or Natural Science. The important fact is, that by so doing he does not lower his position in the school or lessen the chance of future promotion, as he receives a full equivalent of marks for actual work.

At Eton, in the "trials" for school promotion into the Middle division of the 5th Form, and into the Upper division, one Science paper is set. The papers are 12 in all.

At Harrow, the same weight is assigned as to other subjects, the proportions being determined by the time given to the several subjects.

At Clifton College, marks are assigned for each hour of scientific work just as for any other kind of work, and on the same scale the principle being to award a fixed number of marks for every hour's work, whatever the subject.

At Wellington College, in the Classical Sixth, the science-lessons are 1-15th of the classical lessons in hours; but have 1-10th of the marks of the classics.

Classics	-	-	600
Mathematics	-	-	360
German	-	-	180
Drawing	-	-	60
Science	-	-	60

In Mathematical School—

Mathematics	400 (lower forms 300)
Modern languages	300
Latin	150
Science	100

At Winchester College, about one tenth of the whole marks in class work and examinations,

At Rossall School, in the Modern Side, about 10 per cent. of weekly marks, determining the boys' places, are allowed to the Natural Science lessons.

At Marlborough College, there are marks assigned to each boy who does Science in some Forms in his weekly work, and in others in quarterly examinations. These marks are added into the total to assign his final place. The exact proportion observed in adding the Science marks to those attained in other subjects probably varies to a certain extent in different Forms; but in every Form a boy would gain very considerably by having really distinguished himself in the science work.

At Dulwich College, the classification for science is entirely independent. Prizes are awarded in each class at the annual examination. In the award of exhibitions 200 marks are assigned to science as against 220 to English, 220 to Latin, 150 to each modern language, 150 to elementary mathematics, and 300 to the higher mathematics.

At Cheltenham College, in the Classical Department, 7 per cent. in marks of the half year, in examination 12½ per cent. in the Military Department not quite 20 per cent.

At the Manchester Grammar School a boy's position in the Science forms, and his prospects of promotion, depend almost entirely on his scientific attainments. The Science and Mathematical forms are regarded as equal to the highest classical forms.

At Isington College School it is the desire to give exactly the same value in school marks to science, mathematics and languages.

In University College School, "the foremost place in the Science Classes is sought for with the same interest and eagerness which attend the struggle for corresponding distinction in the traditional and more generally established subjects of school education" [Appendix III, p. 119].

§ 7.—METHODS OF TEACHING AS REGARDS ORAL DEMONSTRATION, BOOK WORK, AND PRACTICAL WORK.

The Commissioners will gather from the answers to questions 10 and 11, that mere book work in Science teaching is practically dead in all those public and first grade schools from which returns have been received, but I think I shall not be wrong in stating that this opinion is to be gathered in a much more definite way from actual inspection of the schools than from the returns.

From Christ's Hospital we are told "there is no doubt that oral teaching by a good teacher is far more effective than any book can be," at Rugby and many other schools book work is stated to be only "supplementary" to a lesson, at Rossall it is "subsidiary," at Clifton the boys are "generally expected to read certain portions of the text-book in use as preparation for each lesson," at Winchester the book is abolished altogether for the lower classes; at Wellington College books are not used more than twice or three times in a term; and at Marlborough the possession and use of text-books is not compulsory,

except in the middle divisions A and B of the Modern School.

This being so, we come to oral demonstration and practical work. In schools where there is no opportunity for practical work, I find the lecture system thought a great deal of; but, at the same time, I think there is evidence that where there are opportunities for practical work, the more developed the practical work is, and the more perfect the laboratory arrangements, the more is practical work preferred to oral demonstration, much more time being allowed to be given to it, and oral demonstration, in some cases, altogether dispensed with in the case of volunteers for laboratory practice. Although I am aware that these circumstances arise, to a certain extent, from the local teaching conditions, still we must assume that they would not be permitted if it were not agreed among the teachers that such proceedings were educationally sound.

The following table shows the relative proportion of oral demonstration and book work in the lessons, and the subjects which are taught practically in the various schools:—



College or School.	Lessons.		Practical Work.
	Oral Teaching and Demonstration.	Book Work.	
Eton - - -	All - - - - -	Subsidiary and supplementary.	Practical work in the laboratory is done entirely out of school, the time devoted to it being from 8 to 8½ hours in each week. The time spent in regular school lessons is about one half of this.
Rugby - - -	All - - - - -	Supplementary - - -	Botany in lessons, chemistry in laboratory.
Gifton - - -	All, when not catechetical, or occupied with working out examples and propositions	Preparatory or supplementary.	Botany in lessons, botanical and geological expeditions, chemistry.
Marlborough - - -	All - - - - -	Preparatory - - -	Various branches of Natural History.
Winchester - - -	All in lower classes - - - Part in upper classes - - -	Nil - - - - - Part in upper classes - - -	Nil.
Westminster - - -	All - - - - -	Preparatory and supplementary.	Nil.
Cheltenham - - -	From one fourth to one half - - -	Varying with subject and with master.*	Botany, electricity, chemistry in lessons
Wellington - - -	Two thirds - - - - -	Supplementary - - -	Electrical measurements in lessons, chemistry in laboratory (voluntary).
Rossall - - -	Lectures followed by oral and written examinations.	Subsidiary to lectures - - -	Chemistry in the laboratory
Charterhouse - - -	All - - - - -	Supplementary - - -	Nil.
Christ's Hospital - - -	Chemistry, one half, natural philosophy, three fourths, elementary mechanics, and examples are set to be worked from books.	Chemistry, one half; natural philosophy, one fourth, supplementary and to supply problems and examples	Chemistry in laboratory.
City of London School	All - - - - -	Preparatory at home - - -	Chemistry in laboratory. Also, with a select few, Experimental Physics, Physiology, and Botany
Taunton College School	Of physiology, all, of botany, one half; of chemistry, for the Upper School, one third; for the Middle School, all; of mechanics, all.	Out of school as an assistance to notes taken at the lectures.	Botany, half of each lesson employed in dissections, schedule writing, and classification; chemistry in laboratory
Dulwich College - - -	Each of the classes receives two lessons per week of an hour or an hour and a quarter each. A course of evening lectures (generally four or five lectures) on some branch of science is also given in each term. Attendance at these lectures is voluntary. They are open to all boys, whether pupils in any of the science classes or not.	Book work is got up during the "preparation time," which, for the more advanced pupils, amounts to about two hours for chemistry and one hour and a half for physics.	Chemistry in laboratory, one hour a week for advanced pupils, two hours; out of ordinary school hours. Physics in laboratory, during the school time assigned to the Science lesson.
University College School	In chemistry and chemical physics, the subjects are explained solely by means of oral teaching and demonstration, no portion of any lesson being ever devoted to book work. This oral teaching includes the explanation of those portions of sciences which the boys are expected by the Universities to know, but which are not capable of experimental proof in the class rooms of a school. All the subjects in physics and mechanics are explained by means of oral teaching and demonstration, no books being used. The lessons are alternately devoted to experimental demonstrations of general principles and to the working of illustrative exercises and problems on, or deductions from, these principles.	Preparatory at home - - -	Chemistry in laboratory, accompanied by oral teaching; and occasionally there is added such further demonstration as is considered necessary to supplement the experiments made by the boys themselves [A laboratory for physics has been recently constructed in the new building]
King's College School	Physical classes, one half - - -	One half - - - - -	Chemistry in laboratory; physics in laboratory.
Manchester Grammar School.	All, with very few exceptions - - -	Preparatory, excepting when used in the absence of large diagrams.	Chemistry in laboratory. Optical, heat, and electrical experiments

\*NOTE.—Masters and methods differ, subjects differ also. One master would reply, chiefly preparatory, both for first (or demonstrative) lesson, and also for last (or catechetical) lesson. Another master would say, simply preparatory, except so far as useful for revision of work before examination. The Head Master of the Military Department, a man of great experience and great wisdom in teaching, who himself taught science for many years before any special master for science was appointed, says: "The subject matter of each lesson should generally be explained in advance, it is then learnt from text-books during preparation hours, and tested at the next lesson time. If any points are not clearly understood, they are again explained, and notes made by the boys."

## § 8.—TESTS OF PROGRESS

*Intermediate Examinations.*

The tests of progress adopted at the several schools may be classed under the following heads, viz:—

- 1 An oral examination after each lesson or lecture.
- 2 A written examination after each lesson or lecture
- 3 An examination of note books.
- 4 Intermediate examinations.

At the Manchester Grammar School the first method is adopted.

At the City of London School and King's College School the first and third methods are adopted, with the addition of the following tests in the case of the City of London School.—For "home work" the boys have to write answers to certain questions on the subjects treated of in the lecture. These answers are brought on the next lesson day. In the Lower School the boys have to bring drawings of the apparatus and experiments shown at the lecture. Boys who take an interest in the subject are encouraged to remain after the lesson to receive extra instruction, and to try the experiments for themselves.

At Christ's Hospital the second and third methods are adopted, the latter for the chemistry class.

At University College School the first and third methods are adopted, together with monthly intermediate examinations.

At Eton, a part of each lesson is spent in putting questions on the previous lesson. Note books or abstracts of lessons are looked over and marked once a week. Once in three or four weeks there is a written examination, three times a year, by a paper on the work of the school time.

At Clifton College and Wellington College there is an examination of note books and there are also intermediate examinations every three weeks or so.

At St Peter's College, Westminster, there are weekly examinations.

At Marlborough College, questions are put, and when a boy answers badly, his note book is examined, and, if insufficient, is filled up out of school, or re-written. Examinations are held at the end of the Term.

At Cheltenham College and Taunton College School the examinations are monthly.

At Rugby School, Winchester College, and Charterhouse School there are frequent examinations during the term.

At Harrow, the note books are examined once a week, or oftener.

At Dulwich College there are written examinations two or three times each Term, by the Teacher, who looks over and corrects the boys' note-books from time to time.

I append some of the intermediate examination papers handed to me at Clifton (where this method of testing is carried out in a most complete manner), together with some of the terminal examination papers.

These examinations are held once in three weeks the teacher sets and looks over the papers on his own subjects. This is considered necessary as a means of showing him where his teaching is successful, and where and how it is failing. These papers with the marks and reports all pass through the hands of the Head Master when they have been looked over by the Master, before being given back to the boys.

*Terminal Examinations*

These examinations, which take place at the end of term or half yearly, are generally conducted by independent examiners.

At Eton, a general yearly examination ("trials") is held for deciding places in the school, and a paper on the scientific work of the school for that year is set.

At Harrow, the terminal examinations in science are conducted by the teacher, but, once a year, there is an examination in the work of the year for two prizes given by the Head Master. This is conducted by an independent examiner (generally from Oxford or Cambridge).

At Dulwich College Terminal Examinations are held at the end of the First and Third Terms. There is also an Annual Examination, conducted by an Independent Examiner. The Order of Merit and the award of Prizes are determined by a combination, in equal proportions, of the marks assigned by the Examiner, and those gained by school-work in the previous half-year.

It is stated that at Rossall a written examination, usually conducted by an outsider, is generally accompanied by "unsatisfactory results."

At Clifton, at the end of the summer term, which completes the school year, the work is examined by an examiner from one of the Universities. At the end of each of the other two terms, the masters examine and report upon each other's work, it being a rule that, where it can be avoided, no one examines his own work.

## SPECIMENS OF INTERMEDIATE AND TERMINAL EXAMINATION PAPERS

## CLIFTON COLLEGE

## INTERMEDIATE EXAMINATION.—February 13th, 1871.

## BOTANY.

III.  $\alpha$ . and III.  $\beta$  To be written on separate paper

1. What is the "receptacle"? Sketch and describe its form in the geranium and strawberry.
- 2 Give the meanings of these words: *perianth*, *polysepalous*, *acstivation*, *stigma*, *distachite connective*.
- 3 Describe the structure of the stamen, and show how its parts correspond with those of the ordinary green leaf.
- 4 In what way are the floral leaves of the sweet pea arranged in the bud?
- 5 What forms of the calyx are found in the dandelion, daisy, and gooseberry?
- 6 Sketch and name some of the chief varieties of the regular gamopetalous corolla.

## INTERMEDIATE EXAMINATION.—February 27th, 1871.

BOTANY, III.  $\alpha$ . and  $\beta$ .

Half of the time allotted for the examination is expected to be given to this paper.

- 1 Give a minute account of the various parts of a *tamen*, and refer each one to its corresponding portion in the ordinary green leaf.
- 2 How many stamens are found in these plants.—*Wall-flower*, *dead nettle*, *sweet pea*?
- 3 What do these terms mean: *Monadelphous*, *diadelphous*, *polyadelphous*? Give examples.
- 4 Write down the terms applied to the anther in the following conditions.—

( $\alpha$ .) Filament adhering along the whole length of the "back"

( $\beta$ ) Filament extending only to the base of the lobes.

( $\gamma$ .) Apex of filament attached to a single point only.

- 5 How does the pollen escape from the anther?
- 6 Describe the structure of the pistil in the pea. Distinguish clearly between its two sutures, and compare it with a foliage leaf.

## TERMINAL EXAMINATION.—Easter, 1871.

BOTANY III $\alpha$  &  $\beta$ —JUNIOR SCHOOL, IV $\alpha$  &  $\beta$ , III.

Examiner, Rev. G. Macloskie, LL.D.

1. What is meant by the word "superior," with reference to the calyx and ovary? Give examples of a superior and an inferior ovary.
2. Describe the petals, the stamens, and the fruit in a *Cruciferosus* plant.
- 3 Give, very briefly, the meanings of these words:—

Epicalyx	Introrse	Pome
Pepthonaceous	Syncarpous	Achene
Polyadelphous	Dehiscence	Cone

- 4 What is remarkable about the calyx, corolla, and anthers in the dandelion or thistle?
- 5 Show how these three fruits differ: Strawberry, blackberry, and mulberry.

- 6 Describe the fruit called a "legume." Show how it resembles an ordinary leaf, and contrast it with the "follicle."
- 7 Name the principal forms of cells and vessels.
- 8 Distinguish between the exogenous, endogenous, and acrogenous stem. Give examples.
- 9 What action have plants upon the atmosphere?

Candidates are not expected to write upon more than six questions, and a few good answers will receive more marks than a larger quantity of inferior ones.

## INTERMEDIATE EXAMINATION.—October 20th, 1873.

## CHEMISTRY

## VI, V., and First Set below V.

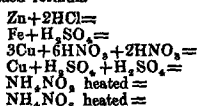
- 1 How would you make nitric acid? Calculate the weight of nitric acid obtainable from 20 ounces of nitra.  $K=39$
- 2 Give the formulae for nitric anhydride and nitrous anhydride, and show the action of water upon them.
- 3 Give equations showing the action of heat on ammonium nitrate and ammonium nitrate.
- 4 Describe the properties of nitric oxide, and the process by which it is usually made.

*First Set, Modern.*

1. Describe, as fully as you can, the process for estimating the carbon and hydrogen in benzoic acid,  $C_6H_5O_2$ .
2. One hundred parts of an organic compound contain carbon 63.15, hydrogen 3.17, oxygen 33.68. Find the formula, assuming its molecular weight = 190.
3. Explain the processes both of experiment and reasoning by which you would establish the formula  $C_6H_5O_2$  for acetic acid.

*Second Set Classical, and Second Set Modern.*

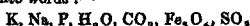
1. Describe fully, with equations, the preparation and properties of hydrogen nitrate (nitric acid)
2. Complete the following equations, adding the name to each formula:—



3. Give the names and formulæ of all the oxides of nitrogen, and describe the properties of one of them.

*Third Set, below Fifth Classical*

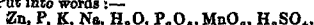
1. Composition of the air, and the action of animals and plants upon it.
2. Give three ways of preparing oxygen gas.
3. Describe the action of sodium upon water.
4. Put into words:—

*Third Set, Modern*

1. Describe the preparation and properties of nitric acid.
2.  $3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 4H_2O + 2NO$ . Read this, give molecular weights of each substance, and the whole relative weights.
3. How much NO will 100 lbs Cu give?
4. Name the following substances:—HCl, ZnSO<sub>4</sub>, KHSO<sub>4</sub>, KHO, H<sub>2</sub>PO<sub>4</sub>, N<sub>2</sub>O<sub>5</sub>.

*Fourth Set, Modern.*

1. When phosphorus is burned in a bell-jar standing on a vessel of water, what happens, and why?
2. What is the composition of the air, and what is the action of plants and animals on it?
3. If sulphuric acid (hydrogen sulphate) is put into a flask containing zinc and water, what gas is formed and what are the properties of this gas?
4. Put into words:—



## PHYSICS.

*VI., V., and 1st Set IVths.* } 1-6  
*I and II Moderns.* }  
*2nd Set IVths.* } 1-4

1. What is meant by the co-efficient of linear expansion? Given the linear, find the superficial and cubical co-efficients.
2. Give some instances where the expansion of metals by heat has to be allowed for.
3. Explain how the fixed points are determined for a thermometer. Find a formula for changing temperatures reckoned on the centigrade scale to the corresponding temperatures on the Fahrenheit scale. Find what temperature on centigrade scale is equal to 68 on Fahrenheit.
4. What corrections and precautions must be applied to get the true temperature from the readings of a thermometer.
5. Distinguish between conduction and convection of heat. Describe some means of determining the relative conductivity of metals.
6. Describe fully the principle of Dulong and Petit's method for determining the absolute dilatation of mercury.

*Third Set, below 5th. Classical.*

1. Prove the expansion of liquids, solids, and gases by heat.
2. Explain the difference between Fahrenheit, Centigrade, maximum, and minimum thermometers.
3. When a bar of iron and copper are riveted together and then heated, what happens, and why?
4. Describe any applications of the unequal expansion of metals by heat.

*Modern Side, Third Set.*

1. Define the term force—give a list of the principal forces, and describe an experiment to illustrate the mutual convertibility of several of them.
2. Illustrate inertia.
3. Explain what is meant by the resultant of two or more forces; and give a diagram showing the magnitude and direction of two forces of 4 lbs. and 7 lbs. acting on a point at right angles to each other.

*Fourth Set, Modern.*

1. Explain what is meant by "gravitation" and "cohesion."
2. How do solids, liquids, and gases differ from each other?
3. Water finds its own level. Explain this.
4. What is meant by specific gravity? How do you find specific gravity of liquids?

## INTERMEDIATE EXAMINATION.—November 10th, 1873.

You are requested to divide your time as evenly as possible between the two subjects of examination.

## CHEMISTRY

*First Modern Set.*

1. Describe the preparation and properties of marsh gas, and give its graphic formula.
2. Describe the preparation of common alcohol, and give equations showing the action of potassium, sulphuric acid, and acetic acid upon it.
3. Name the compound  $CHCl_3$ ,  $C_2H_2$ ,  $H$ ,  
 $\left. \begin{array}{l} C_2H_5 \\ C_2H_5 \end{array} \right\} O$ ,  $\left. \begin{array}{l} C_2H_5 \\ H \end{array} \right\} N$ ,  $\left. \begin{array}{l} C_2H_5 \\ C_2H_5 \end{array} \right\} N$ ,  $\left. \begin{array}{l} C_2H_5 \\ C_2H_5 \end{array} \right\} Zn$ ,  
 $\left. \begin{array}{l} H \\ H \end{array} \right\}$

and describe any one of them.

*VI., V., first set below V., and Second Set, Modern.*

1. How much ammonia by weight and volume would be obtained from 20 grams of ammonium chloride?  $N = 14$ ,  $Cl = 35.5$ .
2. Name and classify the following compounds:—KHO, H<sub>2</sub>SO<sub>4</sub>, NaCl, ZnSO<sub>4</sub>, FeCl<sub>3</sub>, HCl, HNO<sub>3</sub>, NaHO, NH<sub>4</sub>HO, and give a general equation showing the action of a metallic oxide on an acid.
3. Explain fully why solution of ammonia is supposed to contain the hydrate of ammonium.

*Second Set Classical, Nos. 2 and 3 of the foregoing, and*

4. How is ammonia made? Give the equation with weights to formulæ ( $Ca = 40$ ).

*Third Set below Fifth.**First two questions same as Modern Fourth Set*

3. Put into words:— $H_2CO_3$ ,  $CaCl_2$ ,  $CaO$ ,  $HCl$ ,  $CaCO_3$ ,  $C + O_2 = CO_2$ .
4. Give the symbols of—calcium, sodium carbonate, potassium nitrate (saltpetre), nitric acid, sulphuric acid.

*Third Set Modern.*

1. Define the terms acid, salt, base. Write down an equation showing their mutual relation.
2. Classify  $SO_2$ ,  $NH_4Cl$ ,  $H_2PO_4$ , KHO.
3. The preparation and properties of chloride.
4. Read and give molecular and whole weights of  $2(NH_4)Cl + CaO = CaCl_2 + H_2O + 2NH_3$ .
5. How much  $NH_3$  will 160.5 lbs.  $NH_4Cl$  give?  $H = 1$ ,  $N = 14$ ,  $Cl = 35.5$ ,  $Ca = 40$ .

*Fourth Modern Set.*

1. How is carbon dioxide (carbonic acid) prepared?
2. How is carbon dioxide distinguished from hydrogen, oxygen, and nitrogen?
3. Put into words, —  $NH_3$ ,  $H_2CO_3$ ,  $CaCl_2$ ,  $H_2SO_4$ ,  $HNO_3$ ,  $CaO$ ,  $NH_4Cl$ .
4. Put into chemical formulæ—sodium, sodium chloride, sodium carbonate, potassium nitrate (saltpetre), ammonium.

## PHYSICS.

*VI., V., and 1st Set IVths.* } 2, 3, and any two others.  
*I and II Moderns* }  
*2nd Set IVths.* } 4, 5, 6, and any other.

1. State the laws of Boyle and Gay Lussac. Are they strictly true in all cases?

2. 20 litres of air are measured off at zero and under a pressure of 760 m m of mercury, find the volume of the air (1) when the pressure is reduced to 570 m m. of mercury, (2) when the temperature is raised to 91°. The co-efficient of expansion for air may be taken as  $\frac{1}{273}$  or '00366

3. When is a vapour said to be at its maximum tension? Describe some arrangements for determining the maximum tension of aqueous vapour at different temperatures

4. Describe the different ways in which a body may be changed into a vapour. Show that heat disappears when the change takes place.

5. What circumstances affect the boiling point of a liquid?

6. Give some of the laws of evaporation.

#### Fourth Modern Set.

1. Give proofs of the pressure of the air
2. Describe the common barometer, and state how and why it can be used to measure the height of mountains.
3. What is the construction of the common pump? On what does its action depend? What is the greatest length from the lowest valve to the surface of the water in the well, and why? What would the length be if you were pumping mercury?

#### Third Set below Fifth

1. How is heat propagated in solids, liquids, and gases?
2. Describe experiments to prove that some bodies conduct heat better than others.
3. Prove that radiant heat is given out equally from all sides of a body, that it travels in straight lines, and is not affected by the air it passes through

#### III Set, Modern

1. A stone dropped into a well takes 4 seconds falling; how deep is the well, and with what velocity does the stone strike the water?
2. How is work measured? Define horse-power. Of how many horse-power is an engine which lifts 90,000 lbs to a height of 66 feet in 15 minutes?
3. Describe and draw the three kinds of levers, giving a familiar example of each kind.
4. (a) In the 1st kind of lever, if the power is 15 lbs, power arm 8 in., weight arm 3 in, find the weight  
(b) If the lever is 1 ft 4 in long, the power 4 lbs, and weight 12 lbs, where must the fulcrum be placed?

#### INTERMEDIATE EXAMINATION—December 1st, 1873.

##### CHEMISTRY.

#### First Modern Any four questions.

1. C is tetratomic. Show that no compound of C and H can contain more H than is represented by the formula  $C_nH_{4n+4}$ .
2. Let  $C_nH_{2n+2}O$  be the formula of a primary alcohol. Write the formula of the corresponding aldehyd and acid.
3. Complete these equations, with name to each formula:—  

$$N \left\{ \begin{array}{l} C_2H_5 + 2K \\ CO \end{array} \right\} O =$$

$$C_2H_5I + NH_3 =$$

$$C_2H_5NH_2 + HCl + KHO =$$
4. Describe the preparation and properties of acetic acid, with equation.
5. How is ethylene obtained? How may it be converted into common alcohol. Give the formulæ of glycolic and oxalic acids.

#### VI.—V., and First Set below V.

##### Second Set Modern.

1. How many pounds of chlorine can be obtained from 150 lbs of common salt? Na = 23
2. Write down the weights and volumes represented by these formulæ:—Cl, Cl<sub>2</sub>, HCl, H<sub>2</sub>O, NH<sub>3</sub>, O, assuming that H stands for 1 litre of hydrogen, weighing, 1 crith (.0896 gram.).
3. Why does chlorine bleach?

##### Second Set below Fifth

1. How is chlorine made? To what use is it applied?
2. Complete these equations, with weights and names to each formula. (Mn = 55.)  

$$NaCl + H_2SO_4 =$$

$$2NaCl + H_2SO_4 =$$

$$2NaCl + 2H_2SO_4 + MnO_2 =$$

$$MnO_2 + 4HCl =$$

#### Fourth Set Modern and Third Set below Fifth.

1. What takes place when sulphur is heated till it boils?
2. What are the properties of sulphur dioxide?
3. Put into words —Na<sub>2</sub>SO<sub>4</sub>, NaCl, FeS, FeSO<sub>4</sub>, SO<sub>2</sub>, S + O<sub>2</sub> = SO<sub>2</sub>, KI + Cl = KCl + I
4. Give symbols of chlorine, bromine, iodine, fluorine; and formulæ of copper sulphide, calcium sulphate, silver chloride, potassium oxide.

#### III. Modern.

1. Preparation and properties of hydrochloric acid
2.  $CaF_2 + H_2SO_4 = CaSO_4 + 2HF$ . Read and give weights and classify
3. How much CaF<sub>2</sub> will give 100 lbs HF?
4. From what sources are bromine and iodine obtained? Give properties of iodine
5. Name HClO, HClO<sub>2</sub>, HClO<sub>3</sub>, HClO<sub>4</sub>

#### PHYSICS.

#### VI., V., First Set IVth. } any four of first two First and Second Mod } Second Set IVth, 7, 8, and any two others

1. Describe Daniell's hygrometer, and the method of using it. What are its defects, and how have they been remedied?
2. Give an account of the spheroidal state
3. Give the laws of fusion. Why does a mixture of salt and pounded ice produce cold?
4. Define the specific heat of a substance—6 lbs of boron at 100 are mixed with 1 lb of water at 10, the specific heat of the boron is  $\frac{1}{2}$ , what will be the temperature of the mixture?
5. Describe Bunsen's ice calorimeter.
6. Describe some experiment to show that the specific heat of different bodies varies.
7. Mention some good and some bad conductors of heat. What are the uses of bad conductors?
8. How may you tell which of two bars of metal is the better conductor? What is a safety lamp?

#### Fourth Modern, and Third Set below V.

##### Any three questions (but not more)

1. Two tin vessels—one of which has the outside dull and black and the other polished and bright—are filled with cold water, and exposed to the same amount of heat. In which will the water sooner become hot, and why?
2. What effect has pressure on the boiling-point of a liquid? How and why can the height of a mountain be found from the boiling-point of water?
3. Prove that heat can be reflected
4. What is meant by the spheroidal state of liquids? Give instances.
5. What are the sources of heat—mechanical, chemical, and physical?
6. Describe how heat can be converted into work.

#### Third Set, Modern.

1. Describe the three systems of pulleys, and find the weight supported by a power of 10 lbs when there are three pulleys of which the weight is neglected
2. Explain the principle of the screw. Give the relation of power to weight. If the circumference of the circle described by the power is 5 ft., and the power is 3 lbs, and the distance between the threads is 1 in., find the pressure or weight.
3. The height of an inclined plane is 3 inches, its length 18 inches, the weight is 24 lbs. find the power acting along the plane.
4. Explain the action of the pendulum. Mention the principal laws. What is the length of the pendulum which vibrates once in 3 seconds?

#### TERMINAL EXAMINATION.—Christmas, 1873.

##### CHEMISTRY.

#### First Set Modern.

1. Describe the process for the determination of the amount of carbon and hydrogen in an organic compound free from nitrogen. What precaution must be taken if nitrogen is also present?
2. A volatile organic compound contains—  

$$\left. \begin{array}{l} C \ 78.94 \\ H \ 10.53 \\ O \ 10.53 \end{array} \right\} \text{in 100 parts.}$$

Find the simplest formula, and explain how you would correct this by referring to the specific gravity of the vapour.

3. What are homologous series? Give one or more examples.
4. Distinguish between metameric and polymeric compounds, and give an instance of each.
5. Give the formulæ of common alcohol, aldehyd, and acetic acid, and describe the production of one of them
6. Give the formulæ of ethylamine and acetamide, and describe the properties of the former.
7. Describe starch, and give its formula and chemical re-actions

*Sixth and Fifth and First Set of Fourths. Second Set Modern, also Woolwich Set.*

1. Describe the method of preparing nitric acid, and give equation
2. What is the result of acting upon sulphuric acid with (1) zinc, (2) copper oxide? Give equations
3. Describe the action of heat upon ammonium nitrate and ammonium nitrate. Give equations
4. The preparation and properties of chlorine gas. Why does chlorine bleach?
5. How much ammonium chloride ( $\text{NH}_4\text{Cl}$ ) will furnish 100 grams ammonia ( $\text{NH}_3$ )? What will be the volume of the ammonia formed? (1 litre of hydrogen = 0.0896 gram.)
6. Write out in words and give molecular weights of:—  
 $3\text{Cu} + 8\text{HNO}_3 = 3\text{Cu}(\text{NO}_3)_2 + 2\text{NO} + 4\text{H}_2\text{O}$ .  
 How much  $\text{Cu}(\text{NO}_3)_2$  could be obtained from 254 gram. of Cu, by the above equation (Cu = 63.5).  
 7. How do you classify the oxides?  
 Classify  $\text{H}_2\text{O}$ ,  $\text{MnO}_2$ ,  $\text{Ca}(\text{HO})_2$ ,  $\text{KHSO}_4$ ,  $\text{CaCl}_2$ ,  $\text{NH}_4\text{HO}$ ,  $\text{N}_2\text{O}_5$ .  
 Write down three anhydrides and the corresponding acids.
8. Name and give the formulæ of the ammonium, sodium, and calcium salts of  $\text{HClO}_2$ ,  $\text{HNO}_2$ ,  $\text{H}_2\text{SO}_4$ .

*Second Set Fourths.*

1. How many compounds does oxygen form with nitrogen? Give their respective names and formulæ
2. From which of these oxides may nitrous acid and nitric acid be prepared?
3. Give an account of the preparation of nitric acid from sodium nitrate. Equation.
4. Complete the following equations:—  
 $\text{CuO} + 2\text{HNO}_3 =$   
 $\text{Zn} + \text{H}_2\text{SO}_4 =$   
 $\text{ZnO} + \text{H}_2\text{SO}_4 =$   
 $3\text{Cu} + 6\text{HNO}_3 + 2\text{HNO}_2 =$   
 $\text{MnO}_2 + 4\text{HCl} =$
5. Give the formulæ of ammonia and ammonium. How is ammonia made? Equation.
6. How may chlorine be obtained from common salt? Why can it not be collected over mercury or water?
7. Give the process for the preparation of hydrochloric acid from common salt, with equation.

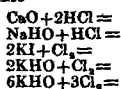
*Third Set Modern.*

Answer questions 1, 2, 4, and 6 of those given above to Second Set Modern; also the following.

A. State some of the reasons for saying that the characters of bromine are intermediate between those of chlorine and iodine.

B. Give the formulæ and composition, both by weight and volume, of hydrochloric and hydrofluoric acids.

C. Complete the following equations, with name to each substance:—



*Third Set Classical and Fourth Set Modern.*

1. Name the two chief constituents of the air and the proportion in which they are mixed. How is that proportion influenced by the burning of a fire or the breathing of an animal?
2. Describe the pneumatic trough and its uses. Why may oxygen and hydrogen—but not chlorine—be collected in the pneumatic trough?
3. Give the symbols and atomic weights of carbon, nitrogen, oxygen, and sulphur, and name these bodies. —  $\text{H}_2\text{O}$ ,  $\text{SO}_2$ ,  $\text{NH}_3$ ,  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ .
4. Define an acid, and give an example
5. Describe the gas which is given off in this reaction:—  
 $2\text{NH}_4\text{Cl} + \text{CaO} = 2\text{NH}_3 + \text{CaCl}_2 + \text{H}_2\text{O}$ .

6. Classify these oxides:— $\text{CO}_2$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{MnO}_2$ ,  $\text{SO}_2$ ,  $\text{Na}_2\text{O}$ ,  $\text{CaO}$ .

7. Describe chlorine.

8. How may carbon dioxide be prepared? What tests may be used for a carbonate?

**PHYSICS.**

*VI., V., First Set of Fourths.*

*First and Second Sets Modern.*

1. Describe what occurs when water at  $0^\circ\text{C}$  is gradually heated to about  $8^\circ\text{C}$ .
2. What precautions must be taken in using a thermometer for determining the boiling point of a liquid?
3. Amongst solid bodies which are the best conductors? Give some instances showing that gases are almost destitute of conducting power.
4. 100 cubic inches of air are measured at  $0^\circ$  and 760 m. m. pressure. What would be the volume at  $15^\circ\text{C}$  and 749 m. m.?
5. Describe some good way of ventilating a room.
6. Equal weights of mercury and water are exposed over the same source of heat. Which of the two will have the higher temperature at the end of, say, ten minutes, and why?
7. State the law of Dulong and Petit. What circumstances influence the results in determining the specific heat of a series of solids?
8. Under what circumstances is a vapour at its maximum tension? How may the tension of a vapour be determined?
9. Describe some form of calorimeter, and the method of using it.

*Second Set below Fifth*

1. How is a mercurial thermometer made and graduated?
2. Express  $4^\circ\text{C}$ . on Fahrenheit's scale, and  $100^\circ\text{F}$ . on the centigrade scale
3. Describe some form of compensating pendulum.
4. What sort of bodies are the best conductors of heat? Give three examples each of good and bad conductors among solid bodies
5. What is meant by "convection"? Explain the trade-winds
6. Why is mercury better suited for filling a thermometer than either alcohol or water?
7. What is meant by latent heat? when ether is dropped upon the bulb of a thermometer the mercury sinks. Why? Explain this fully.

*III Set below V Classical*

1. How do you know that heat is not matter? What do you believe it to be?
2. How would you fill a thermometer with mercury?
3. How do you know that a bar of metal expands? Mention instances where the expansion has to be allowed for.
4. Explain the meaning of the term specific heat. What substance has a great specific heat?
5. What is latent heat? What would happen if the latent heat of water was very small?
6. Prove that boiling point of water depends on the pressure. What would you do if you were at the top of a high mountain, and wanted water at  $100^\circ\text{C}$ ?
7. Distinguish between conduction and convection, giving experiments to show what you mean by each.
8. What are some of the uses of bad conductors?
9. Will coffee keep hot longer in a bright or blackened pot? Give reasons for your answer
10. Describe the different ways in which heat can be produced.

**IV. Classical**

1. Explain what you mean by mass, motion, velocity. What do you mean by the velocity at any given moment of a train coming to a station?
2. Define force, and use your definition to prove that force is exerted,—  
 (i.) When a cricketer plays a ball.  
 (ii.) When a boy falls down.  
 (iii.) When a goal is tried for.
3. Give an account of the force of cohesion, and point out how it differs from the force of gravity.
4. How can you find the centre of gravity of a sheet of iron? Where would its c.g. be if it were (1) round, (2) square?
5. Define solids, liquids, and gases.

6. Prove that water presses in all directions, and draw and fully describe Bramah's press.

7. What loss of weight does a solid suffer when weighed in a liquid?

A cylinder of wood, 1 foot long, of sp g .75, floats upright in water. How many inches will be out of the water?

8. What do you understand by the phrases porosity, impenetrability of matter?

### III Modern

1. Define velocity, momentum, force. In what two ways can forces be measured?

2. Explain the phrase impenetrability of matter. How is it that mercury can be forced through a piece of cane.

3. What three things must be given to tell you all about a force? Show that forces may be represented by straight lines.

4. Two forces of 6 and 8 lbs act upon a particle at right angles to each other. Find the position and magnitude of their resultant.

5. What space will a body falling from rest have travelled over in four seconds? What will be its velocity at the end of the fourth second?

6. How is work measured? Is any work done by a heavy body moving with uniform velocity over a perfectly smooth and flat table. What is the use of machines?

7. Draw and describe the three kinds of levers, and give practical instances of each of them.

8. A nut can resist a force of 4 lbs. only, and I compress with a force of 3 lbs. the ends of a pair of nut crackers 6 inches long. What distance from my hand must the nut be placed so as just to crack?

9. Draw the three systems of pulleys you have seen. If in the first system there are 3 pulles, what weight will be supported by a power of 3 lbs.?

10. What is the law of attraction discovered by Newton?

### Fourth Set. Modern.

1. "Liquids find their level." Explain this.

2. Explain the fact that when a body is plunged into a liquid it loses weight. How much weight does it lose?

3. A small bottle is capable of holding 120 grains of water; another of exactly the same size will hold 1,620 grains of mercury. Find the specific gravity of the mercury.

4. Describe the common barometer. If the tube were made twice as wide in the bore would that alter the height of the mercury?

5. Describe some experiment to show that bodies expand differently when heated. Is this true of all bodies?

6. What is meant by convection?

7. If a red hot ball is supported on an iron tripod, mention the different ways in which it may lose its heat.

## § 9.—MOST EFFECTIVE FORM OF LESSON.

As to the form of lesson which is found to be most effective, the Head Masters of Taunton College School and Rossall School consider practical work unquestionably to be so. The former says, for senior boys, "We aim at extending it in all subjects as our means and our teaching power increase, but for junior boys, oral teaching and demonstration, accompanied by frequent examinations, are for some time almost exclusively necessary." Similarly, the Head Master of Rossall writes that, next to practical work, "the oral teaching, when accompanied by, and based upon, constant repetition and examination" is the most valuable.

At University College School, experience proves that practical lessons are "the best form, the only true form; though much less ground is got over by this method, yet the knowledge thus acquired is at once more valuable and more lasting." "The best—indeed only thoroughly satisfactory—results are found to follow in the case of those boys who have not depended on books at all, but solely on the oral lessons and demonstrations. Oral teaching and demonstration are, indeed, far more effective than unaided practical work, hence their fusion [at this school] in the class of practical chemistry." Book-work has been tried as an experiment but with signal failure, it would undoubtedly be the most effective form of lesson, if external examiners were employed, unless, perhaps, the examinations were carried on *vis à vis* before the Science masters."

The Teacher of Physics at the Manchester Grammar School says, "I find the 'Socratic' form of lesson the most efficient. In this form of lesson the information required to be taught is either elicited or built up by series of logical questions systematically put to the boys, not on what they have acquired verbally from the book or the teacher, but put to them on the apparatus, the experiments, or the phenomena, or problems as they are actually before them. In this way the observing and reasoning processes, and those of scientific and literary exposition, are cultivated simultaneously."

The Science Master at Harrow says, "As far as it has been attempted, a lesson in which the boys are made to repeat experiments which they have seen performed by the teacher at a previous lesson, or other simple experiments, is found to be by far the most effective."

Mr Madan, Assistant Master at Eton, says, "It is not quite easy to compare the oral instruction with the practical work. The latter is strictly supplementary to the former, and serves to fix in the mind what has been previously shown. It is doubtful whether practical work by itself is sufficient. Without previous oral teaching, a boy is apt to do an experiment mechanically, without realising its full meaning. During laboratory work, the boys are advised to consult their text-books and note books, and constant reference is made to what has been shown in lecture."

In the opinion of the Head Master of Rugby the best form is a combination of catechetical lecture and lesson, the boys themselves being often encouraged to ask questions upon any points not clearly understood. And the Head

Master of Marlborough College considers lectures to be most effective, so long as they are of such interest that the attention of the boys is well maintained upon the subject which is being taught.

The Master of Dulwich College says, "No one of them can be dispensed with, without impairing the efficiency of the entire system of instruction."

The Head Master of Clifton College remarks that "in teaching boys of ordinary ability who possess but little knowledge, it is necessary, in the first place, to lecture a good deal and to impress important facts, principles, and methods as distinctly as possible by illustrative experiments. Without such help, owing to the great want of imagination, many boys would not discover their own tastes, and such conceptions as they might derive from their reading or catechetical lessons would be extremely confused and indistinct, besides that, good lectures greatly facilitate the progress even of those boys. On the other hand, however, it is at least equally necessary to guard against the passive attitude of the learner who is merely or chiefly a listener to lectures. Thus, a good lecturer will always take great pains to keep his class alive by means of test questions, or by insisting on well-written notes, or such other method as may be most conveniently applied. A good deal of the scientific instruction which has hitherto been given in schools has failed, comparatively, as a means of educational training, simply from the fact of the teacher or lecturer having allowed the boys to be too exclusively passive and receptive."

The Head Master of Cheltenham College writes, "Speaking generally, the combination of oral teaching and demonstration with book-work and practical work is more effective than either oral teaching and demonstration, or book-work, or practical work alone; but much depends on the nature of the subject and the character or genius of the teachers; and when diverse forms are used as supplementary to each other, it is impossible to contrast their efficiency."

The Head Master of the City of London School says "I am of the opinion that a combination of oral teaching with demonstration, book-work, and practical work will be found the most effective form of lesson, but I am unable to form a comparison, as in no division of this school is the teaching exclusively confined to any one form. The class for practical chemistry, of course, shows to the greatest advantage, as it is composed of the most advanced boys from each of the upper divisions."

The Head Master of King's College School considers the best form to be "where the oral teaching of the lecturer is followed by the use of the text-book."

The Head Master of Wallington College is of opinion that oral teaching accompanied by experiments will be the best mode, at least as compared with book-work.

And the Head Master of Christ's Hospital says, "There is no doubt that in all cases oral teaching by a good teacher is far more effective than any book can be."

*Use of Note Books*

It will be seen from the replies to question 13, that although note books are generally employed for oral demonstrations, the way in which they are used (*i.e.* during or after the lecture), examined, and marked, varies considerably. In almost all the schools I have visited I have inspected some note books taken at random, and it has not been difficult to see that the best teaching and the best kept note books were closely associated. There is abundant evidence that a boy of average ability can, if he chooses, expand his rough notes into a tolerably connected and methodical account of the lecture he has just heard, illustrate it with copies of some of the more important diagrams, and accurate descriptions of experiments or objects which have been placed before him. I have seen such expanded notes made by boys of 10, who were learning botany, notes which were models of method and clearness, while each flower placed before them had been drawn and coloured wonderfully well, and all its parts named on the margin of the notes. This

is almost an education in itself: a habit of mental tidiness flows from it as readily as a habit of general tidiness flows from good laboratory work; and although such carefully expanded notes entail much labour on the teacher, it will doubtless become, in time, to be considered as among the most important work, and good notes will be encouraged by higher marking than they always receive at present.

A strong argument against full notes being taken during the lecture is thus stated by the Teacher of Physics in the Manchester Grammar School. He says:

‘My own experience has shown me that, in scientific teaching, where mere memory is the least important active faculty, but where the activity of the observing, reasoning, constructive, and investigating powers is continuously required, the mental condition essential to the taking of full notes is inconsistent with the real scientific progress which should be made during the course of any really well-reasoned out and demonstrated scientific lesson; the notes made after the lesson cannot, however, be too full or complete.’

## § 10.—ALTERNATIVE SUBJECTS.

The subjects are fixed at Eton College, Winchester College, Cheltenham College, Taunton College School, Charterhouse School, King's College School (except in very special cases), and the City of London School. At the Manchester Grammar School, though in the scientific forms the scientific subjects are fixed, there are voluntary classes for chemistry, mechanics, and physical geography, any or all of which a boy may attend at his pleasure.

At Rugby as much elasticity as possible is given to the whole system of Natural Science work in the school, so as to enable a boy to take the subject he has the greatest desire to learn, as, for example, in the selection of chemistry, heat, or electricity, in the upper school. At Clifton College the rule is to make all boys in any particular part of the school do the subject prescribed for that division; though it has happened, in a few cases, that boys have been allowed to take up physiology instead of physics, or, when preparing for a government examination, to confine their attention for a little while to the subjects required.

It is most important to add here that in the higher part of the school, a boy who shows ability is allowed to drop verses, together with a certain amount of general classical work, and devote the extra time to Mathematics or Natural Science. By so doing he does not lower his position in the school or lessen his chance of future promotion, as he receives a full equivalent of marks for actual work.

At Marlborough College, in the fifth forms, a boy may

choose between verses, history, and science, and in the upper shell and upper fourth (A and B) forms, a boy may choose between verses, history, and French, and a second non-compulsory hour of science work.

At Wellington College, the boys in the classical school may learn drawing instead of science; only 4 out of 29 do so, the other 25 choose science, though much harder work and involving great trouble in writing out notes. In the Mathematical School at this College there is a choice between Greek and science, and science is chosen in about five cases out of six. No choice is allowed between different departments of science.

At Christ's Hospital boys who are preparing for a special career or examination are often allowed to drop a large part of their classical work, and devote the time to special branches of mathematics or science; thus, at present, two boys, who are preparing for Cooper's Hill College, have given up Latin and Greek composition, and study light, heat, &c.

At Dulwich College, the science subjects are grouped as follows:—

- |  |  |
|--|--|
| I. Chemistry, with laboratory work                   | } alternative subjects taught at the same time by different masters. |
| II. Physics (at present electricity and magnetism) - |  |
| Geology -  |  |
| III. Physical geography.                             |  |

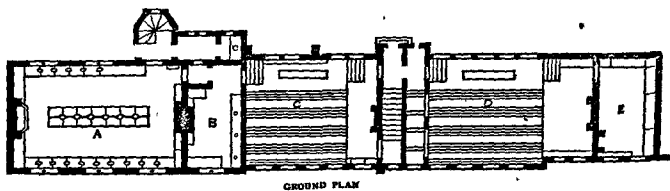
Boys have the opportunity of receiving instruction in one or more of these groups.

## § 11. CHEMICAL AND PHYSICAL LABORATORIES.

## RUGBY.

The accompanying ground plan will give a general idea of the arrangements adopted in the Chemical Laboratory at Rugby (there is no Physical Laboratory), and of its connexion with the Chemical and Physical Class Rooms, the

Natural Science Schools being only part of an extensive block of new buildings containing several classical and other schools.



- A. Chemical Laboratory.  
B. Private Laboratory.  
C. Chemical Lecture Theatre.

- D. Physical Science Lecture Theatre.  
E. Work Room and Apparatus Room.

As will be seen from the plan, the laboratory is 35 ft. by 22, and can accommodate thirty boys. It was formerly the only Natural Science lecture-room, but it has been entirely refitted, in order to convert it into a laboratory, to replace B, which was the room formerly used for this purpose.

The following account of the detailed arrangements have been derived from information which the Rev. T. N. Hutchinson has been good enough to supply.

The working tables are divided into compartments, seven on each side of the centre table, and ten and six in those along the sides of the room. Each compartment comprises a cupboard and two drawers, two shelves for bottles containing the ordinary reagents used in analysis, two gas taps, waste basin with water supply, and a working space of 3 ft. 6 in. by 1 ft. 9 in. As there are often between 40 and 50 boys using the laboratory in a term, the same compartment is frequently assigned to two boys, who share the

drawers and cupboard, &c., between them, it being arranged that the boys shall not have their laboratory lessons at the same hour. Each cupboard contains 1 retort stand with wire gauze and sand bath, 1 flask, 2 funnels and funnel stand, 2 evaporating basins, nest of small beakers, test tubes and rack, wash bottle, and two blocks of wood for supports.

In the drawers are a blow pipe, iron tongs, 2 watch glasses, test tube holder, glass rods, and tubes.

All other apparatus, such as retorts, deflagrating jars and spoons, gas bottles, &c., is used in common, and is given out to each boy as he requires it. The water taps and basins in the central table are placed so as to serve for boys working on either side, and thus much space is gained. The water taps have a small orifice, and are specially adapted for filling test tubes. A water pipe is also carried along the highest shelf, and there are taps at intervals for filling tall vessels, for working with Liebig's condenser, &c.

The sink, with arrangements for washing and drying bottles, is seen near the door in the drawing.

At one end of the room is an open fireplace, with shelves and nests of drawers on either side. The drawers contain the various articles that are in general use in the laboratory, such as corks, cork-borers, elastic tubing, holders of different kinds, glass tubes and rods, &c.

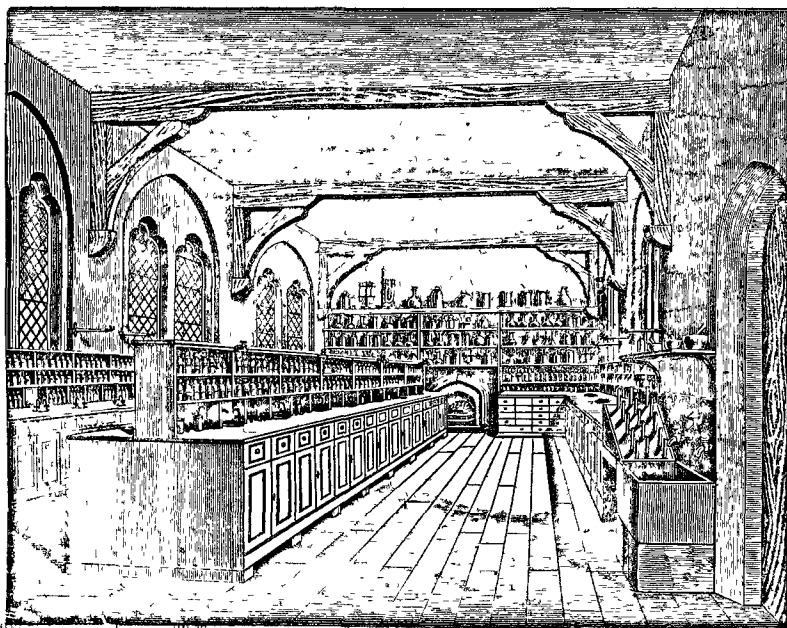
The lower shelves above the drawers contain all the dry chemicals required in Harcourt and Madan's "Practical

Chemistry" (the book chiefly used in the laboratory), together with the more costly reagents, and others that are in less frequent use. Each boy, as before stated, has a complete set of all the ordinary acids and test solutions on the shelves of his compartment.

The contents of the drawers and shelves on either side of the fireplace are arranged in duplicate—a complete set on each side. In this way all chance of confusion and crowding is avoided, as no boy can have occasion to cross over from the side of the room on which he is working to the opposite side, everything being ready to his hand.

A common balance with sets of grammes weights is placed on the table above each nest of drawers. Here also are kept the various measuring flasks and cylinders. At the other end of the room is an ordinary six-foot kitchen range, which has been slightly modified so as to serve for a furnace. It has sand-bath, boiler, and drying-oven. On one side of the furnace is a cupboard to contain a stock of glass and porcelain apparatus. On the other side are two spacious evaporating closets with sliding glass doors. These are supplied with hoods and jets for creating a powerful draught. The draught can be still further increased, when necessary, by lighting a large ring of jets in the flue communicating with the closets.

A small cupboard for tools and a glass blower's table complete the furniture of the laboratory.



GENERAL VIEW OF LABORATORY

The room marked B, in the ground plan, was formerly the only laboratory for the use of the school. It was built some years ago, at the same time as the Natural Science lecture-room, and, though small, was exceedingly well arranged. It is now converted into a private laboratory for the use of the chemical lecturer. It contains a large evaporating closet, also a sand-bath and distilling apparatus, both of which are worked by the fire in the school laboratory by means of appropriate dampers. Here also is the flue for obtaining a down-draught at the lecture-table in the adjoining chemical lecture theatre. As several pipes open into this flue, it was found necessary to place the large ring of gas-jets for creating the draught at a considerable elevation above the floor. To light this ring an artifice was employed that it may be worth while to mention. A supplementary gas-pipe was carried alongside of the supply-pipe from a few feet above the floor to the ring of jets. This was pierced with small jets at short intervals all the way to the top. A separate tap turns on the gas in this pipe, and upon applying a light to the lowest jet the flame runs rapidly up the pipe and lights the ring at the top. The gas is then turned off from the supplementary pipe and the ring alone left burning.

34734.

From the private laboratory a door opens into the chemical lecture-room. This is provided with seats for 50 boys, the forms and desks rising tier above tier, so that experiments at the lecture table are well seen by all. The down draught at the lecture table, already alluded to, is most useful. Experiments with chlorins may be performed with hardly any smell escaping.

The theatre is well supplied with shelves, cupboards, apparatus cases, diagram-screens, and black-board. There is also a capital cellar for stock chemicals, batteries, and empty cases.

The laboratory instruction is given by the senior Natural Science Master and a qualified assistant. As the boys are allowed to come to the laboratory at such times as fall in best with their other work, there are few hours in the day when there are not at least two or three there; occasionally as many as 14 or 15 are at work at the same time; but as boys require much individual attention, a larger number than this is not thought desirable.

Under ordinary circumstances each boy has two lessons week, of rather over an hour's duration.

F



The laboratory is used by three classes of boys—

- (1.) By those whose parents wish them to obtain a knowledge of practical chemistry in addition to all their other work. These boys become the private pupils of the senior Natural Science Master, and pay an extra 10 guineas per annum. The number is at present limited to 30.
- (2.) By boys who have been so long in the school that they have gone through all the ordinary Natural Science courses of lessons. Such boys, instead of recommencing a subject, are allowed, if they wish, to attend the laboratory at the times when they would otherwise be at a Natural Science lesson. In some cases, however, they have preferred to go through one of the courses a second time, often with very satisfactory results.
- (3.) By boys who have been allowed to join the laboratory as a reward for special industry and success in one of the regular Natural Science courses.

The plan of practical work pursued is as follows—A boy at first begins with Harcourt and Madan's *Practical Chemistry*. He performs all the experiments himself, constructing and building up his own apparatus with such assistance as he may require. After the ordinary elementary manipulation with gases, distilling, &c., he studies the properties of the different classes of salts, metals, and acid radicles, and so is prepared for the converse process, in actual analysis, of determining a substance from observing the properties which he finds it to possess. Then, after working out some 40 or 50 simple salts as exercises in easy qualitative analysis, he proceeds to mixtures more or less complicated, using Fresenius or Galloway.

Very few boys at Rugby have gone beyond this and attempted quantitative analysis. In every case a boy is required to write out a complete account of every step he has taken in each analysis.

Lately the system has been introduced of allowing quite young boys from the Middle School, who have expressed a strong desire to learn practical chemistry, and have a real taste for the subject, to work in the laboratory. Probably their answers, if pressed too closely as to the precise nature of the chemical changes going on in their

experiments, might not be very satisfactory. But, for all this, the senior Natural Science Master is clearly of opinion that *they are beginning in the right way*. He states, "They are getting acquainted with facts and real things, they see with their own eyes the effects of different classes of bodies upon each other, and acids, bases, and salts, become with them something more than mere terms." Such boys, when, later on, they join a chemical "set" in the Upper School, generally take the lead, and prove, by the greater readiness with which they follow the lecturer in his theoretical explanations, the advantage they have gained by commencing chemistry from the "practical side."

In addition to the laboratories (A and B) there is a chemical lecture theatre (C), a physical science theatre (D), and an apparatus room (E).

#### ETON.

The arrangement of the Chemical Laboratory at Eton is shown in the accompanying ground plan.

As at Rugby, there is no Physical Laboratory.

There are two rooms on the upper floor—

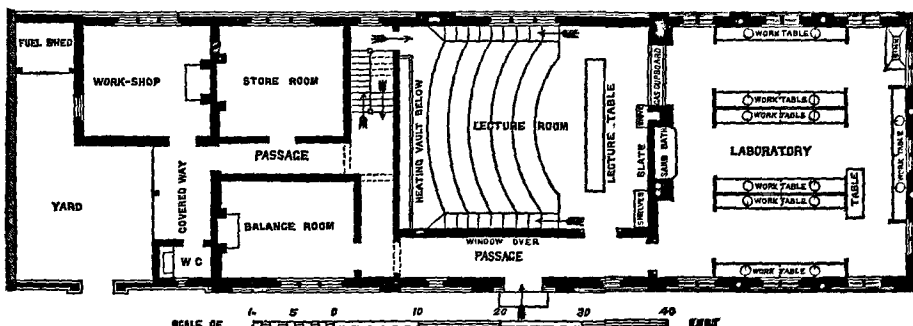
- (1.) A private laboratory
- (2.) A sitting room.

The laboratory is most efficiently arranged, and has table accommodation for acts of 28 students.

The walls of the building are of local red brick, with Bath stone dressings; the roofs are covered with brindle-coloured Staffordshire tiles, those of the laboratory and lecture-room being open-timbered. Special attention has been paid to the arrangement and general detail of the fittings, in order to make them as suitable and convenient as possible.

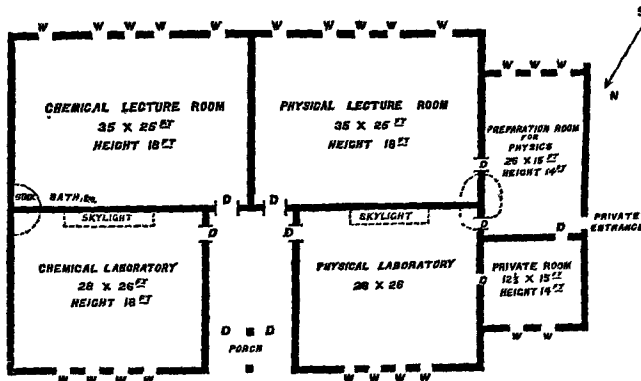
The building is heated by a boiler apparatus in the vault, and hot-water pipes in connexion; the ventilation of both laboratory and lecture-room has been well provided for, and provision is also made, by means of pipes, acted upon by gas jets, for effectually carrying off the noxious fumes and gases.

The cost of the building, inclusive of the fittings, has been about 4,000l.



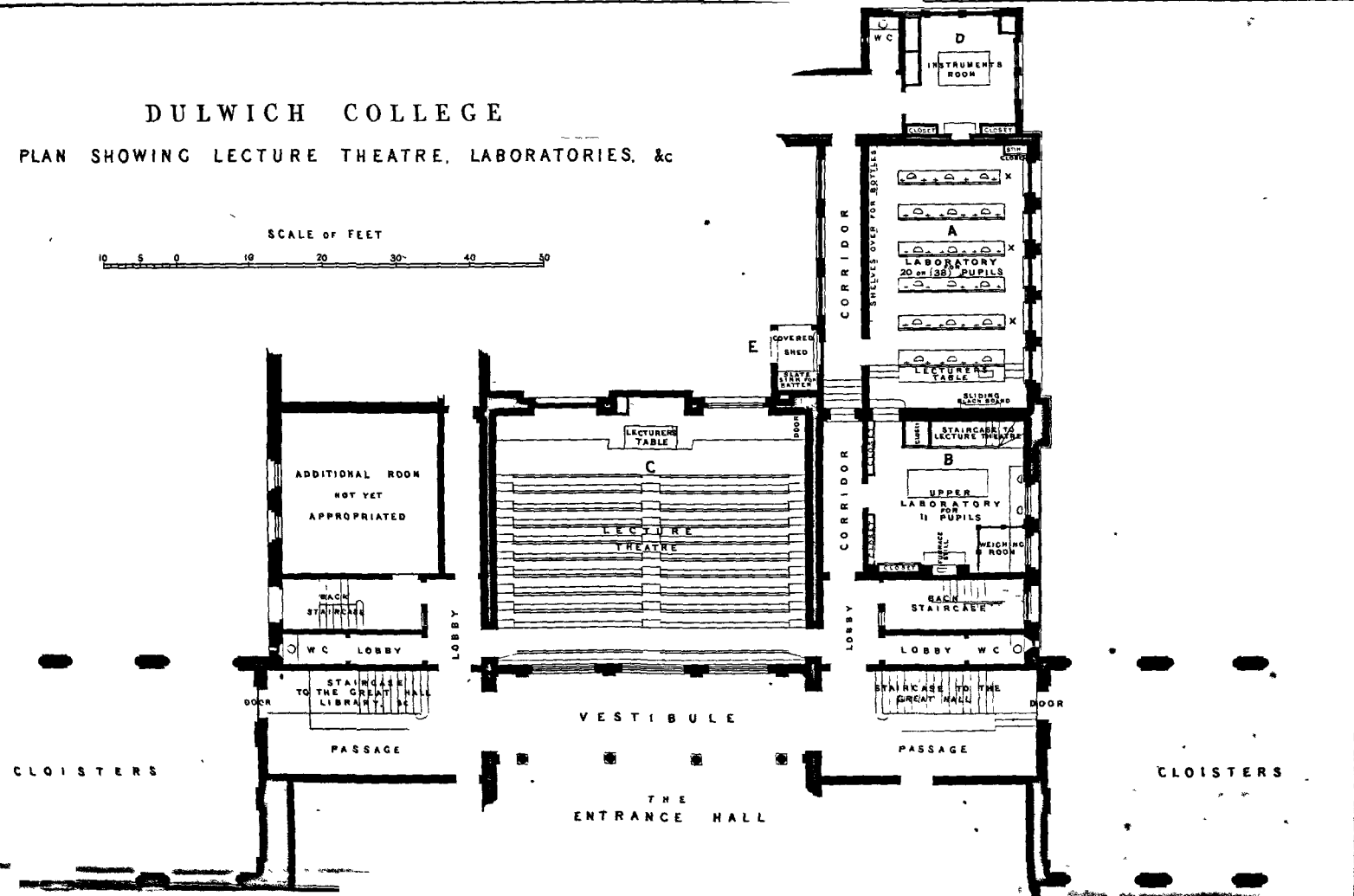
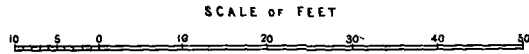
#### HARROW.

The erection of Chemical and Physical Laboratories and Class Rooms at Harrow is of quite recent date. The proposed arrangements are shown in the accompanying plan.

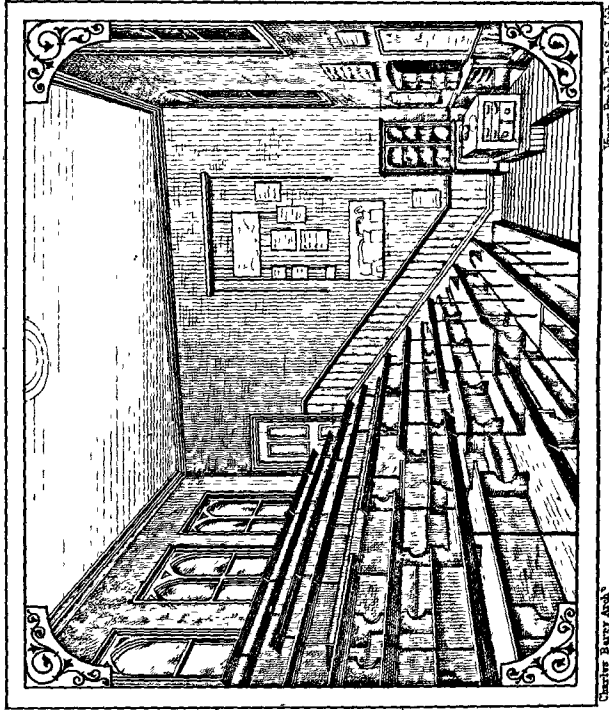


# DULWICH COLLEGE

## PLAN SHOWING LECTURE THEATRE, LABORATORIES, &c



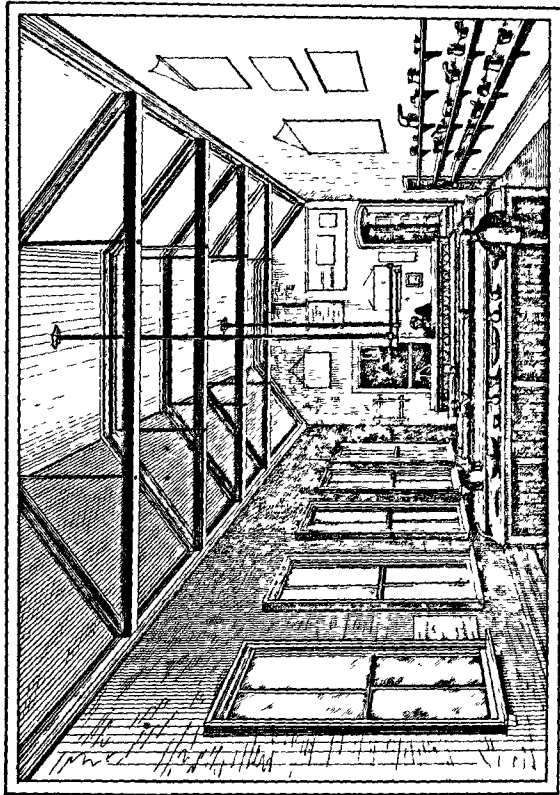
LECTURE THEATRE - DULWICH COLLEGE



Charles Barry Esq.

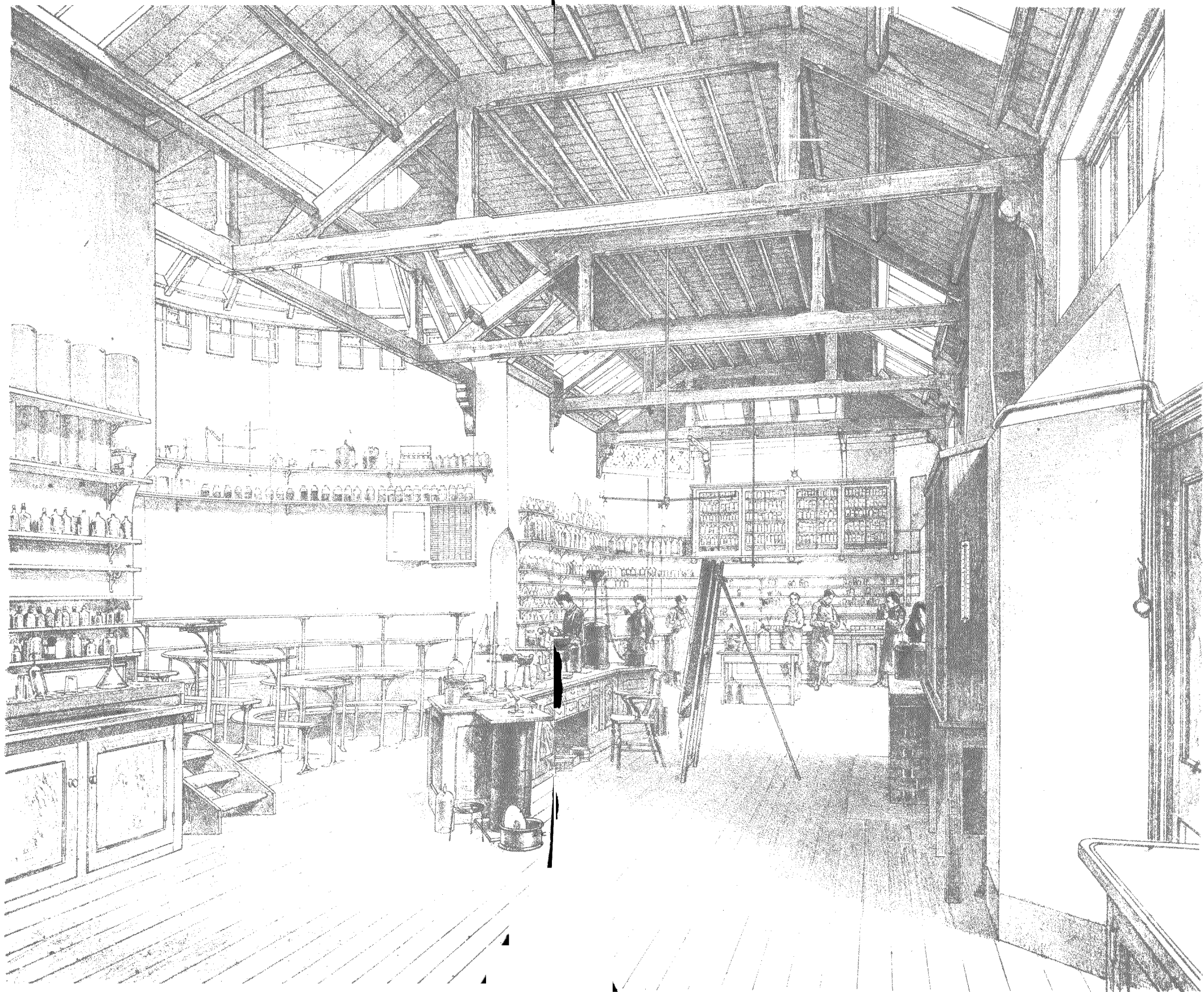
1845

CHEMICAL LABORATORY DULWICH COLLEGE



Foster Brothers, Eng. & Archt. Ltd.

Charles Barry Archt.



Below the Chemical Lecture Room there will be a room of the same size (35 x 25 ft.; height, 12 ft.), which will be used as a room for holding Physiological and Natural History Specimens

Below the Chemical Laboratory, there will be two small rooms, which will be used, it is hoped, as Work Rooms for Physiology, &c

The rooms below the Physical Department will be only 10 feet high—one of these will be used as a Balance Room; another as a small workshop, a third, as the room for supplying hot air to all the buildings, the remainder as store rooms

The shell of the buildings will cost about 4,800*l*

**DULWICH**

At Dulwich there are two Laboratories—the Lower (or Chemical) Laboratory (A), and the Upper or Small Laboratory (B), shown in the accompanying plan,—thus described in a Statement furnished by the Master

A. The Lower Laboratory is 36 feet long by 21 feet wide and 16 feet high. At one end is a platform raised 1 foot 7 inches above the floor of the room. On this is placed the Teacher's or Demonstrator's table. The table is provided with a sink and a leaden cistern (which serves as a pneumatic trough), with several Bunsen burners and the various appliances necessary for Chemical Demonstrations. On the wall behind is a large sliding blackboard, so placed as to be in view of all the pupils at the working tables. Three steps at either end of the platform bring the teacher to the floor of the room to inspect the work of the pupils from table to table

The working tables are arranged parallel to each other, and are so placed that all the pupils face the teacher. Each table is adapted for six pupils. There are a sink and a water-tap between each two, and a Bunsen burner for each separately. In front is a shelf for bottles containing the re-agents ordinarily in use, &c

In the spaces below the tables—which are divided into compartments, but not closed with doors—each boy keeps the various pieces of his apparatus, retort stands, filter stands, &c; and also a box with divisions to hold his store of test tubes, elastic tubing, glass rods, &c.

These last are provided at his own expense, and are kept by him under lock and key. Except for apparatus of this kind, which is necessarily treated as personal property, there is no additional expense incurred by a boy joining the Science Classes. The re-agents (as well as the use of all the more expensive apparatus required) are supplied by the College without special fee or extra charge.

There are, at present, in the Chemical Laboratory three working tables, as above described, supplying accommodation for 18 boys. Two more pupils are similarly accommodated at the end of the Teacher's table on the raised platform. Additional accommodation for 18 boys can at any time be provided by the erection of three more tables. These were, in fact, included in the original design (as indicated in the plan and marked with a X), and gas, water, and drain pipes are already laid for them. It is doubtful, however, whether more than 20 boys can be efficiently taught at one time. The existing accommodation is, at any rate, found sufficient at present, if used by different classes in succession.

The Laboratory is lighted by five large windows on the left of the pupils, and warmed by hot-water pipes. At the further end of the room is an aperture in the wall connected with a flue, and supplied with a powerful Bunsen burner, to carry off noxious vapours and assist in ventilating the room.

B The Upper Laboratory, 21 feet long by 18 feet wide, is fitted with cases and cupboards for keeping the apparatus for physics and chemistry. It is also used as a Physical Laboratory, and occasionally as a Science Class Room for special instruction. It is provided with a working-table for chemical purposes similarly fitted to those in the Large Laboratory, and giving accommodation to four pupils, and has, in one corner, a large glazed closet for weighing

D The small room marked D is at present occupied by the boys' school library, but is intended to be used, when required, as a room for apparatus, and, probably, at the same time, as a private room for the Science Master or Masters.

E The covered shed or lobby, built out into the open yard, is fitted with a slate slab and sink for the galvanic battery. Wires are carried from it to the Lecturer's table in the theatre, and to the Science Master's table in the Lower Laboratory

Below the Upper Laboratory and the adjoining corridor is a Basement Laboratory fitted with a furnace for the study of metallurgy, &c.

In the basement is also a workshop with a lathe for wood and metal turning. A skilled artisan (who acts also as engineer and mechanist in the College) is in charge of this workshop, and is able to construct and repair a large part of the less delicate apparatus used in the Science Department

A separate room, not included in the plans, is used as a class room for instruction in Geology (or Botany). It is one of the ordinary class rooms of the College, well lighted and ventilated, and with ample wall space for diagrams. It will contain from 30 to 36 boys.

C The Lecture Theatre is 43 feet wide by 35 feet deep. It is fitted with 10 parallel rows of seats, and is capable of accommodating 250 or 260 people. There are narrow desks to each row of seats, adapted for the purpose of taking notes. These desks will accommodate about 220 students. They are supported by strong iron rods, dropping into sockets, and can, therefore, be easily removed when not required

The Lecturer's table is well supplied with gas burners of various shapes and apertures. It has a sink and a large sunken cistern to serve as a pneumatic trough. Immediately behind the table is a glazed closet, with sliding sash, to carry off noxious and offensive gases

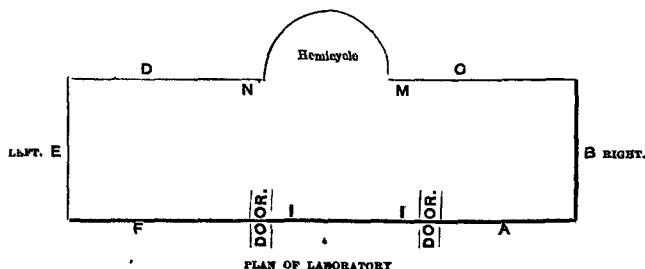
The theatre is lighted by a "sunlight" burner, which also serves to assist in ventilation, and it is warmed by hot-water pipes. A glass cupboard is provided for the storing of apparatus, and the space beneath the lecture table is occupied by drawers for the various necessities of a lecture room

The theatre is used (1) for oral instruction and demonstration to the Science classes, and (2) for courses of evening lectures, on Science or Art, given in each term generally by some lecturer not belonging to the College staff. These evening lectures are open to all boys in the College, whether members of the Science Classes or not, but attendance at them is quite voluntary.

**UNIVERSITY COLLEGE SCHOOL**

At this School there is a good Chemical Laboratory recently constructed on a plan suggested by Mr. Temple Orme, who has furnished the following account of it.

The General Arrangement is shown in the accompanying sketch. It will be seen that it is at once a Laboratory and a Class Room



1. Benches and Desks.—There are three concentric arrangements of benches and desks within the hemicycle. Breadth of benches 9 inches, and desks 12 inches. A space of about 1 foot between each desk and next interior bench, each

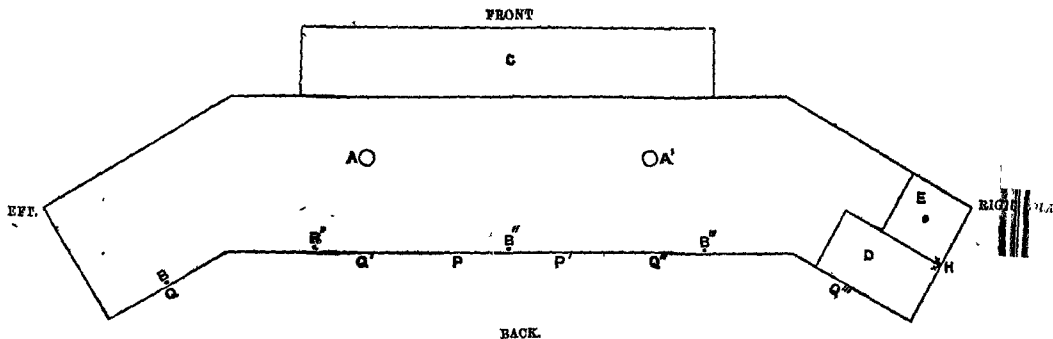
bench being raised at least 1 foot above the next interior bench.

2 Lecture Table (vide Sketch)—8 feet long parallel to the diameter of the semicircle, with two returns of 2 feet

each, at an angle of  $150^\circ$  with the main body of the table. Breadth of table 2 feet 3 inches, height 2 feet 8 inches. The top of the table projects about an inch over the face of the cupboards beneath, but there is also a groove along

the surface all the way round,  $\frac{1}{2}$  an inch from the edge; this groove is about  $\frac{1}{4}$  an inch broad and about  $\frac{1}{8}$  of an inch deep.

2a Drawers.—In the centre of the table (P and P') at



Plan of Table, half an inch to a foot.

A, A' Down draughts.  
B . . . B''' Gas-pipes at edge of table.  
C Specimen table.

D Trough, with waste-pipe.  
E Sink  
H Taps for water.

P, P' Position of drawers  
Q . . . Q''' Cupboards

least four drawers; if possible, two rows of three each. Each drawer to be about 2 feet long, 1 foot broad, and 3 inches deep.

2b Cupboards (Q, Q', &c.) These occupy the remainder of the space available for that purpose. They are provided with one shelf about 1 foot above bottom of cupboard and coming to within  $\frac{1}{2}$  an inch of door; also with two sliding trays, 4 and 8 inches respectively from the top of the cupboard.

2c Trough (D)—In the right-hand return, and at the front of the table, a pneumatic trough constructed of slate, dimensions, 1 foot broad, 1 foot and a half long, 1 foot deep. The interior is quite plain, except that there is a hole with plug at the bottom connected with waste-pipe. There should be a grating just below the plug to prevent stoppage, and a joint within easy reach.

The top edge of the trough (which will be about 1 inch thick) should be a little below the level of the table, and a wooden lid should be provided, which, when placed over the trough, will completely cover it and be flush with the table.

Tap (H) for water supply.

2d Sink (E) of glazed stoneware, 1 foot in diameter, placed behind the trough.

Tap (H) for water supply.

2e Down-draughts (A, A') of glazed stoneware, coming out at right hand of furnace, where, on a level with the floor, a small air-tight door is provided, within which is a ring of gas jets; thence passing into the flue of furnace.

2f Gas Pipes (B, B', &c.)—One pair in left-hand return, and three pairs along the central portion. All these being as close as possible to the back edge of the table.

3 Specimen Table (C).—Placed in front of lecture table. Length 6 feet, breadth 1 foot, height 2 feet. The upper surface will be used solely for the display of specimens.

4 Blow-pipe Table, placed near the back wall on the left of the still (q v).

5. Slate, on easel.

6 Work Tables (26 in number), 3 feet long, 1 foot 9 inches broad, 3 feet high. Upper surface of wood, quite plain, neither painted, paraffined, nor stained, &c.; groove as with lecture table, and projecting 3 inches over the cupboards beneath, there is no partition between any two contiguous desks, since the sinks will be quite sufficient to indicate the limits of each.

6a Cupboards.—Beneath each table, a cupboard similar to 2b, except that there is only one sliding tray 4 inches from top, and there are two shelves, one of which is 1 foot from bottom and the other midway between this and the tray, both coming to within an inch of the door.

6b Sinks, 1 foot in diameter, of glazed stoneware, waste pipes of same, with plug, beneath which is grating, joints within easy reach. One sink for every two tables.

6c Tap, for water supply, one for each sink.

6d Gas Pipes.—One pipe dividing into two smaller ones (one for each table), placed alternately with the sinks. Also near each sink one fish-tail burner for lighting purposes.

6e Shelves.—Four in number above each table; strongly fixed to the wall; about 4 inches deep. The first shelf is 1 foot above table, the others are 6 inches apart. The shelves of one table are continuous with those of the adjacent tables, but separated from them by a narrow upright placed against the wall; these uprights may, but need not, come to the front.

7 Sink at N, on the left-hand side, with tap and arrangements for washing and drying bottles, &c.

8 Teacher's Work Table at M, on the right-hand side, 5 feet long, 1 foot 9 inches broad, and 3 feet high; cupboards beneath with revolving doors and two drawers about 4 inches deep. Desk grooved. Separate sink, tap, and gas supply (two gas pipes in middle, close to the wall). Shelves above, the same as with the other tables. This table will be used for the preparation of class experiments.

9 Shelves for large apparatus, &c. Against the wall and extending, as far as the structure will permit, all round the room (except over the desks at B and E), there are two firmly fixed shelves. The lower one is about 1 foot above the top shelf of the work-tables, and the other not less than 1 foot 3 inches higher. Depth about 8 inches.

10 Cupboards for specimens, with glass doors, fixed against the wall at a convenient height over the desks at B and E. These cupboards should be very broad, and neither too high nor too deep, so that as many specimens as possible within them may be visible from outside.

11 Furnace, with plate and sand bath in the centre of the back wall. Facing the furnace, there is, on the right of it, the flue from the down draught of the lecture table. Still further on the right—

12 Draught-cupboard as long as possible, 2 ft. deep and 3 ft. high. Gas jet in flue. The flue opens ultimately into the furnace flue from the lecture table.

13 Still, on separate fire, placed on the left of the furnace.

14 Gas burners or chandelier for supplying light during lectures on foggy days.

15 Exercise chest. A small wooden chest, similar to that in the mathematical theatre of the College, but with a sliding door, which can be altogether removed at pleasure, and containing about 200 partitions, is placed at the back of the class benches. Each partition is about  $2\frac{1}{2}$  inches broad, 4 inches deep, and  $\frac{1}{2}$  of an inch high.

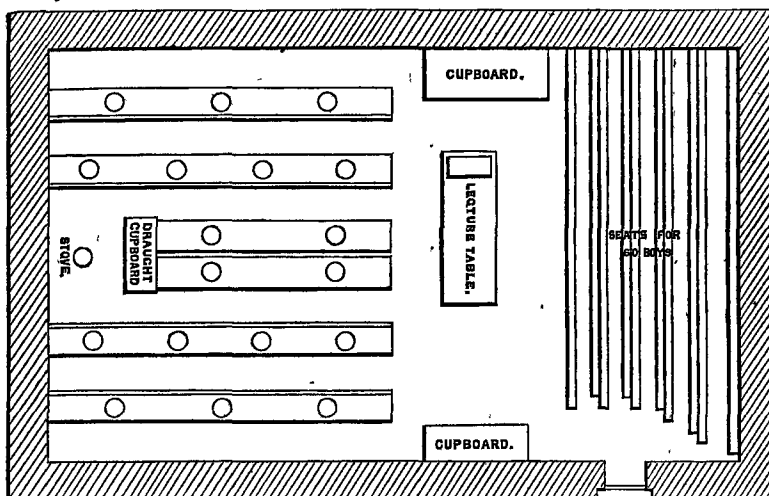
#### MANCHESTER.

There are, in the Manchester Grammar School, two distinct Chemical Laboratories: the old one, in which the Laboratory and Lecture Room are conjoined; and the new

one, in which they are separated. Both these Laboratories are comprised in one large building, occupying the site of the original Grammar School, built by Hugh Oldham. The arrangements of the two Laboratories are thus described by Mr. Francis Jones.

#### I.—The Old Laboratory and Lecture Room

This Laboratory was fitted up in 1868, and was previously one of the ordinary schoolrooms. Its arrangements are shown in the accompanying plan, from which it will be



Ground Plan of the Old Laboratory at the Manchester Grammar School.

seen that the lecture table separates the Laboratory from the lecture seats and desks. The cupboards on either side and others fixed to the wall, and not shown in the ground plan, contain the apparatus used during lectures, as well as the solutions and solid substances given to the boys for analysis. Above the lecture table, a glass cupboard, connected with a good draught, serves to contain any apparatus evolving unpleasant or poisonous odours. The remaining portion of the room is fitted up as a laboratory. It is arranged to accommodate 30 boys, each of whom is provided with a cupboard for apparatus, and with a set of reagents, which are placed on shelves fixed to the top of the table. Gas and water taps are fixed at convenient distances along the tables. The small circles marked on the plan denote the positions of the sinks for waste water. A draught cupboard for general use is placed at the end of the double table in the middle of the room, and behind it is a stove which is used for warming the room as well as for heating crucibles, &c. Ventilation is provided for by means of small windows, and also by a flue above the large gas burners used for lighting the room. The cost of this Laboratory and Lecture Room was 350*l*.

#### II.—The New Laboratory and Lecture Room

When the increasing size of the Grammar School required the erection of new buildings the old School (a building 93 feet long by 28 broad) was converted into the present Laboratory; the alterations were completed in 1871. The accompanying sketch shows the ground plan and elevation of the four rooms of which the laboratory consists. These are—

- A.—The Lecture Room
- B.—The Laboratory.
- C.—The Balance Room
- D.—The Sulphuretted Hydrogen Room.

##### A.—The Lecture Room.

This room is 32 feet long by 24 feet broad, and has seats and desks constructed for 76 boys, but capable of accommodating 90 without inconvenience. These seats rise tier above tier so as to command a good view of the experiments performed at the table. The lecture table is well supplied with gas and water taps, and has likewise binding screws fixed in it, connected with wires which pass along the floor to the galvanic battery, which is placed in the draught cupboard behind the table. By this means space

is saved on the table and the fumes arising from the battery are kept out of the room. The draught cupboard, which is well seen from the seats, is constructed as far as possible of glass, and is used for all experiments which give rise to unpleasant odours. The apparatus used for the lectures is contained in seven cupboards, two of which (marked D. E. on the plan) are close to the lecture table, and the remaining five are in the gallery (E. E.). The windows are all provided with sliding shutters which can be very rapidly closed, they are made of blackened wood and exclude daylight completely. By this means the room can be perfectly darkened in one minute for the performance of experiments which require the absence of daylight.

##### B.—The Laboratory

The Laboratory is 48 feet long by 24 feet broad, and is provided with four working tables, the centre one being double. These tables are provided with 84 cupboards and drawers, which contain the apparatus belonging to the boys. The drawer is so connected with the cupboard that one key suffices to lock both.

The common reagents are placed in shelves at the back of each table, and special reagents are placed in suitable parts of the Laboratory for general use. The small circles marked on the tables in the general plan, denote the positions of the water-taps and basins, and near them, at convenient distances, are the gas taps, of which there are 40. The cupboards at the end of the Laboratory contain the substances given to the boys for analysis, and also the stock of reagents for filling the smaller bottles on the shelves. A draught cupboard similar to the one already described is placed beside the reagent cupboards. In the gallery (D. D.) are five more cupboards containing various chemicals and apparatus.

Although the laboratory contains cupboards for 84 boys, the number working at one time never exceeds 40, each of whom is provided with a Bunsen lamp, a retort stand, and set of chemical reagents. With these exceptions, each boy provides his own apparatus.

##### C.—The Balance Room

The balances are contained in a small well-lighted room at the end of the Laboratory, as shown on the plan. It contains two fine Oertling's balances, and a smaller one for less exact weighings. The Library of the Philosophical Society connected with the School, is also kept in this room.



#### D.—The Sulphuretted Hydrogen Room.

The corresponding room to the Balance Room, on the opposite side of the Laboratory, is fitted up with three large draught cupboards for the use of the boys. In this room all experiments with sulphuretted hydrogen, chlorine, and other injurious gases, are performed.

The Laboratory is used chiefly by the three Science Forms, the highest two of which work in it six hours weekly, and attend, besides, two lectures on Chemistry. The boys of the Lowest Science Form attend one lecture weekly, and work in the Laboratory for two hours. The boys of the Highest Mathematical Form in the School work one hour weekly at Practical Chemistry, and two of the Modern Language Forms devote three hours weekly to Chemistry, the time being equally divided between lecture and laboratory work.

The cost of the two Laboratories, with the fittings, has been 990l.

#### CLIFTON.

Plans are given of Chemical and Physical Laboratories and Lecture Rooms proposed to be erected at Clifton College, to replace the smaller ones which have been in use up to the present time.

#### GENERAL REMARKS ON LABORATORIES FOR SCIENCE SCHOOLS.

The Commissioners will observe from the replies received that, whereas chemistry is practically taught in many schools, the boys willingly giving up much of their play time to laboratory work in this subject, with the exception of University College School and King's College School, there is no school physical laboratory.

There is also an opinion among the Head Masters that, on the whole, it is better to begin with the elementary facts of physics than with chemistry.

There are many indications that the teaching of even the elementary parts of physics to young boys is best accomplished by associating the teaching with experiments, and by allowing the boys to do the latter for themselves, as far as possible.

It is clear that for this junior teaching much apparatus and a specially prepared room are not necessary, for the higher teaching special arrangements are as necessary as they are universally considered to be in the case of chemistry.

There are now in America several such laboratories, in which large classes of students perform various experiments instead of, or in addition to, attending lectures.

One of the first institutions to attempt this method was the Massachusetts Institute of Technology in Boston. In this system, obviously, the great difficulty is to enable twenty or thirty students to perform the same experiment without duplicating the apparatus, and to avoid the danger of injury to delicate instruments. The plan adopted at the Institute in question has thus been described by Professor Pickering:—

"Two large rooms (one nearly a hundred feet in length) are fitted up with tables, supplied with gas and water, somewhat like a chemical laboratory. On each is placed the apparatus prepared for a single experiment, which always remains in this place, thus avoiding the danger of breaking it in moving. A full written description is also given of each experiment, pointing out the proper precautions to avoid error or breakage. Near the door is an indicator or board containing the names of the experiments, and opposite each is placed a card bearing the name of the student. When the class enters the laboratory, they go to the indicator, and each member notices what experiment is opposite his name, he then goes to the proper table, reads the description, and performs it. He next reports his results to the instructor in charge, and if they are correct his card is moved to some unoccupied place, and he proceeds as before. Care is taken that the number of experiments shall exceed that of students, and there is therefore no delay. The instructor in the meantime is enabled to pass from student to student, and to see that no errors are committed. As quantitative work is far more valuable than qualitative, most of our experiments are of the former kind, and the student learns to measure physical constants, and to verify laws numerically. For example, in one experiment a steel bar is supported on knife edges, and a weight is applied at the centre. The flexure is then measured by a micrometer screw, the exact point of contact being determined by including the screw

and bar in the circuit of a battery and galvanometer. After making a number of experiments with various weights, the student constructs a curve, in which ordinates represent deflection, and abscissæ weights applied. The law of elasticity shows that this curve should be a straight line, and the close agreement is convincing proof to the student of its correctness. In the same way the law of the conjugate foci of lenses is tested, and the observed curve compared with that deduced from theory. Some experiments are introduced to accustom the student to general methods of research, such as the computation of probable error by least squares, various forms of interpolation, &c. The graphical method is largely used, as it at the same time enables the student to take in all his observations at one glance, while the instructor can constantly tell how carefully the work has been done. For the microscope a few objects are selected to show certain general methods of using this instrument, as one requiring a diaphragm, a second oblique illumination, and so on. Again, the student views by polarised light such objects as unannealed glass, crystals, designs in selenite, and studies the effects produced by various agencies. By thus handling the instruments, he acquires a facility in using them, and comprehension of their construction which he could never obtain from lectures. The excellence of the work done by many of the students led to the hope that valuable results might be obtained by assigning to different students the experiments in a research, taking care that each should be repeated several times by different individuals. These results, if concordant, would be much more conclusive than those obtained by a single experimenter, since they would be free from all personal bias. In this way some interesting results have been obtained on the foci of lenses placed obliquely, the flow of air through straight and curved tubes, and other similar subjects. Photometry and electrical measurement seem especially suited to this purpose, and the application of the latter subject to submarine cables would be both interesting and instructive to the student. During the winter term of 1869 and 1870 about sixty students worked in one laboratory, so that the experiment was tried on a sufficiently large scale to enable us to speak with confidence of its success. We found the system described above worked well, the students were interested in the subject, and obtained results of considerable accuracy. The loss by breakage was exceedingly small, and the current expenses insignificant compared with a chemical laboratory, since there is but little consumption of the materials employed."

The following suggestions as to the amount of space requisite and the arrangements for chemical laboratories have been made by the Science and Art Department, and published in the *Science Directory* for the information of Committees of Schools who propose to erect buildings or to convert existing buildings to school use. It is expressly stated that they are to be considered merely as suggestions, and not as absolute rules to be followed implicitly under all circumstances; still, as suggestions merely, they are so valuable that I append them and the accompanying plans.

#### 1. Laboratory for 20 Students.

"A room about 35' x 19', 16' high to ceiling (or collar beam), lighted by windows on both sides and, if possible, a skylight, and fitted up with working benches. The method of arranging these benches must depend upon the special circumstances of the case, but, when possible, a very convenient way is to arrange them in groups of four along the side walls. Each working space should be 3' 6" x 2' 6", which would make each group 7' x 6", and in a room of the above dimensions a passage of 5' (which might, however, be reduced to 4') would be left down the middle of the room between the ends of the benches, and about 6' would be left in the clear between the benches. Five groups of benches would accommodate the 20 students. Three groups would be on one side of the room, and the benches of the third group might be made a little longer to give more room to advanced students. On the other side of the room would be two groups of benches, and opposite the third group of the first side would be a space for sand bath, steam apparatus, gas furnaces, &c.

"In each wall space between the benches should be a closet about 16' x 9' and 2' high for sulphuretted hydrogen. The closet should have a flue which may be made of 2" drain pipe carried up in the wall, and the draught maintained in it by a small gas jet, or if there be a good upcast shaft from furnaces in the basement these flues may be led into it.

" Another way of arranging these closets, which has been found to answer where there is a good upcast shaft, is to construct them of wood and put one on each working bench, a wooden tube carried along the top of the bench to the wall, and thence along the wall forming the flue from it to the shaft. In this case it would probably be found better to arrange the benches together, and have the passage down one side of the room instead of the centre.

" Each worker should have gas laid on to his space, one sink and water tap between two is sufficient, or one sink with two taps, in the centre of each group of benches, except for the advanced students, for each of whom it will be well to provide a sink and a double tap.

" A room about 14' x 12' should be provided for balances and other delicate apparatus. This might also serve as an office for the professor.

" There would, doubtless, in the same school be other classes, in which case a lecture theatre would be provided for general use. In close proximity to this should be a preparation room fitted with working table, gas furnaces, steam apparatus, &c., to enable the professor to prepare for his lectures. A good flue will here be necessary to remove noxious gases, &c., and it might serve also for the lecture room.

" The laboratory would be best placed either under a separate roof from the other class rooms, or in the top storey of a building, of which the ground floor would give space for the other class rooms, and the basement would contain the heating apparatus, washing and cloak rooms, metallurgical furnaces, and space for any other work which from its nature could not be carried on in the general laboratory."

## 2. Laboratory for 50 Students

" A laboratory about 50' x 19' should be provided for 50 elementary students. This should be fitted with working benches, &c., as the laboratory described above.

" A second laboratory about 36' x 22' 6", or 43' x 19', should be provided for 20 advanced students.

" Each advanced student should have a space 4' 6" x 2' 6", with a sink, double water tap, two gas jets, and if possible a sulphuretted hydrogen closet to himself.

" There should be a steam closet, sand bath, gas furnaces, &c., as in the other laboratory.

" A balance room should be provided in close proximity to the advanced laboratory.

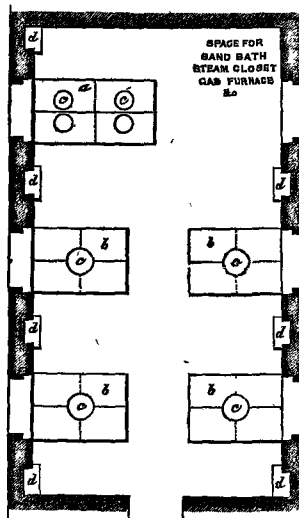
" An operation room should be provided. This may be with the furnaces, &c., in the basement.

" In a school of this size it would probably be found advisable to provide a private laboratory for the professor. A room about 12' x 16' would be sufficient. It should be fitted with working table, steam closet, gas furnaces, &c.

" A chemical library would also be very desirable. This might be kept in the same room as the balances.

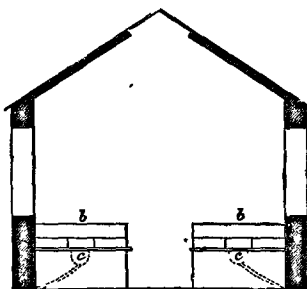
" To save space, one of these laboratories might be constructed above the other; but it is better to have nothing over a laboratory, so that there may be skylights and ample means of clearing out noxious gases."

## " PLAN OF LABORATORY FOR 20 STUDENTS



- " a Group of four benches for advanced students.
- " b Groups of four benches for elementary students.
- " c Sinks, each with two water taps.
- " d Niches for sulphuretted hydrogen closets

Skylight.



" Section.

" Scale, 10 feet to an inch."

## § 12.—OBSERVATORIES.

Up to the present time, a Telescope, to say nothing of an Observatory, has been by no means considered as a necessary instrument for Scientific Teaching in Schools. Nevertheless, both at Rugby and Eton Observatories have been erected, to which attention must be drawn.

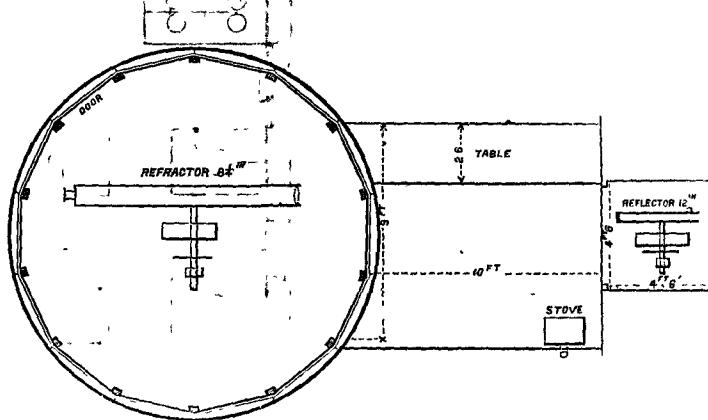
The Temple Observatory at Rugby, which is now playing an important part in the science education at that school, is a wooden building of unpretending appearance, both inside and out; it is in fact built entirely for work. The accompanying plan and drawing, taken from a photograph, will render the following description of it more clear. The circular roof covers the 34 in. refractor by Alvan Clark, and round the walls are shelves and tables for books, maps, &c. In the small room adjoining are kept spectroscopes and other instruments when not in use on the telescope; a Sprengel air pump, and vacuum tubes, batteries and coils

for examination of the spectra of gases, are also in this room; a heliostat above reflecting sunlight down for comparison. At the end of this room is placed a reflector, 12 in. aperture, by With, the whole of the mounting for which has been made in the town of Rugby, according to the plans and with the assistance of Mr. Seabroke, and is good and substantial throughout, although without polish. The spectroscopes made on the return principle is also of local manufacture, costing, we believe, about 10*l*. only, without the prisms, five in number, each used twice. The observatory is under the charge of Mr. Wilson and Mr. Seabroke, and one or both of them are there every fine night, when any of the boys are permitted to come and observe; generally there are three or four present. The work consists of measuring positions and distances of double stars, in which the boys join, their readings being

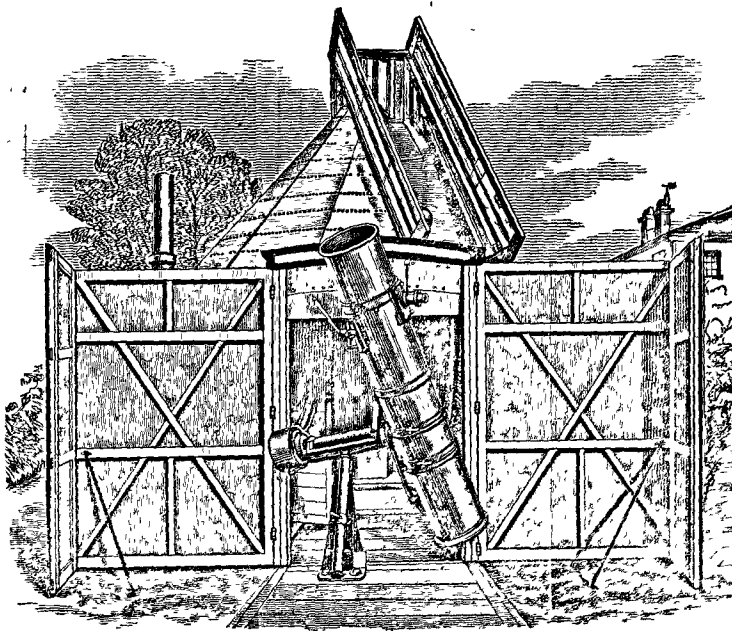
valued according to their experience, those who are not actually observing, receiving instruction till their turn comes round. In the daytime, when the sun is visible, Mr. Seabroke notes the positions and heights of the solar prominences, in which he is sometimes assisted by the boys, who also make drawings of the prominences and spots. Mr. Wilson is also occasionally assisted by the boys in calculating the orbits of binames. The methods followed are

those proposed in the *Philosophical Transactions* by Herschel, one almost entirely graphical and the other analytical; both are used in order that each may check the other.

I gathered from the observatory note book that a number of drawings have been made of Venus, Jupiter, Mars,\* towards which the boys have contributed largely; there are also drawings of Encke's comet, together with its spectrum.



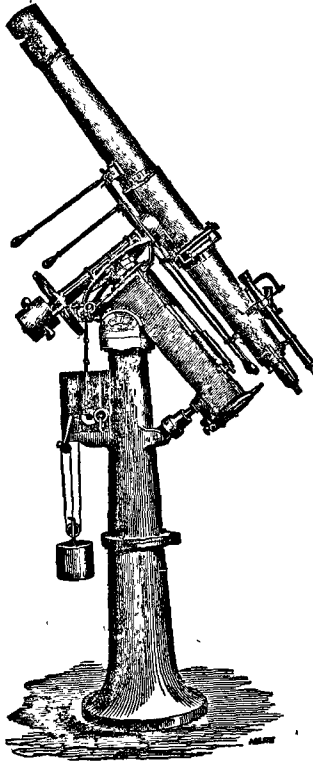
Ground Plan of the Rugby Observatory.



View of Temporary Observatory for Reflector.

The Telescope at Eton, recently given to the school by the energy and liberality of some of the Masters, is a refractor, with object glass of 5.9 inches clear aperture and 88 inches focus, and was made by Messrs Cooke and Sons, of York, who also supplied the observatory and superintended the erection of the telescope. It is, as will be

seen from the drawing, mounted equatorially on the German system, with declination circle reading to 10" of arc, and hour circle reading to 2" of time. The mechanical details do not, with one exception, deviate materially from the pattern usually adopted by Messrs Cooke. The telescope is furnished with a sufficient battery of



THE ETON EQUATORIAL.

eye-pieces, of powers ranging from 30 to 400, and also with a bifilar micrometer. The position circle is permanently attached to the lower end of the main tube. The observatory is erected on the roof of the western tower of the New Schools. It is square, and surmounted by a revolving dome. It is obvious that an instrument erected on a tower cannot be wholly free from vibration; but the latter is reduced to a minimum by supporting the telescope on two massive trussed iron girders stretching across the tower

The floor of the observatory is supported quite independently.

Besides these large Observatories at Rugby and Eton, there is a smaller one at Rossall, which is substantially built, and furnished with revolving dome. It contains a 4½-inch refractor, equatorially mounted by Slugg, of Manchester. It has not been used recently.

I am informed that a telescope of considerable power has been purchased for use at Clifton College, but the Observatory is not yet built.

### § 13.—MUSEUMS AND BOTANIC GARDENS.

#### CLIFTON COLLEGE

The Museum and Botanic Gardens at Clifton College were first projected in 1870, when a fund was begun to defray the cost of their formation and maintenance. A sum of more than 370*l.* has now been raised, and though the expenses have been necessarily heavy, both the garden and the museum are now entirely free from debt.

The Head Master of Clifton College (the Rev. Prebendary Percival), erected at his own expense and presented to the college the extensive building intended for a library

and museum. It is a well-lighted apartment in the early English style, 60 feet by 23 feet, and situated on the first floor. It comprises five bays, the lower one being at present used as the secretary's office. The book-cases are fitted in between the windows, so as to form a series of recesses annexed to the windows of the room, with a table in each for study. The library is already well stocked and contains some 1,300 valuable volumes, comprising works of standard authors. The architecture of the library and museum is in character with the rest of the

college building, the roof being open-timbered, of ornamental construction, with hammer beams resting on wooden columns. The museum cases are arranged down the centre of the room. The fittings are of polished pine.



THE MUSEUM OF CLIFTON COLLEGE

The museum must be considered as still in its infancy, but though there are many gaps in the collections, some of them are remarkably good. An important rule was laid down at the very outset, viz., that "the museum shall be essentially a British one, and shall illustrate the natural history and antiquities of our land by good specimens systematically arranged, under the departments of zoology, botany, geology, mineralogy, and archaeology. In addition to this, there will be a collection of rare and curious objects, which may be considered useful for the purpose of scientific teaching, and a large typical series to be used at the lectures and demonstrations given in the college on comparative anatomy and other branches of natural history. The committee of management will only accept of such specimens as can be classed under some one of these heads." This rule has been hitherto absolutely adhered to and there is little doubt that its adoption will insure the real utility of the museum, and will make the collections much more perfect than could otherwise be expected.

The late Professor Sedgwick sent one of the best typical collections of mesozoic fossils, consisting of 440 species, and 1,100 specimens. The gift is in every way most valuable, and it is one of the most useful that the museum has yet received. The palaeozoic fossils were very imperfectly represented till lately, when a large case was received from the Director-General of the Irish Geological Survey. The specimens are mostly typical, and are all named. Some of them are of great rarity.

Large collections of fossils have also been received from Samuel Worsley, Esq., of Clifton, and many other contributors. The local series of fossils is considered of especial importance in such a museum as this, and under the able superintendance of J. G. Greenfall, Esq., it has already attained considerable dimensions. The expeditions of the geological section of the Clifton College Scientific Society have been the means of procuring large accessions

to this collection, and among individual donors, mention should especially be made of J Rosseter, Esq., and S G Perceval, Esq.

The rock specimens are at present few and unimportant, but Professor Phillips, of Oxford, has promised to give shortly a number of duplicates from his splendid collection in the museum of the University of Oxford. The kindness of a Clifton lady (Miss Wills), has lately furnished the museum with a complete series of polished cubes (101 in number), illustrating the rocks of the Avon section at Clifton. They are arranged (in stratigraphical order) in one of the glass cases, and a complete catalogue of them has been prepared for the use of students.

The minerals in the museum comprise not less than 1,000 different kinds, many being very valuable. The greater portion of them was lately acquired in the following manner—W Sanders, Esq., F R S., wishing to dispose of a large mineral collection which he had formed, kindly offered it to the museum at a sum very much under its real value. He further offered to give one-third of the amount as a donation from himself. The Rev J Heyworth, Chairman of the College Council, on hearing of Mr Sanders' offer, generously contributed another third, and thus, for the small contribution of ten pounds from the college fund, this very extensive and excellent set of minerals has been secured. A catalogue of the collection is in preparation, and will shortly be issued.

There is a large collection of shells, arranged in three series, i.e., 1. British land and fresh water shells; 2. British marine shells; 3. Generic examples from all parts. Woodward's *Manual of the Mollusca* has been used in arranging them, and they are now in excellent order. A. Crutwell, Esq., O C, was one of the largest contributors to this department, but valuable gifts have been made to it by many others. There are a great many duplicates, which are offered for exchange.

A report on the Lepidoptera of the museum has been drawn up by the Rev. J. Greene.

The Coleoptera are represented by a great number of specimens, and Mr. Barton, an experienced coleopterist, has very kindly undertaken the re-arranging and labelling of them. Professor Westwood, of Oxford, is the contributor of one-half of these insects, and he has given so much time and trouble to the selection and naming of them, that the warmest thanks of the society are due to him. J. F. M. H. Stone is also the donor of a large proportion of the whole collection. In other departments of entomology there are very few examples.

The eggs of British birds are numerous and well arranged; and there are a good many stuffed specimens of British birds, lists of which have been drawn up mainly by J. F. M. H. Stone and P. A. Ogilvie.

The curator of the museum and botanic gardens has lately begun the formation of a zoological series, intended to illustrate typically the leading forms of animal life, and it is hoped that this may be made one of the most interesting portions of the museum, though the limited space at command will prevent it from becoming very extensive.

An Osteological collection has also been undertaken, and it already contains some good specimens, one being a fine elephant's skull, procured for the college museum in India by General McLeod. Both the osteological and the zoological series will be of very great use in instruction, and the curator is anxious to receive additions to them.

The coins form a large collection, and many of them are rare and valuable. W. Ballie and J. Prinsep have for some time been occupied in arranging them, but there is much need of a good cabinet, for the purchase of which funds are needed. R. Bamford, W. Hill, and A. Paul, Esq., O. C., have contributed largely to this department of the museum.

A good museum is of little use without a good scientific library, and a great many standard works of reference, mostly illustrated, have been purchased for the use of the students. A welcome addition to this scientific library has lately been made by Thomas Proctor, Esq., whose donations to the Museum and Botanic Garden have been most munificent. The naming of fossils had hitherto been a difficult task, from the want of good drawings for comparison and reference, but this want Mr. Proctor has now supplied, by presenting to the library an entire set of the publications of the Palaeontographical Society. F. F. Tuckett, Esq., has also presented many useful scientific works to the library.

The Herbarium is at present placed in the Museum, suitable drawers having been provided for it. It is now of considerable extent, and most of the plants are uniformly mounted on stiff paper, and labelled. The nucleus of the collection was an old but most extensive herbarium, formed by the late Miss Mills, and contributed by her nephew. The Rev. James Heyworth has lately presented a very large number of specimens, collected by himself (especially rich in ferns and seaweeds), together with another series made by Mr. Thwaites, of Ceylon. It is proposed to make a local herbarium.

It remains to say something of the Botanic Garden. It may be gathered from the announcements of donations made at the Scientific Society's meetings, the gifts to it have been very numerous. The following institutions and private individuals have given the most zealous help in the formation of the garden: the Royal Botanic Gardens, Edinburgh (Professor Malfour); Trinity College, Dublin (Professor Percival Wright); Royal Botanic Gardens, Regent's Park, London (W. Sowerby, Esq.); Royal Botanic Gardens, Glasnevin (Dr. Moore); Botanic Gardens, Hull (J. C. Niven, Esq.); Rev. H. N. Ellacombe, Bitton, J. Saunders, Esq., Clifton; George Maw, Esq., Broseley; J. Backhouse, Esq., York; T. Proctor, Esq., Clifton. Further donations are promised by Dr. Hooker, Kew; Professor Lawson, Oxford; Professor Babington, Cambridge, and J. Richardson, Esq., Liverpool.

The formation of the garden was a work of considerable difficulty, the place assigned to it being exceedingly barren and unproving. The garden is divided by a path into two portions, each with a neat iron fence. The hedges are formed of the following shrubs: *Berberis Darwins*, *Spartium junceum*, *Ulex europaeus flore-pleno*, *Cerasus Lauro-Cerasus*, var. *Colchaca*, *Rosa sedica* (monthly rose), *Layustrum japonicum*, and *Aucuba japonica*. At intervals along the hedges are placed examples of the trees and shrubs indigenous to or commonly grown in England. This arboretum (presented by Mr. Proctor) is intended to familiarise learners with the names and appearance of the common specimens which they are likely to meet with. Every tree and shrub has a conspicuous label attached to it, bearing the English and Latin name, the natural order, and the native country of the specimen. There is an extensive

rockery on the terrace in the garden, now completely stocked with Alpine plants, and a number of rare Pyrenean plants, obtained by purchase from Chevalier Bordère in November 1871. The collection of Saxifrages is good and flourishing. The herbaceous plants are disposed in the plots of ground, and they are grown in narrow parallel beds, with strips of grass border between. They are, of course, arranged according to the natural system, a large label indicating the limits of each order, while a smaller one is placed beside every plant. Aquatic plants are grown in large pots filled with water and sunk in the ground—a sorry substitute, however, for a pond, and it cannot be expected that the collection of aquatics can either be adequate or well grown till some pools are formed for the special reception of this important division of plants. There are at present about 1,000 or 1,200 species of flowering plants, but some of the genera (and even orders) are poorly represented, while of others there are too many. But, when it is remembered that the garden is of recent formation, the progress made may be considered satisfactory. The curator has had great assistance in the determination of the different species of plants from his friend, Mr. G. C. Churchill, and both here and in the Museum he has never found lack of ready help among the boys of the college, for whose especial benefit both institutions have been formed.

When the various collections are a little better developed, the curator hopes to issue descriptive catalogues, which he thinks will make their utility much greater. The first of the series is to form a guide to the Botanic Garden, and it will be shortly followed by others on the minerals, shells, and insects in the Museum.

The curator thus concludes his report:—"It remains that I should say how urgently we require further contributions, not only of money, but of specimens. It will give me great pleasure to communicate with intending donors, and all gifts will be duly acknowledged at the Scientific Society's meetings. The following is taken from a circular recently issued. It will give a general idea of our requirements:—

"CLIFTON COLLEGE MUSEUM.—*List of Desiderata.* British Fossils, with name (and, if possible, locality).—Those from the Palaeozoic formations, and local specimens specially desired.

"British Rocks Named.—Any good typical specimens.  
"British Minerals.—A few good ones only, the collection containing already nearly 1,000 specimens. The sub-curator (J. G. Greenfell, Esq., Clifton College), will be glad to furnish mineralogists with the names of those most needed.

"British Shells.—Only the rare ones now wanted.  
"British Crustacea and Echinodermata.—Any. We have very few.

"British Lepidoptera.—The sub-curator (Rev. J. Greene, Apsley Road, Clifton) still requires a considerable number of specimens, but the commoner ones have nearly all been supplied.

"British Coleoptera.—We have a large collection already, which has not been as yet fully arranged.

"British Diptera and Orthoptera, &c.—Any.  
"British Eggs.—Information can be had of the sub-curator, D. Pearce, Clifton College. Many more eggs are needed.

"British Birds.—The nests of British birds are desirable, and a considerable number of stuffed birds.

"British Mammalia.—Skins or stuffed specimens of any found wild in Britain.

"British Plants.—The herbarium now contains more than a thousand species, but good specimens of rare or local plants would be highly acceptable.

"British Coins.—Any provincial tokens of the 17th and 18th centuries are also needed.

"British Antiquities.—Celtic, Roman, or early English remains. Many persons would probably be able to assist in the formation of this collection, which is as yet very small.

"Zoological Series.—Foreign specimens are here admissible, but, as types only of the principal natural divisions are required, it is desirable that the curator should be consulted before any such specimens are forwarded.

"Osteology.—The skeletons of the perch, frog (or toad), snake, pigeon, echidna (*Ornithorhynchus*), cat, rat, mole, bat, monkey, skulls of the pike, crocodile, tortoise, turtle, lizard, any large birds, any marsupials, sloth, armadillo, anteater, dolphin, hyrax, lion, tiger, bear, seal, walrus, monkeys. Separate vertebrae and other bones of fish, crocodile, any large birds, carnivora, &c.

"Scientific Books.—These are much required, especially such illustrated works on Natural History, Geology, and Botany, as would be useful for reference."

## RUGBY SCHOOL.

At Rugby there is also a Museum containing a very fine collection of geological specimens, a large portion of them being local, and collected by members of the school; also a good collection of minerals and numerous rock specimens. The following description of this Museum has been furnished by Mr. Wilson:—

**History.**—The origin of the museum was a collection of common stones from various parts of England brought to the school by the boys at Dr. Arnold's request. These were placed in cases, in many instances without names, or localities, or arrangement. Subsequently, two of the assistant masters, the Reverend C. T. Arnold, and the Reverend H. Highton, arranged and catalogued such of these as could be identified, and added to the collection some specimens of rocks and fossils obtained by purchase.

**Rooms.**—The rooms at present available for collections to illustrate Natural History are a part of the Arnold library, and a small room belonging to the Natural History Society.

**Geological Museum.**—In the Arnold Library are placed the geological collections. These consist of (1) a local collection of *Leas fossils* and *Drift stones*, which has gradually accumulated under its present Curator, Mr. Wilson, partly from the gifts of collections made by the boys. A list of this collection has been published in the R. S. N. H. Society's Reports.

There is also (2) a general collection of fossils arranged stratigraphically in a series of glass cases, with drawers underneath, which is sufficiently complete as regards characteristic fossils, for elementary geological teaching. It contains, however, but few *fine* specimens, being the result not of purchase but of amateur work in various parts of England. Among donors to this collection, besides the present Curator, may be named Mr. J. R. Allen, Reverend T. G. Bonney, Mr. W. H. Dutton, Mr. S. G. Perceval, Reverend T. A. Preston, Reverend C. S. Taylor, Mr. G. H. West.

There is (3) a collection of rocks formed by the present Curator, partly by purchase. This has been lately arranged by Mr. F. C. Houghton, in a series of shelves behind glass, according to the arrangement of Cotta. This collection is also fairly adequate for the elementary teaching of Geology.

Lastly (4), there is a collection of minerals and ores, made from various sources, which has been arranged by the Reverend T. N. Hutcheson, for the most part on a chemical basis. The collection, though very incomplete, must be regarded as adequate to its present use in teaching.

A collection of photographs, sketches, and diagrams has been made by Mr. Wilson, and is found of the greatest use in geological teaching. Some microphotographs have been presented by Reverend H. H. Higgin.

A model of the neighbourhood, on a scale of 6 inches to the mile, is in process of formation.

**Botany.**—In Botany the school possesses a herbarium of British plants, collected by Mr. Kitchener. There is also a special local collection of plants. It being found that a herbarium in its usual form is of hardly any use to a school, as only a few boys can be trusted to have admission to it freely for reference, the local collection is in course of transference into large note books, where they will be securely fastened, and replaced from time to time if injured.

Various collections have been also presented. British ferns by Mrs. Gray; Canadian and other plants by Mr. Moberly; British plants by Mrs. Phillpotts (many plants in this collection were collected and named by the late Miss Warren). British Rubi and Salices by Reverend A. Bloxam; New Zealand plants by Mr. Reid of Otago. The school also possesses the series of drawings and specimens illustrative of the natural orders prepared by Mr. Oliver of Kew, and a considerable number of other diagrams on botany.

**Zoology.**—In Zoology we have a valuable series of dissections illustrating the comparative anatomy of the animal kingdom, and especially adapted to Dr. Rolleston's "Forms of Animal Life." The preparations were arranged by Mr. C. Robertson, Demonstrator of Anatomy in the Oxford Museum, and are duplicates of the original Oxford series. They were presented by Mr. G. H. Morrell, late Assistant Demonstrator at Oxford.

A small collection of skulls and skeletons of local mammals, and a collection of birds' eggs have been commenced by the Natural History Society. There is a small collection of shells of land and marine mollusca.

**The Insect Collections.**—There is at Rugby a collection in process of formation of all the British Lepidoptera. Three smaller collections made in various parts of England, and presented to the school, were united together and made the basis of one general collection. This is increased from time to time by boys who collect for it, besides presents from those who have left and who still keep up the

study. In the cabinet all those species which are found at Rugby (none but well authenticated captures being recorded) are marked with a letter in red ink, so that the local species may be distinguished at a glance. It is hoped that in time this may be made a fairly complete collection for purposes of study. Any remarkable varieties are especially preserved and placed close to the ordinary specimens of the species.

From time to time presents are made to the museum of cases of foreign insects, but not hitherto on a large enough scale, nor generally in a sufficiently satisfactory state of preservation, to make it worth while to attempt anything like an European collection even of a limited group or number of families. For purposes of study, that is, speaking more precisely, for the observation of the general characteristics of groups, and the shades of difference by which they gradually change, the most instructive method would be to form an European, or even an universal collection of one or more small groups, as, for instance, certain well represented and widely distributed families of butterflies, and it is hoped that something of this kind may in future be attempted.

No attempt has yet been made to study any groups of insects except the Lepidoptera. The chief cause of this deficiency is the absence of any cheap or accessible text book on the other orders. But as time goes on, and the Lepidoptera cabinet is filled, it would certainly be desirable to extend the collection to the other orders, at least to the Coleoptera and Hymenoptera.

The whole of the work in this department has been done by the Natural History Society, entirely apart from any school work.

**Desiderata.**—The teaching of all branches of Natural History at Rugby has been much influenced by the fact that the school possesses no better museum than the small and partial collections above described; for there can be no satisfactory teaching of zoology, nor even of geology, without a zoological collection. When these subjects take a higher place in school education, and are taught by men who have themselves had the advantage of the use of museums, the present state of things will not be tolerated. Among our desiderata must be mentioned, in the first place, a proper room for a museum. This it is hoped may be found ultimately in the Arnold Library. When the Temple reading room is built, the Arnold Library will be available for a museum and library of books on special subjects, such as the natural sciences and antiquities. It is large enough for both these subjects, at any rate for some years to come, and is a room suitable for a museum, but unsuitable for a reading room or library. But the establishment of such a museum of geology and zoology as would be of real use in school teaching involves considerable expenditure on specimens, on diagrams and printing, and on proper cases for the specimens. And, moreover, no museum would be of much use unless there was a curator in constant attendance, and this costs more money. The masters have far too much to do to attend properly to the ceaseless work that the care of a museum involves; and a museum only accessible to boys when a master can afford time to be present would be in practice almost useless. Nor can a museum at school be thrown open to all, without the presence of a curator. Accidents are sure to happen, and the result is endless annoyance.

It is probable that the true functions of a museum at school have yet to be discovered, but it cannot be doubted that in Classical Antiquities and in Natural History a museum is essential if the boys are to know things at first hand, and when such a museum exists its use will speedily follow. It is not necessary that it should be large, but it is necessary that it should be well selected. The ordinary museum of the present or past day, consisting of two or three bottles of snakes, a stuffed alligator, and two Burmese idols is not instructive, and is not the ideal to be aimed at. Rigorous exclusion of mere miscellaneous curiosities must be the law of the museum.

A larger room is wanted for the use of a Natural History Society, for preparing specimens, &c., for the museum; but it will not be difficult to supply this want.

Among other desiderata must be mentioned a botanical garden, in which the local plants may be arranged in their orders. It is possible that when the new observatory is built, and it is only a question of site that is causing delay, some part of the ground surrounding it may be made available.

The present writer cannot help expressing his hope that a museum will not long remain a desideratum. A collection sufficient for all school uses could probably be purchased and properly exhibited for 2,500*l.*; and it will be strange if among the wealthy and loyal old Englishmen some one is not found who will by such a gift perpetuate

his name as an enlightened lover both of science and of the school

At Cheltenham College there is a Museum, partly scientific in contents and arrangement, and there is a botanical garden of half an acre. The museum is barely three years old, the botanical garden just 12 months.

At Taunton College School there is a Typical Museum and a Botanic Garden.

At Marlborough School there is a Museum and a Botanic Garden.

At Dulwich College the formation of a Museum of Natural History has been lately commenced

At Winchester College there is a room for a Museum and for the use of boys who collect objects of Natural History

#### § 14.—SCHOOL SCIENTIFIC SOCIETIES.

At all the Schools I visited in connection with which Natural History Societies have been established, I was so fully assured of the value of these organizations in developing a spirit of inquiry and observation among the boys, that I have brought together here the Rules of several of the Societies which are already at work

##### RUGBY SCHOOL.

The Rugby School Natural History Society was founded in 1867, and at the present time (October 1872) consists of nine honorary members (chiefly masters of the school), 39 corresponding members (chiefly old pupils), 15 members (present scholars, who have been elected full members for work done), and 62 associates (present scholars not yet promoted to full membership). The society at present comprises nearly one fifth of the school. It is worked by public meetings (held once a fortnight), at which objects of interest are exhibited, and papers (by masters or boys) are read, by sectional meetings of boys having similar tastes, as for instance, the botanists, the geologists, the microscopists, next, for work or discussion, by occasional (though necessarily rare) excursions from Rugby, the places visited during the year 1872 being Charnwood Forest and several factories at Birmingham, and by the use of a special room to which the members of the society alone have access. In this room are kept collections of insects, plants, &c, dissections and skeletons arranged for study, and a library of books on natural science is being formed for reference. A report of the proceedings of the society is published annually at Rugby. The society is found to have an influence for good on the boys. The meetings show that the society is popular, as there are generally from 70 to 100 present; but as yet great difficulty is found in getting the boys themselves to take part in the meetings, whether by reading papers or sharing in the discussions; hence it is believed that greater real good is done by the smaller sectional meetings. The society is found to be very valuable in bringing forward any boy who has a speciality, which, in the hurry of school work, might have escaped notice. Such a boy is found out either by being introduced by his friends or by asking questions, and the president then introduces him to the other boys in the school who have kindred tastes, and brings him under the notice of the master who has charge of his favourite subject. It is found that the boys are delighted to be of any use, and will undertake any scientific drudgery that may be suggested to them, provided they are assured that it will do some good. Some good work is done in recording meteorological observations and floral dates, and in making sketches of striking or interesting geological sections, &c.

The rules of this society are as follow:—

1. That this society be called "The Rugby School Natural History Society."

2. That the society consist of honorary members, corresponding members, members, and associates

3. That masters, and others connected with the school, be eligible as honorary, and old Rugbeians as corresponding members, that present Rugbeians (having attended as a visitor three of the societies meetings) be eligible—if in the upper school or sixth, as members, if in the middle or lower school, as associates.

##### Of Officers.

4. That the society's officers consist of a president, secretary, and treasurer, and of the keepers of the several albums, and that these do form the committee of management, three to be a quorum.

5. That all officers be elected annually

6. That when any office is vacant, the committee do recommend a member or associate, or (for the office of

president) an honorary member, for election by the members of the society, and that the election be by scrutiny.

7. That the president take the chair at all meetings, but have no vote except in cases of equality

8. That the secretary keep the minutes of the society's proceedings, keep a list of all persons present at each meeting, keep a list of the existing society, with the names and addresses, as far as possible, of all corresponding members, and a list of all benefactors of the society

9. That the president and treasurer form a sub-committee for managing the finances and keeping the property of the society.

10. That the duty of the several album keepers be to receive all notices connected with their several sections, to enter all occurrences of interest in their album, and at the end of each year to furnish a report of what has been done in his section during the year.

11. That in the absence of any officer the committee appoint a deputy.

##### Of Honorary and Corresponding Members.

12. That honorary members be elected by open vote of the society, pay an entrance fee of 10s, but no subscription unless specially called upon; and have all the privileges of members, except that of voting

13. That corresponding members be elected by open vote of the society, without entrance fee, and have all the privileges of members, except that of voting, but be required to pay for the society's reports, for a supply of which they may pay a composition of 10s for six years

14. That members or associates, on leaving the school, become corresponding members without election.

##### Of Members and Associates

15. That members and associates be proposed by a member or honorary member and elected by the committee

16. That there never be more than 20 members, or more than 20 associates

17. That members and associates pay a subscription of 2s 6d per term, and that any member or associate who shall, at the beginning of any term, be reported by the treasurer as not having paid his subscription for the last two terms be struck off the list of the society\*

18. That members may speak at all meetings of the society; may read papers with the leave of the president; may introduce four visitors at all public meetings, and receive a copy of the society's report†

XIX. That associates have the same privileges as members, except the right of voting at private meetings of the society

XX. That associates, on reaching the upper school, do not become members without election by the committee

XXI. That any member or associate may be suspended or expelled from the society by a vote of two-thirds of the members present, if he, from any misdemeanour or want of energy, appear to deserve such suspension or expulsion

##### Of Meetings.

XXII. That ordinary meetings be held once a fortnight, but that the secretary be empowered to call extraordinary meetings when necessary.

XXIII. That visitors may speak and read papers at all public meetings, with the leave of the president.

\* Subscriptions are allowed by a school rule to be charged in the school bills, as soon as a note has been brought to the President, agreed by the boy's tutor to the effect that leave from home has been obtained.

† In consequence of the loss incurred on the sale of the last report, the gratuitous supply of copies of this report has for the present been suspended.



*Of Reports.*

XXIV That a report be printed once a year, or oftener if the committee think fit.

XXV. That an editing committee, of two members and one honorary member, be appointed by the president for each report.

*Of New Rules.*

XXVI That without notice given at the preceding meeting no change can be voted in these rules, or any name be submitted to the committee for membership or association, or any vote of suspension or expulsion passed.

XXVII. That no change be made in these rules, unless proposed by a member or honorary member and carried by the votes of two-thirds of the members present.

## CLIFTON COLLEGE.

The Clifton College Scientific Society, which was founded on the 25th of June 1869, is managed by the boys themselves and one or two of the Science Masters. "This society holds fortnightly meetings, at which scientific papers are read and discussed, objects illustrative of natural history are exhibited and explained, and so forth. A record of its proceedings is kept by the secretaries, the first and second volumes of which have been printed. The number of boys who can belong to it is limited to 70, and the interest excited by it in the school is so considerable, that there are regularly a number of boys waiting their turn for election."

The Science masters and the students are at present engaged in the formation of a museum, which they are making of a strictly educational character, *i.e.*, admitting nothing but what contributes directly to its educational value; they are also stocking a moderate-sized botanical garden with typical specimens of plants, which will materially help the study of botany, and they are about to set up an apparatus for meteorological observations.

In all this the aim has been to make the boys themselves the chief agents, only advised, directed, and assisted by the Science Masters, and one or two scientific neighbours who take a warm interest in these matters.

Thus the Natural History Master is President of the Scientific Society, and curator of the museum and botanical garden, but for everything connected with their management he has associated with him committees of the boys, made up of those most prominent in these subjects.

A new feature in the constitution of the society deserves especial notice. "In February 1871 it was proposed to found 'sections' for the study of certain sciences, and as the plan met with a ready acceptance at the hands of the society, seven of these sections have been formed, and are now in full working order. They are as follow. botany, geology, zoology, entomology, chemistry, physics, and archaeology. A 'director' of each section is nominated by the society, and some one is appointed by him to keep the records, &c, with the title of 'sectional secretary.' Not more than 10 members are admitted into each of these companies, and although it is not absolutely forbidden to join more than one section, it is at the same time discouraged, for the committee believe that the best members of sections will be those who do not distribute their energy over many varied subjects. The president and secretary of the society are *ex officio* members of every section, and may attend the meetings when they please. In this way the sections are brought into close relation with the governing body of the society at large. It is left to the director to summon the members together at such times as may suit general convenience, and, indeed, he is allowed to manage the section as may seem to him best, subject only to the control of the General Committee. In most sections there are both evening meetings and excursions. Scientific journals are taken in and circulated, sectional libraries are being formed, and the geological adherents have already begun to make a collection of local fossils found by themselves. So far the scheme works admirably, and it is hoped that when the next volume of *Transactions* is issued a favourable report will be given from each one of the seven sections."

"I have dwelt," the Head Master observes, "upon this voluntary and extraneous part of our scientific work, as distinct from our school teaching, because it would otherwise have been impossible to give a correct idea of the influence of science in the school; and, moreover, I attach great importance to this voluntary work, and should wish to see it encouraged and fostered in all schools."

The society "has exercised a valuable influence by stimulating the taste and intellect, and giving much

"enjoyment to many boys who would otherwise have lived a very obscure and dull life in the school, whilst it has also been of use in helping to give something of an intellectual tinge to the ordinary intercourse and conversation of the boys. Such institutions prevent the athletic side of school life from becoming too exclusively predominant."

The rules are as follow:—

1. That this society be called the "Clifton College Scientific Society."

*Constitution.*

2. That the society consist of ordinary, corresponding, and honorary members.

*Officers.*

3. That the officers of the society consist of a president, secretary, treasurer, and three members of committee, to be elected from and by members of the society, with the exception of the secretary, who shall be chosen by the committee from their own number. All officers, excepting the president, to be elected terminally.

*Management.*

4. That the affairs of the society shall be conducted by the above officers.

*Secretary.*

5. That the duties of the secretary be, to keep a list of all the members of the society, and of all former members and benefactors, who may wish to receive the transactions of the society; to give notice of meetings, and to keep a detailed report of the proceedings as well as lists of members and visitors present at each meeting. In the absence of the secretary, the president may appoint any member of the committee to take minutes of the proceedings.

*Treasurer.*

6. That the duties of the treasurer be, to collect all sums of money due to the society, to receive all donations of money, and to disburse all sums of money payable by the society out of the funds entrusted to him.

That the treasurer furnish half yearly a detailed account of the receipts and disbursements, to be audited by the committee.

*Members.*

7. That the number of members be 70, of whom 10 shall be elected from the junior school.

That ordinary and corresponding members shall be proposed and seconded at a meeting of the society, and elected at the meeting next following. Less than three-fourths of the votes of the members present to exclude any candidate.

That honorary members shall be elected by the committee.

That a subscription be payable terminally (the amount to be fixed by the committee), but in no case to exceed 2s 6d for the upper and 2s for the junior school.

That all subscriptions must be paid between the first and second meetings of the term, and that any member retiring from the society be required to pay all subscriptions due.

That, under penalty of expulsion from the society, all members be required to attend two thirds of the ordinary meetings in each term, except for reasons deemed sufficient by the president. Attendance at extraordinary meetings to be optional.

That a certain number of tickets for admission to ordinary meetings shall be issued by the president for collegians who are not members of the society, but that on application being made to him, any member may introduce other visitors.

*Sections.*

8. That sections be formed for the more accurate study of the different branches of science, and that the directors of these sections be chosen by the society.

That the sections shall hold meetings as often as may seem fit to their respective directors, at which any members of the college, with the sanction of the director, may attend.

*Meetings.*

9. That ordinary meetings of the society be held once a fortnight, but that the president be empowered to call extraordinary meetings at his discretion.

## New Rules.

10 That any member of the society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another member, and that notice of at least one week be given to the secretary.

## MARLBOROUGH COLLEGE.

A Natural History Society in connexion with Marlborough College (the earliest, it is believed, that was founded at any public school) was established in April 1864, when two or three members of the school, who had a taste for natural history, banded themselves together, electing the Rev. T. A. Preston, one of the masters, as their President, and agreeing to meet on certain nights for consultation. At first difficulties cropped up thickly, but scientific energy, aided by the firm support of the Rev. G. G. Bradley (the late Head Master), in time overcame these. The society grew, and a year and a half after its formation published its first report. The career of the still small but thriving society brightened more and more. About the middle of 1866 the College provided a room as a museum.

From that time to this no cloud of any importance has appeared on the society's horizon. It now publishes its reports half-yearly, numbers more than 50 members, and its collections have outgrown its museum. One of the masters, as already mentioned, is president; other masters frequently attend and read papers. There are fortnightly meetings, at which papers are read, very often by the boys themselves. There are various sections (geological, botanical, entomological, archaeological, &c.), each of which is presided over by one of the members, and which furnish quarterly or more frequent reports. There are one or two field-days every term, on these days the boys go to explore new districts beyond the reach of an ordinary walk.

The papers read at the meetings of the society are published half-yearly with the Report, and in addition, a *Flora of Marlborough*, two portions of which have appeared. This is a second edition of the *Flora* by the Rev. T. A. Preston, which first appeared in 1863, differing, however, very materially from it, principally in containing short descriptions of the different species.

One result of the formation of this society has been the production by a Marlburian (Everard F. Im Thurn) of a work on the *Birds of Marlborough*, in the preface to which the author says: "It is only now, when I feel at last forced to render an account of the work which I have undertaken and have now completed, that I feel its many deficiencies I have, however, one consolation: I feel that I have done my best to render a tribute of gratitude to the school, where I passed so many pleasant hours, and to the Natural History Society of that school, to which, and to which alone, I owe the formation of tastes which now prove a continual and endless source of pleasure and occupation to me."

The present Head Master states that "the influence of this society on the boys is in all respects most valuable, and the extent of practical work which it has effected may be judged by the long series of published reports, as well as by the *Flora* of the district, and full accounts of its entomology, geology, ornithology, &c., it has produced."

The rules are as follow.

- 1 That this society be called the Marlborough College Natural History Society.
2. That it be managed by a committee of five members, and that the vacancies in the committee be filled up by persons elected from and by members of the society.
3. That, in the absence of the President, one of the committee take the chair at the meetings.
- 4 That the election of new members rest with the committee.
5. That any one may be elected a member of the society, if he have attended as many meetings, and have shown as much interest in the proceedings as the committee shall think fit; and that the names of such new members be read out at the next meeting after the election.
6. That each member be allowed to bring one friend to the meetings of the society, and that his friend be allowed and requested to enter into any discussion, or show any object of interest, but be not allowed to vote on any question.
- 7 That each member be responsible for the behaviour of his friend.
- 8 That the meetings of the society be held once a fortnight.
9. That the committee be empowered to eject or suspend any member if, without good reason, he absent himself

twice in succession from the meetings of the society, or be judged guilty of any serious misdemeanor at such meetings.

10 That any person present may exhibit objects calculated to interest the society at their meetings.

11. That it be left to the committee to determine the subjects for lecture or discussion, and that any person may deliver a lecture before the society with the sanction of the committee.

12 That in case of an equality of votes, the casting vote lie with the President, and that he have no vote except in such a case.

13 That a report of the proceedings of the society be entered in a book, to be kept for that purpose by the secretary.

14 That the secretary be chosen out of the committee by the members of the society, and that he hold office for one half year, but may offer himself for re-election at the commencement of the next.

15 That any member of the society have power to bring forward a motion for the alteration of any rule, provided his motion be seconded by another member; and that the making of new rules shall lie with the committee, who shall not have power to alter them without the consent of the majority of the society.

## WINCHESTER COLLEGE.

A Natural History Society has been started in the school, to encourage boys to collect specimens, and to communicate with one another about them. It is limited to 60 boys, who adopt the members. It meets once in three weeks, and two of the masters help to manage it. The boys have shown that they are interested in the objects of the society; they have read papers, and have made creditable collections of plants, shells, insects, fossils, and minerals. Prizes have been given at different times for such collections by the Head Master and one of the assistant masters, but the Head Master considers that the boys collect as well for themselves without prizes. Gradually a museum and library are being formed (one of the class rooms being given up for the purpose), and sets of apparatus are being procured; but these are works of time, and are not yet far advanced.

This society has, in the opinion of the Head Master, given a number of boys an interest which has been quite real and good. Mr. Griffith, one of the masters, has created a considerable geological interest amongst some of the boys.

The Head Master looks forward to the time when a laboratory can be established (there being at present no means of teaching chemistry except by lectures), and also a botanic garden.

## WELLINGTON COLLEGE.

A Natural History Society in connexion with this College was founded early in 1868, through "the efforts of one or two of the masters, and any success which may have attended it during the first year of its existence is due in a great measure to them." The meetings, which are held once a fortnight, have been numerously attended; the members, numbering about 20 boys, have the power of introducing others to the lectures. The average attendance at the meetings is 30 or 40 (often the number is larger), and various interesting papers, contributed by the boys themselves, have been read, on mosses, hawks, photography, fortification, electricity, snakes, manufacture of alum, and the natural history of man. The botanical, entomological, and zoological departments have met with a fair success; but Wellington College is very unfortunately situated in a geological point of view, few fossils and objects of geological interest being found in the neighbourhood. Professor Kingsley and Professor Rupert Jones have taken great interest in the society, and, as well as other friends and some of the masters, have frequently delivered lectures and addresses. Two reports have been published at intervals of about 18 months, and accounts of the meetings appear in the School Magazine.

The rules of the Society are as follow:—

1. That this society be called the "Wellington College Natural History Society."
2. That the society consist of honorary members, corresponding members, 15 members, and 20 associates.
3. That all members of the school having attended three meetings of the society be eligible as associates, and that members be chosen from among the associates.
4. That the society's officers consist of a president, secretary, and treasurer, and of the keepers of the albums of the four departments.

5 That the officers do form a committee of management, and that the committee be empowered to invite not more than two honorary members to join them in their meetings. In meetings of the committee, four to be a quorum.

6 That all officers be elected annually—the president from among the honorary members, the others from the members.

7 That the president take the chair at all the meetings, but have no vote except in cases of equality.

8. That the secretary keep the minutes of the society's proceedings, a list of all persons present at each meeting; a list of the existing society, with the names and addresses, as far as possible, of all honorary and corresponding members, and a list of all benefactors of the society.

9 That the treasurer look after the property of the society, collect subscriptions, and pay debts, producing his accounts whenever called upon by the president to do so.

10. That the duty of the several album keepers be to receive all notices connected with their several sections, to take care of the collections; to enter all occurrences of interest in their albums, and at the end of each year to furnish a report of what has been done in their sections during the year.

11. That in the absence of any officer the committee appoint a deputy.

12. That honorary and corresponding members be elected by a vote of the society, and have all the privileges of members except that of voting.

13. That honorary members pay an entrance fee of 10s., but pay no subscriptions unless specially called upon.

14. That members or associates, on leaving the school, become honorary members without any charge, except for a supply of the society's reports.

15. That members and associates be proposed by a member or honorary member, and elected by the committee.

16. That members pay a subscription of 1s. 6d., and associates of 1s. per term.

17 That members may speak at all meetings of the society; may read papers with the leave of the president; may introduce one visitor at all public meetings, or if on the committee, two; and receive a copy of the society's report.

18 That associates may speak at all public meetings, and read papers with the leave of the president, and receive a copy of the society's report, but not have the privilege of introducing visitors.

19. That members provide with tickets the visitors whom they introduce at any meeting, and that no visitors, except those introduced by honorary members, be admitted to any meeting of the society without such a ticket, but that in special cases the committee be empowered to issue extra tickets.\*

20. That any member or associate may be suspended or expelled from the society by a vote of two-thirds of the members present, if he, from any misdemeanor or want of energy, appear to deserve such suspension or expulsion.

21. That ordinary meetings be held once a fortnight, but that the secretary be empowered to call extraordinary meetings when necessary.

22. That visitors may speak and read papers at all public meetings, with the leave of the president.

23. That without notice given at the preceding meeting, no change can be voted in these rules, or any name be submitted to the committee for membership or association, or any member or associate be suspended or expelled.

24. That no change be made in these rules unless proposed by a member or honorary member, and carried by a majority of the votes of the members present.

#### CHELTONHAM COLLEGE.

At this College there is a Natural History Society, consisting of 10 of the masters (of whom three are working members), and 40 boys. The secretary is a boy. The meetings are held weekly or fortnightly during the winter six months; and in summer there are fortnightly excursions. Subscription, annual, 3s., with entrance fee, 2s. 6d.

The influence is found to be good decidedly; but it does not act on a large number of the boys.

#### ETON COLLEGE.

At Eton there is a Literary and Scientific Society, managed by the boys, and the members elected by them. The members read papers, and a discussion takes place. Occasionally lectures are given by persons not resident at Eton, by invitation of the Society.

#### HARROW SCHOOL.

Of the Harrow School Scientific Society, meetings are held about once a fortnight. Papers are read by the members, or, occasionally, by strangers. It is almost impossible to estimate its influence on the boys generally. The members themselves undoubtedly receive benefit from the papers, and the discussions which follow. The society also exercises good influence on those who make botanical and other collections. The rules of the society are appended.

1. That the Harrow School Scientific Society consist of members, honorary members, and associates, who take sufficient interest in scientific pursuits to guarantee their steady assistance in carrying out the objects of the society.

2. That the honorary members of the society consist of those masters who express a desire to join the society, and others who may be elected by the society.

3. That ordinary members, not being below the fifth form in the school, be elected by ballot, after having been duly proposed and seconded at the previous ordinary meeting; one adverse vote in three to exclude.

4. That each member pledge himself to contribute in his turn, or when required by the committee, a paper on some subject connected with science.

5. That each member, or resident honorary member be allowed, with the consent of the committee, to nominate, as an associate, any one boy not below the remove; and any member of the committee, two such associates.

6. That the president be allowed to nominate as many associates as he shall think fit, from any part of the school he may think desirable.

7. That such nominations only continue in force for one school-term; but that any boy, after three successive nominations, becomes, *ipso facto*, an ordinary member.

8. That associates shall not be liable to read papers before the society, and shall have no vote on questions of administration, but shall be allowed to attend any of the ordinary meetings.

9. That each resident honorary member, ordinary member, and associate, pay an entrance fee of 1s.; and that the subscription for each term be 2s. 6d. for each member and resident honorary member, and 2s. for each associate, which is to be paid to the treasurer at the first meeting of the society in each term, at which meeting the treasurer shall lay before the society an account of all expenses incurred.

10. That the affairs of the society be conducted by a president, vice-president, secretary, and treasurer; and by a committee consisting of these officers, the ex-president, and six ordinary members of the society, four members of the committee, of whom one at least shall be an officer, to form a quorum.

11. That the president and vice-president be appointed by the committee, annually, at the end of the summer term, or in the event of the resignation of either before that period, from among the masters who shall be honorary members of the society.

12. That it be the duty of the committee to propose at the last meeting but one of the summer term, members to fill the offices of secretary and treasurer, and the other vacancies in the committee for the following year, and that it be competent for any member at the same meeting to propose other candidates, whose names, if duly seconded, shall be submitted to the society, together with those of the nominees of the committee, for election by ballot at the next meeting.

13. That any vacancy in the committee, or in the office of secretary or treasurer, occurring at any other time than at the end of the summer term, be filled up in like manner by a nomination at the ordinary meeting next following such vacancy, and by election at the next succeeding ordinary meeting.

14. That the committee be competent to fix the times of ordinary meetings, and the papers to be read at each, and to authorize the expenditure of funds; but that all rules affecting the constitution of the society must be passed by a majority of those present at an ordinary meeting.

15. That any member, on giving notice to the secretary, be permitted to introduce a friend.

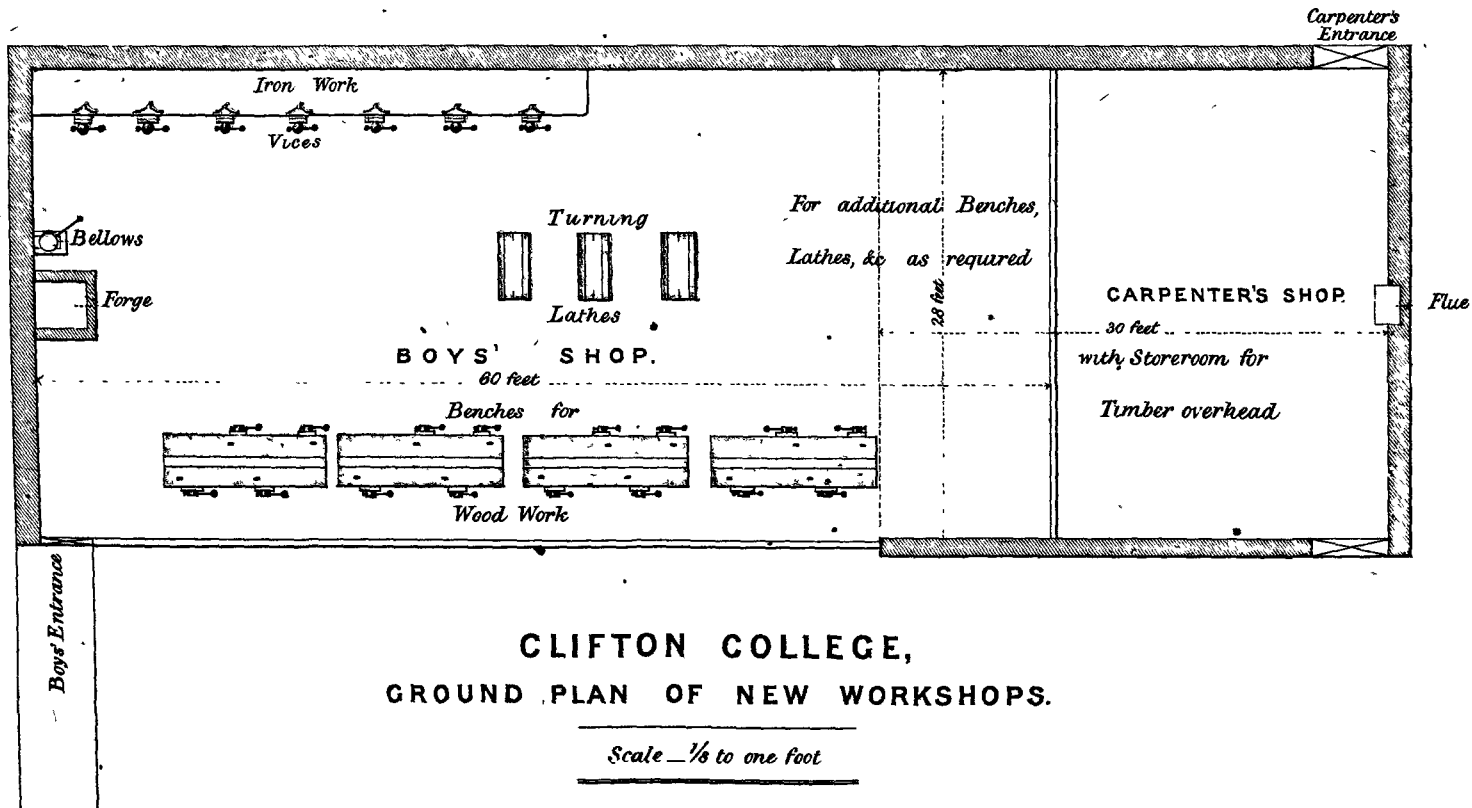
16. That any member or associate of the society who absents himself from two consecutive meetings, without giving some reason to the president, shall pay a fine of 1s.

17. That every member on joining the society, sign the following declaration—

"I hereby promise to conform to the rules, and to give my best assistance in carrying out the objects of the Harrow School Scientific Society, so long as I continue a member of the same."

18. That the members and associates endeavour to exhibit, at each meeting of the society, some object of scientific interest.

\* This was not one of the original rules.



CLIFTON COLLEGE,  
GROUND PLAN OF NEW WORKSHOPS.

Scale — 1/8 to one foot

19 That the objects of the society be - To record scientific observations, to promote the formation of a Harrow School museum of natural history; and to encourage, by offering prizes or otherwise, the pursuit of science in the school

MANCHESTER GRAMMAR SCHOOL  
The Manchester Grammar School Philosophical Society

was established in 1869. It is composed of the boys of the sixth and other science forms, its officers are elected from among its members by ballot, it meets every Friday, after school, for the reading and discussion of scientific papers, written by its members, the subscription is 2s entrance fee, and 2s 6d per term. There are three terms per annum. The society is considered to be decidedly useful in promoting scientific reading and thought among the members

### § 15.—WORKSHOPS.

There are workshops in full operation at King's College School, Clifton College, and Rossall School. At Marlborough, Rugby, and Taunton, where, up to the present time, there are no school workshops, it is stated that buildings will shortly be erected or utilized for that purpose. At Taunton it is contemplated to provide for turning, casting, and modeling, and for microscopical mounting. At Marlborough there is a workshop close to the college, fitted up by a tradesman in the town, and boys are encouraged to learn turning, &c., under his guidance. At University College School, and at Manchester Grammar School (where its absence is much felt), there is no workshop.

Of the three first-named workshops that at King's College, for the joint use of students at the college and school, is the most extensive, being furnished with steam engine and planing machines, and it is worked on the most rigorous system. The building consists of two floors, the upper one for wood and the lower for metal work. The boys are first put through a course of wood work, after completing which they commence iron work, and construct lathes and small steam-engines and boilers and models of machinery of various kinds. The following more detailed statement, taken from the report, will give a better idea of what is actually done.

1. Students of boys of the first year, on joining the department, are made acquainted with the different tools, and their practical application to the purposes of carpenters' and joiners' work, by going through the processes of preparing the wood, setting out and forming, from figured drawings prepared by themselves, the various joints used in constructions of wood, after which they are employed in making models, in which the preceding joints are combined, so as to form trusses for roofs, bridges, girders, and other framing, required for buildings and other purposes.

2. Students are then enabled, in their third term, to proceed with the construction of models of various sorts, in illustration of the different apparatus used in practical mechanics, manufactures, and philosophical experiments, which involve the necessity of turning, for which purpose they are instructed in the use of tools for turning soft wood, hard wood, ivory, and other substances, and also in the mode of preparing and fixing the work in the lathe; the formation of cycloidal, epicycloidal, and involute teeth, for wheels, pinions, racks, &c. They are also instructed in the method of working in sheet metals and soldering.

3. Second year's students commence metal work, the operations of which consist of the various processes of chipping, filing, fitting, turning, boring, screw-cutting, and planing, the construction of foundry patterns in wood or metal and core-boxes.

These students are also instructed in forging wrought iron and steel, and in Easter term a moulder attends who gives practical instruction in the art of moulding.

4. With proper attention to the foregoing routine of procedure, the students become sufficiently proficient to be enabled to make for themselves lathes, and the apparatus connected with them, tools of various sorts, working models of steam-engines, boilers, and other machinery, in the construction of which either metal or wood, or the two combined, are employed.

The third year's students continue the second year's subject, and, in addition, they are encouraged to make experiments on the strength of arches, beams, and girders are constructed from working drawings made by the students themselves.

5. At the termination of the year a prize is given in each year, for proficiency in the execution of some piece of mechanism, the subject of which is given out during the Lent or Easter term.

In order to obtain a prize in either the second or the third year, the student is required to send in with his

model or machine a finished form, dry pattern, with core-boxes, &c., of at least one of the castings used in such machinery or models, which pattern he shall himself have made, accompanied by working drawings of such machinery, also made by himself.

At the present time 39 boys attend. The regulated time for work is on Wednesday and Saturday afternoons, and no student is admitted into the workshops at any other hours without previous permission of the Dean of the Department, as well as that of the Superintendent, this sanction being only given on condition that the applicant is not thereby neglecting other duties in the college.

Every student is expected to furnish himself with a set of the simplest tools requisite for working in wood and metals. In order to diminish the expense of these tools as much as possible, the student may purchase them at the college, and upon his leaving they will be repurchased from him at a reduction depending on the condition in which they are returned. No student is allowed to obtain tools or materials in the workshop to a greater amount than 4s in any one term, without the consent in writing of his parent or guardian.

The boys are provided with a dress for use in the workshop, and this tends greatly, not only to increase the business-like, real look of the place, but, I believe, to make the work itself more real and earnest.

At Clifton College the present workshop is 40ft by 20ft, and both wood and metal work is done; it contains (1) four large carpenters' benches to accommodate 16 boys (2) eight-vices, with steel chisels and other requisites for fitting, &c., (3) a forge, with the necessary appliances, (4) three turning lathes, with one slide rest, for the turning of both wood and iron, but it is found insufficient, and a new one, of which a plan is given, consisting of one large room 60ft by 20ft, is about to be built.

The object of the workshop is described in the report as being: (1) to teach boys the use of all the common mechanical tools, (2) to give them some knowledge of different kinds of material, as wood, iron, &c., (3) to teach them practical carpentering, fitting, turning, forging, &c.

At the present time about 50 boys take advantage of the workshop at Clifton, working in it at such hours as they can spare during out-of-school time, each boy paying a fee of 15s a term, or 2l 5s a year, to cover the expenses of superintendence, instruction, and material.

Joining the workshop is quite a voluntary matter, and any boy can take home anything which he makes there.

The cost of the building, which is quite a plan one, and the fittings, tools, &c., was something under 250l.

The cost of material used, with wear and tear of tools, has been estimated at about 15s. per week.

At Rossall there is a workshop which is popular and well attended. There is only bench accommodation for six at a time; but boys, some of high intellectual power and great refinement, will spend two hours a day, play-time, in carpentry. The boys are taught by the resident clerk of the works. The study of practical engineering, under the chief engineer, is also a matter of considerable interest to boys.

The evidence both from Clifton and Rossall is to the effect that any school will find a workshop to involve very little expenditure, as the superintendent will be able at such times as he is not occupied with the boys to effect a considerable saving, by attending to repairs, the making of desks, forms, &c.

At Eton there is a workshop connected with the laboratory, containing two lathes, work-bench, forge, and a fair supply of tools. It is chiefly used for preparing apparatus for lectures, but boys are encouraged to come there, and taught to make things for themselves. There are, besides this, two or three turners' shops in the town, to which many boys go.

At Harrow large workshops will be erected during the course of 1873.

## § 16.—KNOWLEDGE NECESSARY BEFORE SCIENCE IS TAUGHT.

At Eton boys are expected to have a sufficient knowledge of classics and mathematics to get into the Lower Fifth Form. This may be done by average boys of 13 or 14 years of age.

The examination for admission to the 5th Form includes translation from such books as Homer, Virgil, Xenophon, Cæsar, Latin (prose and verse) composition, ancient history, French. In mathematics—Arithmetic, all, except the higher rules, e.g., discount, profit and loss, stocks. Algebra, to simultaneous equations (inclusive). Euclid, first 12 propositions.

At Harrow no boy is at present allowed to join the Modern Side unless he has been one year in school, and is at least in the Lower Shell.

At Rugby it is considered that a boy "cannot begin physics unless he is fairly high in mathematics," and that "a certain amount of arithmetical knowledge is absolutely required, before a boy can enter the Middle School." At Winchester it is considered that boys should be fairly advanced in classics and mathematics. In the Military and Civil Department at Cheltenham College, a certain amount of knowledge of mathematics is deemed essential, and in the Mathematical School at Wellington College, boys are required to have learnt from two to three books of Euclid, and algebra to simple equations. At St. Peter's College, Westminster, the juniors are required to know the first book of Euclid and arithmetic to decimals, and boys in the upper division, two books of Euclid, algebra to quadratic equations, and a fair knowledge of arithmetic. At Charterhouse, a knowledge of arithmetic, including vulgar and decimal fractions, and of algebra, including

simple equations, and of elementary geometry, is necessary. At Christ's Hospital it is generally expected that a boy will only have learnt arithmetic before he enters the natural philosophy class; that he will have learnt a book or two of Euclid and some algebra before he reaches the chemistry class; and that he will have read six books of Euclid, algebra as far as quadratic equations, and some elementary trigonometry, before he begins mechanics. At Dulwich College, instruction in science is open to all boys in the Senior Section and in the Sixth Form. Boys entering the Senior Section are presumed to have a fair elementary knowledge of English, French, Latin, and arithmetic. At Taunton College School a knowledge of arithmetic to decimal fractions, and of algebra to simple equations is required. At University College School boys are expected to have learnt decimals. At King's College School boys entering the Chemistry Class must have mastered the first two books of Euclid, and algebra as far as simple equations; while those who enter the Higher Physical Class must have done the first three books of Euclid, and algebra as far as quadratics. And at the Manchester Grammar School boys who show an aptitude for mathematics are specially urged to enter the Science Forms, but none would be permitted to enter them (except under special circumstances) who have not reached the Fourth Form. On the other hand, at Clifton College, Marlborough College, and the City of London School, the amount of knowledge required is that which will enable boys to take their position in the main divisions of the school; and at Rossall School no definite rule has been laid down at present.

## § 17.—REWARDS OR ENCOURAGEMENTS TO SUCCESSFUL STUDENTS OF SCIENCE.

*Exhibitions and Scholarships.*

At Clifton College a full share of all the scholarships is awarded for proficiency in Natural Science.

At Wellington College there is an annual exhibition of 20l. a year for two years, tenable at school, at Woolwich, or at an university, towards which proficiency in science counts.

Henceforward, at Charterhouse School, an exhibition is to be given annually for proficiency in Natural Science. It will be of the value of 80l. for four years, and may be held at an university, or anywhere else, provided that the holder satisfies the Governing Body of the School that he is engaged in preparation for some career in life which meets their approval.

At Christ's Hospital a considerable share of the exhibitions to the universities has always been assigned to good mathematicians, and hitherto no special reward has been given to Natural Science. The head master of the school states, however, that he is at present trying the following experiment, which may be a precedent. A Grecian, who showed a marked inclination for Natural Science, has been excused the greater part of his classical and mathematical work, and is attending lectures at St. Bartholomew's Hospital, South Kensington, and the Royal College of Surgeons, on physiology, chemistry, &c. If he should satisfy the masters that his aptitude and progress are commensurate with those of his contemporaries who are studying classics and mathematics, the head master will recommend him to the Governors for an exhibition at Oxford or Cambridge.

At the City of London School there is one exhibition of the value of 14l. 10s., tenable for one year, and science counts in the regular Scholarships of the school.

At the Manchester Grammar School two Science Exhibitions have been lately founded by Miss Brackenbury, of the value of about 45l. a year each, and tenable for three years at the University of Oxford; hence, there is a Science Exhibition awarded two years out of three.

*Prizes.*

At Eton a prize of 10l. and another of 5l. are given upon the results of the annual examination, which is held during the summer half, and conducted by independent examiners. At Harrow two prizes are given annually by the Head Master.

At Rugby School numerous prizes are offered for success in the following branches of Science.—

Physics	-	-	One prize of 3 guineas.
"	-	"	2 "
Chemistry	-	"	3 "
Geology	-	"	2 "
Astronomy	-	"	3 "
Botany	-	"	2 "
Practical Chemistry.		"	3 "

Prizes are also given for the best collections of wild flowers, butterflies and moths, and fossils, made during the summer vacation.

At Clifton College a full share of all the prizes given is awarded to proficiency in Natural Science.

At Marlborough College, though there are, as yet, no Natural Science Scholarships, prizes are freely given to reward success or effort in the acquisition of scientific knowledge.

At Winchester College prizes are given by Lord Saxe and Sele for each of the classes in Natural Science.

At St. Peter's College, Westminster, marks gained for Natural Science are added to Mathematical examination marks, and prizes are given separately for Natural Science, in books, if deserved.

At Cheltenham College prizes are given after the Christmas examination in both departments; there have also been special prizes for herbaria of boys' own collection, and for excellence in physical geography, and the "Old Cheltonian Society" gives a special prize for proficiency in physical science.

At Wellington College there is the Governors' prize annually for an examination in a portion of a text-book (prepared without assistance), and for practical work. [Last subject: Last five chapters of Tyndall's Heat, and to find in solution six specified metals.] Prizes are also given twice a year, for term work and examination in science, to the head boys in this subject in the classical and mathematical schools. Two Governors' prizes for botany, viz., (1) for collecting 40 plants only of at least 10 different orders, to be carefully dried, with descriptive schedule of each, (2) for preparing fixed portion of text-book and describing on schedule plants presented to them.

At Rossall School prizes are given.

At Christ's Hospital the chemistry and natural philosophy classes get their share of the ordinary prizes.

At the City of London School, one silver medal and 24 prizes (the total value being 10*l.*) are given.

At Taunton College School the head master takes care that at least one of the school prizes is given annually for proficiency in some branch of science, but there is no special encouragement beyond this.

At University College School, book prizes are given in each of the Science Classes.

At King's College School the following prizes are given:—

**A Terminal prizes.**

(a) One to the best boy in each of the upper classes, rank being determined by the term's work and examinations.

(b.) Three to the best boys in the large elementary class, one being selected from each of the three divisions, A, B, and C.

**B Annual prizes**

One for Natural Philosophy.

One for Chemistry.

At the Manchester Grammar School the Science Forms take their full share of the general prizes of the school.

§ 18.—EVIDENCE AFFORDED AS TO THE EFFECT OF SCIENCE TEACHING UPON THE INTELLECTUAL LIFE OF THE SCHOOL.

Mr. Madan, the Science Master at Eton, says:—  
"Science work has, no doubt, brought out some (but not many) boys who have previously shown no interest in, or power over, their school studies. Generally speaking, however, the best boys in Classes are the best also in Natural Science."

The Rev. Edward Hale, an Assistant Master at Eton, considers that:—

"The time since which Science has been taught is too short to admit of any professional success, but of three candidates in 1872 for the medals of the Royal Geographical Society, two of the four medals were gained by them, and the other boy received honourable mention.

"Intellectual activity is promoted, and habits of thought and observation are gained. Proofs of this are, that boys not remarkable for proficiency or the interest they take in their usual studies, are sometimes full of interest in learning science, and in rarer instances enthusiastic."

And the Rev. Thomas Dalton, also an Assistant Master at Eton, writes thus:—

"The subject has hardly been introduced long enough to produce success at the Universities. I think it has had a beneficial result upon the school, both generally, and in the case of individuals. Almost all boys have had a certain amount of interest excited in them for this branch of knowledge; in several cases boys who have shown no aptitude for Classics or Mathematics have done extremely well in, and really worked at, Physical Science, but, as a rule, boys who are good in Classics or Mathematics, are good also in Science."

Mr. Wilson, who had had long experience in teaching science at Rugby, in 1866 thus stated his opinion as to the general results of the introduction of scientific teaching, as an addition to the paper read by the Rev. F. W. Farrar before the British Association and quoted by the Rev. T. N. Hutchinson in "Science Work at Rugby," p. 18:—

"The opinion of the body of masters in brief is this. The school as a whole is the better for it and the scholarship is not worse. The number of boys whose industry and attention is not caught by any school study is markedly less, there is more respect for work and for abilities in the different fields now open to a boy, and though pursued often with great vigour and sometimes with great success by boys distinguished in classes, it is not found to interfere with their proficiency in classes, nor are there any symptoms of overwork in the school. This is the testimony of classical masters by no means specially favourable to science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the result of two or three years' work in our Middle School, the introduction of science into our course has been the greatest possible gain, and others who have left from the upper part of the school, without hope of distinguishing themselves in classes or mathematics, have adopted science as their study at the Universities. It is believed that no master in Rugby school would wish to give up natural science and revert to the old curriculum."

The Commissioners will observe that important evidence in the same direction is given in the replies received from Clifton, Wallington, and Manchester.

The Rev. J. Percival writes:—

"I consider that the introduction of science has not in any way interfered with the successful pursuit of the old studies, whilst many of our boys who have gained distinction in classics or mathematics have thus acquired a sound elementary knowledge of two or three branches of science, and many others have had all their powers stimulated by thus finding out that slowness in learning languages does not necessarily mean general stupidity. Thus, the number of boys who do nothing well, and have no intellectual interests, has been materially diminished, and the general tone of the school life has been raised in proportion."

The Head Master of Winchester College says:—

"I think there has been an interest created in botany and geology, which has altered the feeling of contempt for such things which used to be general. I do not think it affects the other studies of the school either way. The principal result is a more general spread of sensible estimates of the value of such knowledge. I do not expect to find individuals do more than *e.g.*, Messrs F. Buckland and P. Sclater, who were at the school when no regular teaching was given in science."

The Head Master of Wellington College remarks:

"The good effect on the school is undeniable, but for individual distinctive science teaching we must look onward for some little time.

"I introduced it into the classical sixth solely with the view of increasing the boys' interest in life (there is not enough to produce results in external examinations), and of improving their literary work by widening their interests. I think it succeeds in both respects."

It is also stated by the High Master of the Manchester Grammar School that:—

"Since the introduction of the science teaching and the connected changes in our system, the number of our boys has largely increased. By the side of the old classical forms, which remain at least as strong as before, there have grown up science and mathematical forms, training, for a life of study and an University career, boys who earlier would with difficulty have found a place for their special aptitudes. The number of prizes and certificates from South Kensington shows that an influence for good has been at work upon the younger boys, and to name the result which (to the schoolmaster) is, perhaps, the most important of all, the number of utterly listless boys between 15 and 18, who seem incapable of being roused to take an interest in anything, has almost disappeared."

Although the Rev. F. W. Farrar cannot trace any influence which science teaching has exercised on the general studies or on the intellectual life of the boys at Marlborough College, he goes on to state:

"There are, however, two good results which it is producing now, and will produce more and more. 1. It enlarges the range of knowledge and intelligent interests for a large number of boys. 2. It has succeeded in stimulating and evoking the powers of a few boys who had failed completely in other studies. These results alone are amply sufficient to justify its introduction, and encourage us to persevere."

## § 19.—SUGGESTED IMPROVEMENTS IN THE TEACHING OF SCIENCE IN SCHOOLS

Mr Madan, the Science Master at Eton, says, with regard to science work at Eton, "It would seem better to re-arrange the divisions for science work more completely than is now done. At present the boys (below the first hundred) are arranged mainly according to their classical or mathematical work; and there is some difficulty in organizing a consecutive course of instruction for the boys. A large room for a museum is also much wanted. There is a good nucleus for a geological collection, but no means of displaying it properly."

And the Rev. Edward Hale, one of the Assistant Masters at Eton, makes the following suggestions:—"By a systematic division of subjects, allotting a certain course for certain school periods, and by making this course progressive, I think, for efficient Science teaching, every boy should be taught Erd-kunde, in some such course as the following:—

- (i) The Earth's position in the Solar system
- (ii) The Atmosphere, Solar Heat (Rain, Snow, &c)
- (iii) Very elementary Geology
- (iv) Changes in the physical features of the Earth's Surface caused by Rain, Rivers, Ice, Snow, &c
- (v) The Sea, Tides, Winds, Climate
- (vi) Various divisions of animals and plants on the earth's surface, and their distribution.

"After each boy has gone through a course of this, he should choose one of three divisions

Div (a) Astronomy, Mechanics, Hydrostatics, &c, and a boy choosing this division should give extra time to mathematics.

Div (b) Chemistry, Heat, Electricity, &c

Div (c) Geology, Zoology, Botany, &c"

The Science Master at Harrow states:

"At present all the teaching of Natural Science is carried on in a room which is used during certain hours of the day by one of the classical masters. As soon as the new rooms are finished, it is hoped that the teaching will be much more effective. No practical work, worthy of the name, is now attempted, except with a few boys, and without practical work no real progress seems to be possible, except in the case of boys of unusual ability."

Mr. Wilson, the Mathematical Master of Rugby School, makes the following statement:—

"We want, in the first place, more Natural Science Masters. Then we should be able to classify boys better, according to their knowledge and capacity for progress. The difference between the top and bottom of our classes is too great. Then, too, we might teach practical work in physiology and physics, which, under existing arrangements, is impossible. Moreover, we should be able to give special attention to advanced students, who are now left rather too much to themselves, or, at any rate, might be so, as our system makes no provision for teaching them. It sometimes occurs to me that this want might be met by the appointment of visiting masters for specialities in science (e.g., dissection, microscopic work, &c.), men who would come, as a drawing master does, for so many hours a week.

"In the second place, we want our Lower School increased and our Middle School diminished: this would improve our classification; for, at the bottom of the Middle School are large numbers of boys too far below the standard of the Upper Middle to be easily brought into the same system with them.

"In the third place, it would be an advantage to have our Upper School examined in Science at the Midsummer Examination by the University Examiner who takes the science in the 6th Form. Lower down than the Upper School, outside Examiners would do us harm, as they would inevitably make masters and boys run too much at immediate results; in fact, make them cram. But in the Upper School an occasional external Examiner would be of use."

As to the improvements which might be effected in science teaching in schools, the Head Master of Clifton College says:

"I hope to improve it by getting the masters to enforce their methods, by developing more fully the system of classification according to ability and proficiency, by giving more time to the study of particular periods of a boy's school life, thus producing the acceleration of progress which comes of concentration. Thus, and in many other ways, I hope to make the teaching considerably more effective than it has been hitherto, though I am well satisfied with our results, considering all the obstacles that beset any branch of new learning."

The Head Master of Marlborough College states:

"We are anxious to build a laboratory as soon as our means allow us to do so, and we wish to have our own workshops. Further than this, nothing can be at present effected consistently with the character and avowed aims of the school. My experience here has been that the demand for scientific teaching is entirely, or almost entirely, limited by the actual practical requirements of the boys. It seems to be impossible at an ordinary public school to furnish any but a very small number of boys with anything that could be fairly called a thorough education in science. In all the various competitive examinations for which the majority of them are being trained, the part occupied by science is very subordinate to that claimed by literature. Now and then we find a boy with marked scientific aptitude, and it would be our object to stimulate and help him to the utmost of our power, but the practical need of most boys, as well as the express wishes of their parents, render it impossible for us at present to extend the science teaching without injuring the school."

The Head Master of Winchester College says:

"We are at present in such an elementary condition in regard to science teaching that the improvements possible in it, if it is settled that this is a school where it should be made a main branch of study, are endless. They would, e.g. involve the entire construction of a system of practical teaching and work. For the purpose of communicating the outlines of general knowledge of some branches of Natural Science in a popular way, and of starting interest and acquaintance with scientific ideas, our courses answer their purpose."

The Head Master of Cheltenham College considers ample apparatus in some respects necessary. He adds:

"No other improvement seems possible, except by giving more time; but that could only be given at the cost of other subjects. More showy results might of course be produced by selecting three or four boys, turning them away from other work, and concentrating all their other time on science. The selected boys would generally get a scholarship, but their education would be one-sided, and the school organization would suffer."

The Head Master of Wellington College thus writes:

"What we immediately want is (1) a larger laboratory, with (2) more hours of attendance from the teacher of chemistry, and (3) a laboratory assistant. A minor necessity is, that in the mathematical school we want one more grade and one more class room. Each master teaching science loses time unless he has a separate class room, but he can perfectly well use such class room for different subjects."

The Head Master of Rossall School thinks it important to direct the study more in the direction of observation:

"Boys" he says "must be taught to know by sight and weight the difference between the 'Arley' and the 'Wigan Four-foot,' between 'Memel' and 'Dantzig,' 'Old' and 'New Red,' 'Arsenic and Salt.' All the theories of combination, number of elementary subjects, doctrines of molecules and atoms of gases, may be reserved till the savants themselves are agreed about them."

The Head Master of Christ's Hospital states:

"I intend proposing to the Governors that we should have, each spring, a course of lectures on Botany (illustrated by specimens given to each boy in the class). I should further wish that the junior classes should have at least one hour a week of oral instruction in some elementary physical subject, treated so as to stimulate their powers of observation and analysis."

The Head Master of the City of London School suggests the following alterations:—

- (1) "Chemical proficiency to count in class promotion.
- (2) An hour's oral teaching with demonstration, followed by an hour's book work, and supplemented by practical work. This would of course necessitate—
- (3) More time to be devoted to the study of Natural Science; and
- (4) More assistants.
- (5) More valuable exhibitions and prizes to be given for proficiency in Natural Science."

The Head Master of Taunton College School states the following:—

"First, and by far the most important, the establishment of a science master. The subject suffers by being put into commission, however good may be the teachers who share it. It has been taken hitherto by the mathematical master and myself; and we have learnt from our expe-



rience that of all possible topics of education, science most urgently requires a single representative professor, whatever aid he may receive from others.

"Secondly Specially constructed rooms and much enlarged apparatus. Our laboratories is of the roughest, our museum cases, which are rapidly increasing, have no special home, we have outgrown our botanical garden, and we have no workshops.

"The Governing Body of the School is keenly alive to our wants and eager to supply them; but the immense expense of new buildings has left them for the present without means, and though they will probably feel justified in shortly granting us a science master, I see no immediate prospect of the other improvements I have stated."

The Head Master of King's College School believes that improvements could be effected in the following manner—

1. "By the appointment of separate science masters for the School, independently of the College
2. By the establishment of an independent laboratory, so that all who attend lectures and do the book work might also do practical work
3. By the appointment of independent examiners to test the work.

4. By requiring of the lecturer in chemistry that he should also take the classes in their book work."

Experience at University College School shows that.—

"A smaller quantity should be taught, but more perfectly. It should be more general in character, and should take in more of the every-day life of a boy, so as to make him think of science despite himself. It should be throughout entirely experimental, to the total exclusion of theories except the few very simple ones, which a boy can easily grasp, and these only sparingly and at long intervals. Far more stress should be laid on the practical work. Boys should be taught some scientific facts much earlier than they are at present, certainly before 13 years of age. As the matter stands now, boys are allowed to acquire unscientific habits of thought before they begin to learn science, and when they do begin, the master has not to teach them science, but to eradicate the evil effects of past neglect—to undo, not to do."

The High Master of the Manchester Grammar School, says—

"I believe an observatory, a physical laboratory, and a boy's workshop would be of great service, but what we most need is an increase in the teaching staff."

### § 20.—ON THE EXPENSES NECESSARILY ATTENDANT UPON SCIENCE TEACHING.

There is a very widely prevalent idea that science teaching, independently of the teacher, is very expensive, and there is very little doubt that this idea has sufficed to keep science out of a good many schools in which it otherwise would have been at the present moment in full work.

The idea has arisen, it may be imagined, from the considerations, first, that, in science, unlike other subjects, the mere book was useless, secondly, that special buildings and expensive apparatus were, therefore, of the first necessity, and, thirdly, that, thus being so, a special teacher, who, as a specialist, would require a higher rate of remuneration than the teacher of the more commonly taught subjects, was also essential.

Let us first consider the question of buildings and apparatus. While it is perfectly true that a great sum of money may be sunk in stones, bricks, and mortar, in building a magnificent laboratory or observatory, and also true that, if the money is forthcoming, there is no reason why science should not be as well cared for architecturally as the other departments of a first-class school, it is equally true that science teaching of a high order may go on quite independently of such outlay or adornment.

The cost of the laboratory buildings at Eton, inclusive of apparatus and fittings, was about 4,000*l*. The sum expended on the shell of the buildings at Harrow (consisting of chemical lecture room and laboratory, physical lecture room and laboratory, balance room, rooms for physiological and other specimens, workshop, and store rooms) was about 4,800*l*. The buildings specially devoted to science at Rugby (comprising a laboratory, two large lecture theatres, apparatus room, a private laboratory, a museum, and an observatory), exclusive of apparatus, cost about 2,000*l*. On the buildings at Taunton College School (which include a laboratory, a museum, and scientific class room), a sum of more than 1,000*l* was expended. The cost of the chemical lecture room and laboratory, with an instrument room and store room attached, at Clifton College, exclusive of chemical apparatus and material, was 600*l*; that of the physical lecture room and laboratory, with a small class room and store room, exclusive of apparatus and material, was 200*l*. At Manchester Grammar School there are two chemical laboratories and lecture rooms, with balance room and sulphuretted hydrogen room, which, with the fittings, cost 990*l*, and the apparatus 289*l* 8*s*. 6*d*. The cost of the materials to start the laboratory (a room not specially erected for the purpose) at Wellington College, was about 50*l*; but a smaller sum, it is said, would have sufficed.

The average annual cost of lectures at Clifton College has been about 15*l*.

At University College School these expenses are met by a fee from each boy attending lectures on Theoretical Chemistry with experiments, varying from 3*s* to 5*s*. for each term of three months.

At Rugby School the expenses of the laboratory are met partly by an annual allowance of 100*l*, and partly by the payment of 1*s*. a term by each boy in the laboratory, for his share of chemicals and the use of apparatus.

At Taunton College School the cost of solutions and apparatus is under 5*s* per annum to each pupil.

At Clifton College the cost is about 30*s* a year for each

student in the chemical laboratory, and the average annual cost of the physical laboratory is 30*l*.

At Dulwich College there is no fixed sum for the purpose, in 1871 a sum of 75*l* was expended on the purchase of apparatus, and about 30*l* in 1872.

At Manchester the annual cost of the laboratory is about 100*l*.

At University College School, for Practical Chemistry (which is taught in a class averaging 25) the fee for each boy is about 16*s* a term of three months, but this does not include gas and water, and each boy has to pay for an apparatus which he breaks, unless the breakage is a necessary part of the experiment.

At Marlborough College the annual expense of maintaining the lecture room, museum, and botanical garden does not exceed 30*l* or 40*l*.

On this point the Rev W Tuckwell, in a paper\* read before the British Association in 1871, says, "It ought to be more widely known for how very small a sum sufficient apparatus can be obtained to teach natural history and experimental science. A laboratory can be fitted up for 20 boys at a cost of little more than 20*l*., while each boy's private stock of glass and test solutions need not cost him more than 8*s* per annum. Botanical flower-trays, containing 18 bottles, may be bought for half-a-crown, electrometers, telescopes, polariscopes, models of pumps, and pulleys, can be made, after a little instruction, by the boys themselves, who will learn in their construction far more of the principles which they involve than could ever be instilled into their minds "by the choicest produce of the shops."

From what I have seen in various schools, I am able to state that this represents the actual facts of the case. At Manchester Grammar School, to take one instance, I saw several polariscopes constructed at home by day-boys of 13 years of age, some of them actually having a metallic framework. One boy had melted up an old teapot for materials.

From Clifton the evidence is to the same effect.

Thus, for continuous courses of Elementary Chemistry and Physics, in which the text books used are Roscoe's Primer and Stewart's Primer, the lecturer adding a good deal to what is contained in these books as he goes along, a lecture table has been fitted up with cupboard, the gas and water laid on, &c, in an ordinary class room, large enough to seat from 50 to 60 boys, at an expense of from about 8*l* to 10*l*.

The master at the outset expended for chemicals and apparatus, such as a pneumatic trough, large retort stand, gas jars, flasks, &c, the sum of 71*5s*.

Some things which he only requires occasionally, such as air pumps, models of pumps, &c, he has hitherto borrowed from the Physical room.

But it is stated, that with a grant of from 3*l* to 5*l* a year, he can keep up and add to his stock of material and apparatus, so as to be able, in the course of about two years, to do all he requires without borrowing anything.

The report then states. "Our experience in connexion

\* The Obstacles to Science Teaching in Schools. [See p. 66.]

"with his room shows that elementary instruction in science can be carried on at a much cheaper rate than is generally supposed, provided that the teacher will take the trouble to think for himself, and expend a little time in preparing apparatus from simple materials."

In these small laboratories it is found that the complete table outfit usual in larger laboratories is quite unnecessary; two or three sets of reagents (mostly prepared by the boys themselves in quantity so soon as the use of each particular one of each reagent is taught) are found to be amply sufficient. This arrangement, of course, largely reduces the initial expenses.

The large use made of the Science Primers in Chemistry and Physics by Professors Roscoe and Balfour Stewart justifies the reference in this place to the sets of apparatus supplied with these primers to illustrate all the experiments given by the authors.

The following is a list of the apparatus with which it is expected that each student of the Government Science School will be furnished:—

	s.	d.
Conical brass blowpipe with bone mouthpiece	-	2 0
6 inches platinum wire	-	0 6
Platinum foil, 2 inches long, and 1 inch wide	-	1 0
Test tube stand, 24 holes	-	2 0
18 test tubes, 6 in. by $\frac{3}{4}$ in.	-	1 9
12 test tubes, 5 in. by $\frac{3}{4}$ in.	-	0 10
2 boiling tubes, 8 in. by $1\frac{1}{2}$ in.	-	0 5
2 test tube brushes	-	0 5
Set of 3 beakers	-	1 0
German flasks, 1 of each, 2 oz., 4 oz., 8 oz., 16 oz., and 30 oz.	-	1 9
Berlin porcelain crucible $1\frac{1}{2}$ inch diameter	-	0 4
Berlin porcelain evaporating basins, one of each, $2\frac{1}{2}$ in. and $3\frac{1}{2}$ in. diameter	-	0 11
Funnels, one of each, $1\frac{1}{2}$ in., 2 in., and 3 in.	-	0 6 $\frac{1}{2}$
English filter paper, cut, two packets of 100 filters each $2\frac{1}{2}$ in. and $4\frac{1}{2}$ in. in diameter	-	0 9 $\frac{1}{2}$
Iron retort stand with two rings, clamp, and square iron block	-	7 0

	s.	d.
Iron wire gauze, 5 inches square, 2 pieces	-	0 4
Tin plate sand bath, 5 inches diameter	-	0 4
6 watch glasses, 2 inches diameter	-	0 6
$\frac{1}{2}$ lb soft glass tubes $\frac{1}{8}$ in. to $\frac{1}{4}$ in. diameter	-	0 8
$\frac{1}{2}$ lb combustion tube, $\frac{1}{8}$ in. bore	-	0 8
$\frac{1}{2}$ lb glass rod $\frac{1}{8}$ in. diameter	-	0 4
2 feet black caoutchouc tube $\frac{1}{8}$ in. bore	-	1 4
2 feet black caoutchouc tube $\frac{1}{4}$ in. bore	-	0 8
Thistle funnel, 18 inches long	-	0 4
3 dozen assorted corks	-	1 4
Woulf's bottle, 2 necks, pint size	-	1 3
Stopped German glass retort, 2 oz.	-	0 7
Set of three cork borers, $\frac{1}{8}$ , $\frac{3}{16}$ , and $\frac{1}{4}$ in. with iron rod	-	1 0
Triangular file and handle	-	0 8
5 in round file and handle	-	0 9
Bunsen's gas burner, with blowpipe jet, star support, chimney, and rose burner	-	3 6
Iron crucible tongs	-	1 0
4 inch porcelain mortar	-	1 0
Box of test papers, blue and red litmus	-	0 6
Solution of Cobaltous nitrate $\frac{1}{2}$ oz., stoppered bottle	-	0 7
" " argentica $\frac{1}{2}$ oz.	-	0 6
" " platinum chloride $\frac{1}{2}$ oz.	-	1 9
1 pint methylated alcohol in bottle	-	1 6
Glass spirit lamp, 4 oz capacity	-	0 9
Deal box to contain the set of apparatus	-	2 0
	£2	5 1

It is stated in the *Science Directory* that the set complete can be obtained in a box for 2l from Messrs J J Griffin and Son, Garrick Street, London, W.C.; Messrs. Townson and Mercers (late Messrs. Jackson and Townson), 89, Bishopsgate Street Witham, London, E C; Mr. M. Jackson, 65, Barbican, London, E C; Messrs Zimmermann, 6, Pen Court, London, E C.; Messrs. Harvey, Reynolds, & Co., Leeds; or Messrs. Mottershead & Co., Market Place, and St Mary's Gate, Manchester; but schools are not required to purchase the apparatus of these manufacturers.

## § 21.—SCIENCE TEACHERS.

There is great divergence of opinion as to whether it is difficult or not to obtain qualified teachers of science. There is much evidence, however, to show that there is a real difficulty in obtaining "down-right good men," except in the case of the richest schools. In fact, in the case of many schools, the area of choice is limited, as there is a widespread feeling among the Head Masters of the old foundation schools that it is important that the Science Masters, like the Form Masters, should be University men. Nor is this all. The Head Master of Rugby states—

"I do not think I could improve upon the teachers who might be selected from Oxford and Cambridge. They have been specially trained as students. As teachers their proficiency has been attained by practice. As students, the University curricula with professorial guidance, and the competition for the various distinctions open to them, have given them the necessary training. I would here observe that a mere chemist, geologist, or naturalist, however eminent in his own special department, would hardly be able to take his place among a body of masters composed of University men, without some injurious effect upon the position which science ought to occupy in the school. I would add that it seems to me highly important that a school teacher of these subjects should be thoroughly practical in his knowledge, skilful in experimenting, and ready in devising simple and inexpensive lecture illustrations. In preferring the two older Universities, I do so only by reason of their stronger general sympathies with public school teaching. I am aware that, if I merely wanted a highly scientific man in any branch, I might find him equally at Dublin, London, or a Scotch University."

The Head Master of Clifton refers to the "want of previous training or experience on the part of the masters,

"each one having to a great extent to discover his method "by experiment"; and he further states that he is of opinion that Oxford turns out the best teachers for such a school as his than any other single place. He adds—

"But they cannot be said to be in any way trained for their work, having in fact to learn their business when they come to us; and the Oxford system has at best this very grave defect, that the men who are trained in it are apt to take away with them very extravagant notions about the apparatus necessary for teaching science in schools. They might with advantage be made a great deal more capable of helping themselves."

This want of training of the masters in the art of teaching and in practical work is often referred to, and forms the subject of many suggestions.

The Master of Cheltenham states, as a condition of things strongly opposed to Graduates of either Oxford or Cambridge undertaking the duties of Science Master at a school, that—

"The Universities offer now-a-days so attractive a home for men of science, whether married or unmarried, combining the advantages of ample leisure, fair emolument, splendid collections from museums and libraries for study and observation, that even large public schools, in pleasant positions, find it hard to attract first-rate teachers of science, except the man himself has a genuine love for boys."

The Head Master of Winchester alludes to "the difficulty of finding teachers possessing actual knowledge of practical and experimental kinds, who are also able to manage a class of boys."

The Head Master of Christ's Hospital states that "the teachers of the existing staff are mostly unacquainted with Natural Science, at any rate in such a measure as to be adequate teachers of it."

## § 22.—ON THE OBSTACLES TO SCIENCE TEACHING IN SCHOOLS.

In those Schools which I visited, I was very careful to inquire into the opinions of the Masters with regard to the various obstacles which exist to the introduction of Science into schools. Some of these obstacles are very real, some, I believe, are more or less imaginary. In the answers to question 32 will be found very important evidence concerning these obstacles; and I may say that so far as the real obstacles go, the opinion which I have formed from my visits to the various schools, induces me to place this statement in the strongest possible form.

First of all, I think, really comes the very grave obstacle, that if Science is intended to be introduced into a school at the present day, a crowded curriculum is to be met. The curriculum in most schools is already so large that it is taken for granted that it cannot be extended. It therefore becomes a question of eliminating something before Science can be properly introduced. The next question is, what should be eliminated? And this question is one extremely difficult to be answered, or at all events it is answered with difficulty; although if a school were merely considered as a place of training, and not a place where useful knowledge is imparted, the difficulty would really be seen to be a lighter one than it is supposed to be.

It is stated at Marlborough that the boys' time is already absorbed by studies which have of late years been largely multiplied, and which in most cases they know to be essential to their future prospects in life, seeing that most of them will have to be examined in all those subjects. It is not merely a question of the time taken up by the other subjects; the boys are absolutely distracted by them, and cannot approach a new subject, and especially such a new subject as Science, with that undivided attention which is absolutely necessary, if any advance is to be made in it.

The Head Master of the Manchester Grammar School states, "The boys in the classical Forms are fully tasked, I think overtaxed, by their present work, so that under existing conditions they cannot be taught Science with any good results; many boys, however, are detained by their parents in the classical Forms, who mentally would profit far more in a Science Form, but this generally is done for the sufficient reason that a literary training is of vital importance to the boy's prospects in life."

I do not find that this difficulty of introducing Science has been at all regarded in connexion with the fact of the new kind of training altogether which comes from dealing with the sciences of experiment and observation, and I believe that it is extremely important that this point of view should be developed in order to introduce Science into Schools where at present it is not taught, and to extend the teaching of Science in those schools where it has already obtained a footing.

But the want of time, after all, is only one of the difficulties. In the old schools the tone of the school is distinctly against Science, not so much on the part of the Masters as on the part of the parents, and, to a great extent, on the part of the boys themselves; and I believe it is from this point of view (and I express my opinion with much diffidence) that the introduction of Science into the modern aides merely of schools, whether of this class or of any other class, will eventually be a matter extremely unfavourable to Science. Not only will Science be looked upon as onerous, but its training power will be entirely disregarded.

Mr. Madan's idea of the obstacles at Eton is as follows. "The natural unwillingness of parents and tutors to allow boys to give up much time to a Science which has not hitherto had much influence on a boy's place in the school, and which does not often serve as an introduction to any recognized career or profession—this unwillingness is quite justifiable." Mr. Dalton points out, "The whole tone of the school has until lately been so absolutely classical, that Science had to start with a certain amount of prejudice against it. This, I think, it has certainly overcome, it being now generally allowed that the subject has done good work for the boys."

There is ample evidence to show that where Science has been best taught its effect upon the boys is most acknowledged. Thus at Eton, as already seen, it is acknowledged that the subject has done good work for the boys. At Wellington it is acknowledged that the past feeling of inferiority to other subjects is perhaps hardly just, and I am sure that the Head Master of Clifton College is quite willing to acknowledge the importance of a Scientific training, although he states that a prejudice against Science, as a new study, to some extent lingers in the minds of both men and boys.

Another real obstacle is connected with the Science

Masters. It is stated in evidence that in the great schools the Science Masters, as a rule, are not sufficient in number, and are not sufficiently trained. When Science has been introduced into a school, it has been introduced very much as any other subject would be—any other subject, I mean, of quite an inferior kind, and one, like most of the old studies, in which the book is all sufficient. The Science Master has faced his work, lectured to his classes, prepared his experiments, revised his note-books, prepared his examination papers, and has then either broken down, or has appealed for more help, which he has not been able to obtain. Thus we read in the information placed at my disposal by Mr. Wilson of Rugby, that the greatest obstacle is the want of time on the part of the Masters. He remarks, "They have time to do their regular work, prepare lectures, look over books, &c., but not time to give to individual boys the help and encouragement that they need. Boys are not unwilling to work, but they require absolute direction what to do. They will often undertake very laborious work, if it is absolutely defined, but to direct scientific work takes much time."

I have referred in another section to the evidence concerning the training of the Masters, which goes to show that although the present staff of Science Masters is altogether inadequate, more might be done by the existing staff, if, as a rule, they were more conversant with the methods of teaching and experimentation.

A host of obstacles in the various schools depends upon the organizations of those schools, and I say this, because it is not a general complaint, the complaint only exists in the case of certain organizations. Thus at King's College School the necessity of accommodating the hours of Science lectures to the arrangements of the College is pointed out as one of the obstacles.

At Eton it is acknowledged that an obstacle exists in the fact that the divisions of the school are made with reference to classical work only.

Again the Master of Clifton College acknowledges a difficulty in classifying boys according to proficiency, and arranging the teaching so that the boys may be kept as active as possible, and not remain simply passive listeners to a lecture. He then goes on to add, that another obstacle lies in the fact of the difficulty in the way of a progressive arrangement of classes, at least in a large school, to get over which it is necessary to teach several classes simultaneously. Thus, of course is met by having more Science Masters. At Clifton three or four sets are thus taught simultaneously.

From King's College School comes the statement of an obstacle which it is perfectly simple to overcome. This obstacle consists in the late age and the backward state in which boys join the school, especially the Modern Department, and we may add to this, the rapidity with which boys pass through that Department. I believe that when the importance of Science teaching comes to be generally acknowledged, such an obstacle as this must cease to exist, and it is noteworthy that the obstacle is in the main urged in connexion with the Modern Department.

Another drawback is one which, it is to be hoped, is also easy of correction. The requirements of the Universities, and especially the University of London, have a most objectionable influence upon the schools. We learn from University College School that "The Universities require more than can be properly learnt by a boy of 16; they require that knowledge to be very special in character, and not by any means to have any connexion with the daily life of the boy, he is asked about chemical substances, which he may never see or hear of again for the rest of his life, they seem to lay more stress on theoretical than on experimental knowledge, judging from their questions and from the candidates who pass, indeed, the boys will often leave the practical class for the purpose of preparing for the examination. Lastly, they require an inordinate amount of knowledge in other than scientific subjects, so that a boy cannot well begin Science before 14 years of age."

Another obstacle which is urged, and which I believe to be more unreal than is generally imagined, is the cost of introducing the new study. No doubt a Laboratory is needed, no doubt a special class room is desirable, but in many schools these requirements have been met without any additional expenditure, but when once the *locale* is found I believe that Science can be introduced at one tenth of the cost which is usually supposed to be that which is absolutely essential.

But to come back to the real obstacles, we find what I have had to refer to in other sections of my report, viz., the

utter absence of an assured career for any student of Science. At Eton it is stated that the rewards for success in Classics are so great, that a boy must hesitate about endangering his progress in them, and it is difficult to reward him adequately for success in Science. Another Eton Master also refers to the belief amongst parents and Masters, that Science does not pay.

At Marlborough it is acknowledged that the demand for Science teaching amongst parents is very small. The general opinion seems to be that an ordinary knowledge of Science does not open the way for any career in the future, and that a boy is more likely to win for himself a future position by following the studies which form the main curriculum of teaching.

At Wellington the feeling that Science does not pay as well as other subjects do is also distinctly referred to.

Again let us take the case of Christ's Hospital. Most of the boys leave that school before 16, and at present there are hardly 30 boys in the school over that age. These are all aiming at University Scholarships; and it is stated by the Head Master that to these hitherto Classics and Mathematics have been found the only, or at least, the readiest, avenue.

The Head Master at Rossall not only points to the greater inducements held out by the Universities for the study of Classics and Mathematics, but he refers to the unsettled state of opinion as to what is the real aim of scientific study; and the instinctive feeling of the boys that, as at present taught, Science is not equal to Latin and Greek, or Mathematics, for educational purposes.

### § 23.—HOW THE UNIVERSITIES CAN BEST AID SCIENCE TEACHING.

The Commissioners will gather from the replies to Q. 83, that there is an almost unanimous opinion among those connected with the great Schools, that the Universities can best help the cause of Science by offering more Scholarships and Exhibitions for that subject, so as to diminish the disparity in the rewards held out for the various studies—a disparity so great at present that many Head Masters feel that in recommending the study of Science they are injuring the prospects of boys.

More Fellowships are also suggested, but the opinion is that Scholarships are more important than Fellowships for the immediate purposes of the Schools.

It is also felt that the Science-teaching at the Universities might be more adapted than it is to turning out Masters; special courses of lectures on the art of teaching (similar to those at the Science Schools at South Kensington), and on the construction and use of inexpensive apparatus, being given. The Head Master of Christ's Hospital suggests that the Universities might supply the deficiency of highly-trained Scientific Teachers, by endowing a class of local Sub-Professors who should further the teaching of Natural Science in the schools of a given district, by lectures, examinations, and inspection, and by their advice and suggestions to the teachers of the several schools with regard to subjects and method of teaching, choice of apparatus, &c. The Head Master of Rugby points out how Science Teaching in schools would be aided by the Universities maintaining a high standard of teaching and examining, so that they will be able to send out the best possible teachers and examiners. I have already referred to this question of Teachers in § 21.

Some Head Masters suggest modifications in the University curriculum. The Head Master of Winchester would make it incumbent on the Universities that their best men should know some rational amount of Natural Science. The Head Master of Harrow suggests making some branch of experimental physics or chemistry a necessary part of the first examination that is passed by every undergraduate. The Rev. J. Percival proposes the institution of "examinations such as those asked for by the Head Masters' Conference, and the modification of the general curriculum, so as to offer a fair field for these new studies." The Head Master of Taunton College School considers that Science Teaching would be aided "most materially by making a certain amount of Science compulsory in the matriculation and little-go examinations. Cambridge might also include Science in the list of subjects on which the Syndicate offer to examine schools; and Oxford might rescind the mischievous rule which limits junior candidates in the local examinations to five optional subjects."

The High Master of the Manchester Grammar School and the Head Master of the City of London School make substantially the same proposal that the Commissioners have already embodied in their Third Report.—"Much additional good would be done if the Universities instituted a general matriculation, or leaving examination, comprising—1, Mathematics; 2, Science; 3, Language and Literature, and allowing excellence in one subject to compensate for defects in another."

The Head Master of Christ's Hospital adds that, "If the scheme of organised examinations of schools by the Universities (suggested by the Conference of Head Masters), should be adopted, Natural Science would find its place in such examinations."

The Head Master of Winchester also suggests that the Universities should frame "some definite courses of Natural Science teaching: (a) Of a standard fitted for a boy's main study; (b) Of a popular kind, fitted to be an universal study for all boys, subordinate in position, but sufficient to give some real knowledge."

The enormous influence for good or evil of University examinations upon school teaching may be gathered from the evidence from University College School.—"Every improvement the Universities introduce into their examinations must be attended with improvement in our teaching, e.g., if the examinations of the University of London became practical in all departments of Science, as they are, for instance, at University College, in the case of botany, classes under instruction would be stimulated to much greater interest in, and attention to, the details of arrangement and manipulation of apparatus; and the substitution of practical instruction for teaching by the exhibition of experiments only, must soon follow."

Mr. Wilson, the Mathematical Master of Rugby School, is of opinion that the Universities could best assist "by teaching Science well themselves, and sending out good teachers, men of real culture and education. Boys," he continues, "soon find out the man of one idea: they use him, and get knowledge from him as they would from a laboratory assistant. They ought to turn out men who will show that Science is a branch of culture as well as a department of knowledge."

"By gradually, as the competition increases, giving more scholarships for Science, and making their examinations more uniform."

"Most of all, by making themselves famous as schools of Science, and having the most distinguished Professors; that boys may aspire to be students under Stokes or Rolleston, as they used to aspire to read Greek with Jowett, or Latin with Conington."

### § 24.—HOW THE GOVERNMENT CAN AID SCIENCE TEACHING.

It is acknowledged that Science is neither recognized nor paid nor rewarded by the State as it ought to be; that mainly owing to this, there is no career for Science, and that parents and masters are justified in avoiding it.

The Head Master of Rugby states, "A scientific career, as such, opened to the aspirations of candidates such as I believe exists in some countries, might probably influence for good both pupils and teachers by giving a definite object with tangible results."

Mr. Wilson, the Mathematical Master at the same school, writes, "The main influence of Government is indirect; if they honour science, and value it, and make its study a national object, they do more to encourage Science in schools than by any direct interference."

I have found the Head Masters of the Schools I have visited fully impressed with the idea that the Government can, if it chooses, bring a great influence for good to bear upon Science Teaching in Schools.

One of the means most frequently pointed out is the introduction of Science into all examinations for the Government Service. The Head Master of Marlborough would make some branch of Science compulsory in all such examinations. The Head Master of Christ's Hospital thinks that the Government should require Natural Science in its competitive examinations. The Head Master of Rossall remarks — "One way in which Government might help, would be to offer us commissions or civil service or colonial appointments for excellence in Science studies anything, in short, to balance the overwhelming attractions of classical and mathematical proficiency as a means of getting a livelihood."

With regard to inspection by an officer of the Government, though the opinion on this point is not unanimous, there is a balance of evidence in its favour. From Eton comes the suggestion that the Inspector should be also a lecturer, so that a greater interest for Science might then be developed.

The late Head Master of Wellington College, though in favour of inspection, is of opinion that the inspection should be general — "It is important that all the subjects of a school education should be pressed forward with an even hand, and the relative values affixed to them should not be destroyed, though from time to time they may be carefully remodelled. The inspection of any one single branch of work would destroy undesignedly, but steadily, the balance of studies. The examining power (whatever it is, Government or University) should be comprehensive, and provide for the inspection of all subjects." Here I would venture to remark that it is not a question of *destroying* but of *creating* a proper balance.

This view is exactly that of the Head Master of Taunton College School, who states — "For some years to come, until Science is thoroughly established, I think an annual Government inspection, with grants or prizes of moderate value or a reward for attendance, would work exceedingly well. But I hope ultimately to see the day when all boys at all schools shall undergo a compulsory public examination in Science, as in every other subject taught, at least once a year."

The opinion of the High Master of the Manchester Grammar School on this point is thus stated — "Nothing, in my judgment, would be so beneficial to endowed schools as systematic inspection and subordination to some central authority. Whatever assistance scientific studies would receive from such a change, and it would be great, Classics, Mathematics, and Modern Languages would receive hardly less."

The Head Master of the City of London School is of opinion that Government inspection (if not carried to excess) by one experienced in teaching, would be extremely useful. I next come to the aid which can be so readily afforded

by Government, and by no one else, in the matter of museums, instruments, &c.

The Head Master of Winchester considers that important aid may be rendered "by carrying into other branches what has been done for botany by the preparation of sets of plates, &c by organising a system for supplying sets of typical specimens of zoology, geology, &c. Nothing," he adds, "but a central organisation can insure schools, which have no special opportunities, the possibility of obtaining the necessary collections."

And the Head Master of Marlborough — "By setting aside a building at South Kensington, or elsewhere, in which the finest modern physical apparatus could be seen, such as the collection of the Conservatoire des Arts et Métiers in Paris, or the Physical Cabinet in Leyden." "By the grant of moneys for the purchase of apparatus and diagrams, or the loan of such apparatus, or the authorisation of the sale of such apparatus at cost price, and by accredited agents."

Mr Madan, of Eton, suggests "grants or loans of apparatus, diagrams, &c., as is done in the case of Art Schools."

The Head Master of Clifton College thinks that "the Science Department under Government might be of great service by cheapening still more the supply of books, diagrams, apparatus, &c."

The Head Master of King's College School desires that aid should be rendered by "donations of scientific books to form a school library of Science, and scientific specimens and instruments of various kinds."

The Head Master of Christ's Hospital would wish Government aid in the formation of School Museums and Collections.

As to how Government could assist Science teaching in schools, Mr Wilson, the Mathematical Master of Rugby School, makes the following observations — "Help might be given towards the formation of museums by free grants of duplicate specimens, diagrams and photographs might be published by the Geological Survey that would greatly facilitate the teaching of Geology. A Training College for Science Teachers for Second-Grade Schools is, I believe, urgently wanted."

Mr Griffith, the Science Master of Harrow, says — "If 'Leaving Examinations' were established, increased attention would necessarily be given to Natural Science at schools, if some branch of the subject were made compulsory in these examinations, whether conducted by the Government or by the Universities."

The Head Master of the City of London School considers that aid might be rendered by awarding prizes, and he suggests "that the pupils of such schools should be allowed to take the prizes and medals awarded by the Science and Art Department (South Kensington), but at present limited to the students of Government Science Classes. Also, that the list of successful candidates be published."

#### MEMORANDUM ON THE MODERN DEPARTMENT.

In the chapter dealing with the Organisation of Schools, I have pointed out that the schools may be arranged into four Groups — Schools with only one main line, and that Classical, Schools with only one main line, but in which general fitness determines the place. Schools with a Modern Side, and, finally, those Schools which, in consequence of some peculiarity, do not conveniently fall within either one or the other of these divisions.

It is not necessary that I should remind the Commissioners that the "Modern Side" is a recent introduction, and that not only have we now many schools with Modern Sides, but even Modern Schools altogether, and a gradually increasing desire that more Modern Schools should be established. Although this desire exists, I have not heard it clearly expressed whether it is the intention of those educationalists who propose the erection of Modern Schools that these Secondary Schools should be feeding grounds for the Universities; but I wish to point out that, if it is intended that they should be feeding grounds for the Universities, then a condition of things will be brought about diametrically opposed to the spirit of the Commissioners' Report on the Universities of Oxford and Cambridge. In that Report it is proposed that in the case of every student who proposes to carry on his education at the University, there should be an Examination, preferably on leaving school, which "might serve to mark the limit between School studies and University studies, so that the student whose performance in the Examination had come up to a certain standard, might be supposed to have acquired such an amount of general culture and scientific knowledge as to entitle him, thenceforward, to be left as free as possible to choose for himself among the great lines of literary or

"scientific study." In fact, the Commission has proposed that in the case of all those students whose education may be expected to culminate at the University, the bifurcation between the various lines of study, Classical, Mathematical, and Scientific, should take place at the entrance to the University, and not before. With the introduction, however, of Modern Sides to existing Classical Schools, and with the interpolation of Modern Schools into our general educational system, we have a bifurcation coming at a much earlier date, and under the present disorganised system we may have any number of bifurcations going on at any number of epochs in a boy's life.

Although it is impossible to speak too highly of some of the arrangements of several of the Modern Schools which I have inspected, I am not saying too much when I state that my impression has been, especially with regard to some of the schools that I have visited, that a Modern Side is a modern mistake. In some schools I am informed that, in the case of boys of the Modern Side, there is an absence of that high tone which is one of the crowning glories of our English Schools, this being no doubt to a certain extent brought about by the limit placed upon a boy's ambition. He finds, in too many cases, boys of his own age, friends of his own, on the Classical Side, going up to the highest places in the School, whereas it is absolutely impossible for him to achieve that position by any amount of diligence in his own studies. In fact, my opinion with regard to Modern Sides is exactly the opinion which was arrived at by Mr Fitch when he inspected the Schools in the West Riding of Yorkshire, and whose Report I have become acquainted with quite recently. He remarks —

"It will be observed that in both these cases the Modern

Department is regarded as of inferior rank to the Classical, is under-offered, and derives little advantage or strength from its connexion with the Grammar School. It is rather an excrescence than an organic part of the school. It exists rather by sufferance than with strong approval. To try an experiment of this kind with success, it is necessary that some of the teaching power of the Larger School should be available for the Modern Department, or that if it be regarded as a separate school it should be well organised on that footing, and have suitable classification and an adequate staff of teachers for its special work.

"But if the ordinary course of instruction in the Grammar Schools were made at once more comprehensive and more intelligent, the need for a Modern Department as a separate institution would be greatly diminished. A course of instruction might surely be devised which, while equally good for the purpose of those who contemplate an University career, would be more serviceable to that large number whose education terminates earlier. If in the Lower Forms of a School English Grammar were taught *pari passu* with Latin, if more attention were paid to reading, to English composition, and to the cultivation of a boy's general intelligence; if arithmetic were taught in its principles, so that as far as it was worked it was understood; and if more pains were taken with the finish of all written exercises, there would be little need to separate the two classes of pupils. Such a course, even if frustrated at the age of 14 or 15, would have an unity and a value of its own. More oral teaching, more frequent appeals to the intelligence and taste of the pupils, in connexion with elementary work, the earlier introduction of History, and Elementary Science, and the postponement of Latin verification, and of Greek, to a later stage of a learner's course, would meet the requirements of 80 per cent of the scholars far more effectually than the present course. And it is difficult to believe that the interests of the remaining 20 would be sacrificed to such an arrangement. On the contrary, I believe that some unexpected advantages would accrue, and that the delay in mastering some technical details would be more than compensated by the intelligence and consequent rapidity with which they could be acquired."

Now with regard to the Higher Classical Schools, such as Eton, Harrow, and the like, it is quite possible that Mr. Fitch would consider that the remedy which he here proposes would be sufficient, but it would be met by the objection to which I have alluded in another section, that the number of subjects already taught on the Classical Side is too large, and the detail in which they are studied is so great that modern subjects could not be properly introduced to the extent which, perhaps, would follow from Mr. Fitch's suggestion. But there is evidence to show, from the admirable way in which Science has been introduced and taught at schools like Rugby and Eton, that, so far as Science at all events is concerned, a Modern Side is not absolutely essential. No doubt the *raison d'être* of most of the Modern Sides in Schools is the crushing weight of competitive examinations, which seem every year more and more to destroy education, and to make the earlier years of a boy's life absolutely destitute of training: turning, in fact, places which should be educational into mere repositories of knowledge more or less useful. I would only point out that if the Commissioners' view of the general culture necessary, as a rule, for entering the University be generally accepted, Modern Sides and Modern Schools will be almost unnecessary, and that no bifurcation will be needed if an mythical simplification of subjects be accepted. If, for instance, the parent of a boy, when he sends him to one of the Higher Secondary Schools, were to be assured that that boy's career in life would not be injuriously affected by his scientific studies, while, at the same time, he would wish him to undertake those studies, what easier method would there be than, by the postponement of Greek, to allow that

boy's studies to commence side by side with the general culture, including the form work of the school from the day of entrance until the day he left that school? Of course this would assume not only the simplification of studies to which I have referred, and for which Mr. Wilson so eloquently pleads, but it would necessitate that a boy's place in the school should depend upon his general fitness. Thus, for instance, we might imagine a school on the scale of Eton, in which the boys would all of them, from the very commencement to the very termination, undergo a general training in Classics, Mathematics, and Science, and that without any strain; whilst in addition to this general training he might at the same time be preparing himself either for University honours, or for a subsequent career in either of the three great branches of culture. That this is perfectly feasible is shown by the fact that at the present moment even in the Sixth Form at Rugby, a boy is allowed to drop certain of the higher Classical subjects and to replace them by Science, which is equally marked with the Classical subjects, so that he is no loser by the change.

It must be perfectly understood that, so far as I have gone, I am considering the case of boys who propose to terminate their career at the Universities. In the case of those, however, who, from various causes, do not propose to enter the Universities, I believe that at the present moment there is a wide gap in our educational system; and that the suggestion of the Head Master of Marlborough, that there should be a school in which Science alone is taught, would be a suggestion of the very highest value; provided, always, that into this school shall come boys who have undergone a certain amount of general training in some Secondary School. I presume that the Commissioners would on no account endorse the suggestion, if it were intended that such a school should replace the present secondary instruction, instead of being supplementary to it, in the case of certain boys who do not go to the Universities.

There is another point in connexion with the Modern Schools, and it is this: it is not too much to say that it is quite possible that the introduction of Modern Schools, and the introduction of Science into the Modern Sides of Classical Schools, will, in the long run, instead of facilitating, as it is thought, the introduction of Science into the Classical Sides, prevent any Science being taught there; so that after Modern Sides and Modern Schools have been in operation many years, the culture will be more one-sided than ever, and such a Leaving Examination, as the Commissioners have proposed, will become year by year more and more impossible. I believe that at the present moment, in the absence of Modern Schools, the Masters are perfectly prepared to add Science to their curriculum, and to teach it well, if they can be only told how this is to be done; if some general consensus can be arrived at with regard to the subjects to be given up, if some general instructions can be given to the Masters, such as those indicated by the Endowed Schools' Commissioners, and if a supply of properly taught Science Masters can be procured, it is my belief, from what I have seen, that if the Commissioners can only succeed in creating a career for a man of science commensurate with the careers opened to the older studies, and, if, at the same time, Greek is given up as a compulsory subject at the older Universities, as it has already been at the University of London, all the other difficulties which harass the introduction of Science into Schools will gradually disappear. The establishment of a career, both at the University and in the national life, will at once relieve parents from the grave and very proper objections which they have at present against their children forsaking the old lines which have always been so well rewarded. With this will come—seeing that more will be taught Science—more people competent to teach it.

#### MEMORANDUM ON SCIENCE PROGRAMMES.

I have often heard the opinion expressed that much good would follow if Her Majesty's Commissioners would frame programmes, showing, however roughly, the order in which, in their opinion, the various subjects should be taken up, and the course of study to be adopted in each. I am certain, myself, from what I have seen, that such a course of action would be largely beneficial, not because such programmes would be, or should be, absolutely followed in

each case, but because such an authoritative expression of opinion would be of the highest value to teachers who, at the beginning of their careers, have necessarily small acquaintance with the best methods of teaching.

I append, as models of what I conceive such programmes could most usefully be, the Sketches of Instruction in Chemistry and in Physics drawn up by Professor Frankland and Professors Goodeve and Guthrie. [See pp. 85-93.]

## APPENDED STATEMENTS.

## I.—VARIOUS PAPERS BY MESSRS. WILSON, TUCKWELL, FOSTER, AND HALE ON SCIENCE TEACHING.

*See Introduction.*

1  
ON TEACHING GEOLOGY and BOTANY as a part of a LIBERAL EDUCATION.\* By J. M. WILSON, M.A., F.R.G.S., late Fellow of St. John's College, Cambridge, and Assistant Master at Rugby School. [Extracted from the "Educational Times" for April 1872.]

In accepting the honour of delivering before you a lecture on some branch of education, I was much more influenced by the desire to state, in as distinct a shape as I can, what seems to me the present difficult problem respecting the true position of these sciences in liberal education, and to make suggestions towards its solution, than by the hope that any remarks of mine, on the methods of teaching the special subjects of geology and botany, will be found valuable to teachers. For these subjects are not particularly difficult to teach, but their right position is rather difficult to assign. And this position, and the whole question involved in it, is of more importance at the present moment than the method of teaching. For we are in real danger of drifting into a new system of education, which loses more, when compared with the old, by its shallowness, than it gains in width. And, therefore, it is necessary that all persons who have in any way influence over educational tendencies in England should consider the whole question, and have, if possible, some definite and coherent aims. And, therefore, on the present occasion, simply to press the claims of one subject, without showing its relations to others, would be to mislead you as to my own views, and would be to avoid the most interesting aspect of the question.

Further, I am bound to confess at once that, except principally with this view, I have no right to make any remarks on the teaching of either geology or botany. Viewed on their strictly professional and scientific side, I should be totally unfit, from sheer ignorance, to teach either of them. I am not a professed botanist or geologist, and can only dare to offer any suggestions as to teaching these subjects by premising that it is only so far as they seem to me legitimately to enter into a course of liberal education, that I have had experience in teaching them, and in seeing them taught by others. I have very often to deplore my want of knowledge in these very subjects, but as it is certain that they will be taught by many who are not professed naturalists, my experience may be of some use to such teachers, and help to enable them to put their boys in a right way of learning for themselves.

What, then, is the proper position of these subjects in a course of education?

We must first get some clear notions in common as to the nature of the problem before us schoolmasters just at present. We have to adjust and reconcile contending claims. The subjects that press for admission into our schools, and compete for the time of our boys, are reducible to five heads. They are classics, mathematics, science, art, and useful knowledge.

Under the head of *Classics* I include all the *libera humaniores*; that is, all that brings man in contact with man, and that develops his intellectual capacities on the side on which Plato and Aristotle loved to contemplate him as a *politikon ζῷον*. It is one thing to discuss whether this is best done by teaching him Latin and Greek, and another to recognise that this is the highest object of education. It is quite true that we are in contact with nature, commonly so called, and external inanimate objects, from the moment we are born; but so also are we with one another, and any training that aims at fitting man for his social and political relations is assuredly the highest in its aim †

*Mathematical training* is quite indispensable, at least to a certain extent. There is nothing so effective in giving quickness and solidity as arithmetic, it is better than grammar, or science, or anything else, and nothing seems to compensate a boy for being ill taught arithmetic as a child. Geometry also gives fibre and muscle, and is particularly desirable in a literary education. But it is perhaps worth saying here that the advantages of prolonging mathematical training beyond a certain very moderate amount seem to me

somewhat doubtful. It is a good employment; gives habits of concentration and accuracy, and gives a certain regularity of thought, it makes the mind a somewhat better machine, but does not do much, as far as my own observation goes, to strengthen or open the mind, or to give available knowledge of tools except in the case of a few who possess special mathematical ability. On the contrary, I think a good deal of time is wasted on mathematics by older boys, who often show distinct ability on other sides, but make extremely slow progress in mathematics, while it commands such a small fraction of their attention.

*Science* does much more than this, it very much widens a boy's horizon, giving him all sorts of ideas and interests and points of view, which he could not attain from his other studies, it kindles the imagination and gives it material, and some branches of it afford an excellent subject for school teaching. Still experience seems to show very decisively that beyond a certain point, either specific talent, or almost exclusive devotion of time, are requisite for the study of natural science. It seems to me, and I doubt not it is equally plain to others, that many boys do not gain any fresh power from the continuance of a moderate study of it, such as is implied in the two or three hours a week that can be devoted to it at school. Just when the science begins to be special and technical and professional, then it seems to elude their grasp altogether. They are bewildered; it is often not from want of ability, but from want of versatility and orderliness of mind; they could do it very well if they had not so many other irons in the fire. I am sure that this type of mind is very familiar to every schoolmaster present.

*Art*, in the forms of music and drawing, has strong claims, but it would be foreign to our present object to discuss them. But it makes demands on the time and leisure, and to some extent adds to the distraction of our students.

*Useful knowledge* is always knocking at our doors. It presents itself in the forms of French and German, and physiology, and the laws of commerce and geography, and the use of tools, &c. And in some of these we must admit it—French and geography, at any rate, are practically indispensable, and though they injuriously increase the number of subjects a boy has to learn, they do give something of training and culture too.

Now, of these five classes of subjects, commercial education presses the last. Its object is to give a certain quantity of available knowledge and skill, and in giving it to give as much training and culture as it can. But the producible results are the first aim. And from its insisting on accuracy, and even drudgery to procure it, it possesses one of the elements of a good education.

And liberal education presses the first. For the only education which claims the title has hitherto been given along with, if not by, the study of literature. Very indirectly, indeed, is it the result of a moderate knowledge of the Latin and Greek languages. It is the outcome of very many influences that have co-operated with direct instruction in these languages, and their history and literature. The most cultivated ranks of society have been almost exclusively, for many generations, educated on these languages, the schools and universities, where culture finds a home, have only lately begun to recognise other branches of knowledge. And so it comes to pass that it cannot be said that the experiment has ever been fairly tried among us, whether or not a good literary and humane education and culture can be given without a study of classical literature.

Many will be found to say that they learned very little at school, forgot what they learned, and have never felt the want of what they forgot. But even these were probably considerably benefited by the indirect culture obtained from the constant association with cultivated minds. Few really saturate themselves with the literary spirit, but these few do very much to refine others.

I am quite sure that this is the first business of our profession as schoolmasters, to hold this truth strongly against all comers, that "humanity," and nothing else, is to be our object. We must make our teaching bear on this, give our best care to the selection of subjects, and the method of teaching, in order to make this teaching more effective. And when I urge the introduction of the sciences at the head of this paper into our course of Education, I wish to make it plain that this is what they ought to be introduced into, and to this they ought to be made to contribute very effectively.

But the problem is not a very easy one, because it seems

\* Delivered at the House of the Society of Arts (by permission of the Council of the Society), on the 22d January 1872.  
† See Dr. Tupney's evidence, Public Schools' Commission Report, vol. ii., p. 512.

to involve the enormous evil of multiplying the subjects of instruction, and so frittering away a boy's time with endless distractions. To learn the Latin and Greek languages alone takes a good many hours a week; if the study of a language is to be of any use, it must be painstaking, exact, and laborious, and it would be a very bad classical education if it did not involve history also, and various kinds of composition, and a good deal also of English literature. For it seems that to acquire literary tastes from Latin and Greek models is too difficult for a vast number of boys. It is not only the unfamiliar language, but the unfamiliar thought—the effort of imagination that is required before they can place themselves in contact with the great minds of classical literature; this is the real difficulty which cannot be got over unless there exists a certain susceptibility and potentiality of culture. It is just the same with ancient history, it is too far off, and many wholly fail to project themselves into it, to be directly benefited by the study of either literature or history. And this renders English literature so useful, as supplying to many what they would otherwise not get at all, and as forming a kind of bridge over to those remote and, in some respects, richer regions. But this implies much additional work, it implies fresh reading, fresh subjects of thought, and much criticism, and this additional work is not one of the least of our difficulties, for it implies more *distractio*.

For let us see what we have come to. If classical education is necessary for all boys, with the literature and history that it implies, in the Latin, Greek, and English languages—and if some mathematics are necessary, and science and art, and French, and German, and Geography,—we are in imminent danger of not giving our boys what is more desirable than all these, *viz.*, *faculty*. We are in danger—and to a considerable extent the danger has been realized in fact—of weakening the intellectual fibre of our boys by distraction. We must admit that we fail if boys leave us without fire, or strength, or solidity, or faculty, call it by what metaphor we will. And the theory of education that we are drifting into has an undoubted tendency, in the case of the majority, to weaken the little strength they have, to burn out all their fire in a number of little jets, to make the material too soft to bear the finer carving tools; in a word, to sacrifice *faculty*.

Such an education levels up, unquestionably. It furnishes mental pabulum for a large percentage of boys, who would otherwise be nearly starved, but it also levels down, and tends to eliminate the close study of detail, and the *drudgery* that is essential in all good work. I cannot too earnestly express to you my conviction of this fact. It does not do justice to the best twenty per cent of our schools. They know more when they leave us, but they have less power of acquiring knowledge.

We are, in fact, trying to hold fast to two theories at once, the old theory of *promise*, and the new theory of *performance*. The old theory was to teach within a limited area of knowledge, with a view of giving faculty in acquiring any other branch of knowledge. But the public now are not content with this. They urge that schools may fail, and often do, to give even faculty, and then their sons get nothing. They say that at any rate the faculty may be tested, and more usefully employed. And so we hear now of University examiners for all the higher schools, who are to see what the results are; and apply to us the same test that has been successfully applied to schools of a lower grade. We must understand the meaning of this movement, and the change in the staple of education we are witnessing. It is to give up, to some extent, the old theory of giving faculty, unless faculty is given equally by a much more varied education, and a constant demand for producible results.

If I did not think this matter one of the very highest importance to us, I should not venture to occupy so much of your time with it. And I have not even yet quite done. I printed a letter on this subject three years ago, addressed to the present Bishop of Exeter, at that time head master of Rugby school, for discussion at one of our masters' meetings at Rugby, which were then of an extremely interesting and valuable kind, and to which I am indebted for some of the remarks made above. Perhaps I may be pardoned for quoting a passage from it.

"The levelling down is due to the distraction caused by a multiplicity of subjects enforced by means of an artificial fame-table, which secures to every one its due minimum. I wish it to be distinctly borne in mind that there are many boys in the school who are learning Latin, Greek, French, German, and English, and doing composition in three or four of these languages; who are learning arithmetic, algebra, and geometry; ancient or English History, and the history of the Bible; and that they are learning some one of three or four branches of natural science, such as chemistry, or mechanics, or botany, or geology, in a short

time to be laid aside in favour of another; and that this is very nearly, though not quite, the case all through the school, and that in general they receive one or more lessons in each of these subjects every week. If boys were but superhuman!

"I am irresistibly reminded of the French method [of fattening domestic fowls. The birds, I understand, are brought in succession before a skilful operator, many times in a day, who, with a tube, squirts a small quantity of previously masticated food down their throats. The birds, it is added, seem to like this treatment, and to thrive on it; and they are ready to be killed in a few weeks.

"We have tried this ornithopachynospadeta; and it has failed. Yet to go back is impossible. We cannot say that we will not teach any of the so-called modern subjects. Equally impossible is it to give them less time. The day is getting longer, the astronomers tell us, but you are aware that it is a lengthening quite inadequate to meet our immediate requirements.

"I shall propose as a remedy for this distraction to adopt, to some extent, the *successes* instead of the *simultaneous* method of instruction. Granted that all these subjects must be taught, will it not be best to omit some in each division of the school? Our education will have an equally broad basis. Abilities of all kinds will not be less recognized than at present. And we shall gain in concentration and force, and I believe also that the variety in the school course will be in a more stimulating form than it is at present.

"But it will be difficult in the actual working to stratify our education satisfactorily; and I confess I am extremely anxious to see the attempt made while you are still with us. *Adieu*! But I can commend to you no greater work than to show us how to stratify English higher education."

In this stratification of studies we began to make some progress in the few months that still remained to Rugby of its great head-master. And this is still the problem before our profession, and proved by our experience to be more urgent than ever. My own belief, however, is, that the problem can only be solved satisfactorily by the exclusion of many subjects from the early course, and bifurcation in the higher. In the early course, as an illustration of my meaning, I should wish to see arithmetic and French and Latin, to be followed by practical geometry and science in the form of lectures in natural history, and perhaps a little practical work in physics, and that then the bifurcation shall commence; the one branch leading to Greek and verse composition, and a mainly literary education, the other to science and mathematics, with Latin and French and English as the literary elements. Neither branch would be encyclopædic; both would be liberal and humane; and between them they would suit the requirements of the great majority of minds. The reformers in education have no programme at present; their apostle has not appeared, but at any rate they ought not to be content till they have got from the Universities an entire recognition of this second branch as a liberal education. The Universities give the crown to all education, and as long as they demand Greek they tie our hands, and condemn us either to exclude science, or to dwarf and cripple it, and to spoil the education of the mass by teaching them too many things. It is only thus that the two courses can fairly compete with one another, when they are on the same level at the Universities, and are taught at the schools by men of equal cultivation.

I have now made it clear what position in a liberal education I conceive ought to be occupied by natural history. It should be common ground for all, taught to young boys before bifurcation has begun, and so taught as to ascertain, develop, and train any scientific powers they may have. These subjects at such a stage cannot be made to give a complete scientific training; it would be pedantic to teach them in strictly scientific order; they must be so taught as to stimulate the thirst for knowledge, to fire the imagination, to open the eyes to the objects and interests of science, and to give a solid body of information which the results of later study may crystallize round. Incidentally, they give the means of teaching the class the orderly arrangement of a subject in their notes, and scrupulous accuracy and clearness of expression.

The range of the subject will depend largely on the teacher; the man is of more importance than his tools. But it will be selected from what the Germans call "Erdkunde," a term with which Huxley has familiarized us. I do not know that there is a better English equivalent for it than natural history, in the widest sense of the words. But it

\* Failed, as I explained elsewhere, to produce results commensurate with the industry of the boys, the perfection of the system, and the ability of the head master. Our honour lists at the Universities were not discreditable at that time.



may be well to sketch the contents of these early lessons on science

An orrery and globe, and a little astronomy, form the natural beginning. Let the boys make the effort involved in realizing the plan of our solar system, and our earth in space with its atmosphere mantling round it, its kinship to the planets, its relations to sun and moon. These, and some of the common phenomena—day and night, summer and winter, eclipses, and the changes of the moon—form the natural and the old well-established introduction to science. They are still subjects of surpassing interest to every successive generation. They take boys on all their sides—memory, imagination, and reason. They show, as nothing else shows, the connexion of cause and consequence. And there is a genuine and deep satisfaction, a real pleasure of the intellect, which boys attain when they first understand the causes of these common great phenomena. They stand thenceforward on a higher platform. The universe presents to them not a mere wonderland but a reign of law. These are the *iterum divina* written in the universe by the finger of God.

Then we pass to the great earth itself, and all its activities; the effects of its still remaining internal heat, its volcanoes and earthquakes, the slow oscillations of level, and the great changes slowly taking place in the familiar outline of the continents and islands, and the proofs still visible of past changes. These things must be well thought out by the class, and illustrated and brought home to them by pictures and specimens. The effect of the attraction of the sun and moon in making tides, and their geological and cosmical action, is a matter that can be to some extent grasped, though so difficult in its complete theory, and is far too important and common a phenomenon to pass by without notice. And then come the complicated consequences of solar heat and light. It is with peculiar interest and pleasure that a boy learns the causes of winds and currents, of trade winds and cyclones, of evaporation and rain, and its distribution on the earth. There is a sense of power obtained by finding out that these great and familiar phenomena are subject to laws, and are not primary facts. And all these are matters, towards which it is only necessary to guide the thoughts of the boys, and they can, with very little help, think them out for themselves. I find it rarely necessary to give a regular explanation of anything, except as a kind of *résumé* of the suggestions thrown out by the class, and successively criticised. Fresh information as to fact must of course be given, when it is seen to be wanted, and not before. And this incidentally gives them a much higher respect for knowledge and the value of facts than they had before. The labours of observers, and mathematicians, and collectors are seen by the class in their true light, as contributing to the store of accurate knowledge in regions more or less accessible to themselves.

The consequences of these activities must then be traced out. And these constitute the principles of Geology. To teach them is not hard, a large stock of pictures, photographs, &c., will be found very useful. We take the work of rain and rivers, their solvent and transporting powers, and straightway the ravine and the waterfall, the rich plain, and the whole river valley, with its wondrous system of drainage, are seen to be the consequences of the familiar forces at work all round us. The work of the sea is easily understood, and behold the map of England is looked at with new eyes, there must be a cause for every bay and headland. The formation of marine deposits, the growth of coral, and Darwin's explanations of the form of coral islands, the ooze of the Atlantic, the work of frost and snow, the glacier and iceberg, the geographical distribution of plants and animals, all are intelligible, and all, if I may so call it, exciting; they excite to further reading and a good deal of thought, they show, moreover, the regions of knowledge, the necessity of chemistry, and meteorology, and astronomy, and zoology is really felt, without being stated in so many words.

And then begins geology proper, a somewhat harder subject to manage, and in which a few scientific-minded boys begin to take the lead. Up to this time, industry, attention, and literary power, general intelligence, in fact, have been the principal qualities required and encouraged, but now there is something more.

One of my former geological pupils made me a water-colour drawing of the Newbold Lias Lime Works in our immediate neighbourhood. It shows a face of rock, some 30 feet high, and 200 feet long, a section of the lower lias. The strata are bent into a curve, though the surface of the ground is level, and there is a small fault running through them. Red sand, containing one or two large syenitic boulders, caps the quarry; the strata themselves are alternations of limestone and the finest laminated shale.

This diagram lasts me for three or four lectures. We begin by finding out what there is to be seen. One sees

the curve, another the stratification, another the sand, while a fourth is much more impressed with the men and their trucks than by the geological features of the sketch. It takes some time before the class really sees all that is put before them in the sketch; the denudation, the unconformability, the alternation of strata, the recent drift sand, the fault, the boulders, and it takes still longer before they are able soundly to reason out and satisfy themselves as to the successive depositions, the upheavals and sinkings, the changes of climate, in a word, the proofs of the prolonged working of the forces they had previously studied. But hurry here is fatal. This is the grand lesson of geology, it took the world some thousands of years to learn, it may well take our classes a fortnight.

Of course, a fluent lecturer could point out all this and more in ten, or possibly in five minutes, and would proceed, perhaps, to the subdivisions of the lias and its ammonite zones. But to do so is, I believe, contrary to the very principles of teaching. Few subjects so well admit of the application of Jacotot's principles, which have been brought before you in this place by Mr. Payne, and in few subjects is teaching by these principles so amply repaid. I think it would be difficult for any member of my class to distinguish between what he had found out, and what he had been told in the study of this section of the lias, he proceeds with a confidence in his powers of comprehension—sometimes destined to a disappointment—which is given by solid knowledge of his own building up. This quarry is the foundation of all our geology. I need scarcely say that very many of the class visit the spot, and severely criticise the drawing, which, from the progress of the quarry, is a little out of date. They bring specimens of all kinds, shale, and fossils, and nodules, and stones from the drift, and your real professional geologist, always a collector, begins to show himself.

This forms the nucleus of knowledge, round which everything has to crystallize. The next step is to discuss the section of our Artesian well. We express publicly our gratitude to our enterprising Board of Health, who bored through 1,145 feet of lias and new red marls, and found salt water at the bottom, that rises to about 200 feet from the surface. Happily a complete section was preserved—the only useful result of the boring. From this and the ordnance map we slowly make out the dip of the strata here, and the strange-looking geological map of England is now no longer a mystery. These bands of colour are the edges of slightly inclined stratified systems. The study of the Warwickshire coalfield, which is bounded by faults, gives us another capital study. The drawing of sections through various parts of England is an excellent exercise, and is the only way to learn the geological map.

We then take to rock specimens and fossils; and here it is advisable to introduce a little of the history of geology; and to tell the class something of William Smith and Cuvier, and their respective discoveries. And whatever time remains is spent in going through the strata in chronological order, with the aid of a museum.

It may seem to some that the amount of positive knowledge gained is too little, and indeed it is not much, not as much as would be gained by half the time spent in learning and being examined on somebody's advanced text-book. But from the one system the boy emerges hungry for more knowledge, and his own reading will supply his wants; he emerges with a clear understanding how science grows, and what it is, and has a framework in which he can fit all knowledge he subsequently acquires; while from the other he comes out—perhaps some of my hearers know how he comes out.

I know of no single book which contains all these subjects. The teacher, at any rate, must draw his knowledge from many books, and from real, personal knowledge of his subject. Methods of teaching are very important, but the teacher is of far more importance, and no teaching of these or any other subject is likely to be worth much unless the teacher is thoroughly master of his work, has made it his own by viewing it in various lights, and is independent of any text-book, or any order of viewing nature. He cannot be too discursive in his reading or varied in his attainments, and if he is further able to be prosecuting some original work, however humble, in which his pupils can assist him, they will learn more of the true scientific spirit by contagion than they will gather from the most eloquent lectures.

I have spent enough of your time now, and do not intend to say anything about botany. I have, in fact, nothing to say about it that I have not said in one of the Essays on a Liberal Education that appeared some years ago. I will only repeat one request to all who wish to see how Botany ought to be taught; order Le Maout's "*Leçons Élémentaires de Botanique, fondées sur l'analyse de 50 Plantes Vulgaires.*" (16 francs.) And I am glad to be able to announce that an English work on similar principles, adapted to English

flowers, is forthcoming in the "Monthly Packet," beginning with the number for next July.

I do not see any reason for doubting that these subjects are the best for early education, say from the ages of twelve to fourteen. At such an age, chemistry or physics cannot be understood, except in the rarest cases. I know that Faraday expressed an opposite opinion. But Faraday loved the children, and never examined them. These subjects, especially the geological course, as I have explained it, give a solid foundation of familiar facts, which form the basis of subsequent scientific knowledge. And they attract the strongest and finest minds, which is not found to be the case with all branches of science.

It may be urged that this teaching cannot be *thorough*,—that boys will be brought in contact with chemistry, physics, mechanics, mathematics, at an age when they cannot understand them, and the result will be, to turn them out capable of talking about a great many things, and knowing theories about a great many things, but without the rigorous training necessary to enable them to judge of these theories.

This is, of course, partly true. But it is no objection. The logical order of ideas is not the educational order. A boy learns to read, and make out the meaning of a story-book before he learns grammar, which might be said to precede logically; he reasons before he can learn logic; and so he has to learn a thousand things by experience and observation and reading and conversation, which form the material out of which science grows. The teaching is thorough so far as it goes, and it is delusive to suppose that the teaching of mechanics or physics can be made exhaustively thorough to a boy. He apprehends only by comparison of one thing with another; and where experiment takes him out of the range of his experience, there his conclusions are not his own, but his teacher's. These subjects, which may be put aside as mere scientific information, have a double value, stimulative and intellectual, that no one who has not tried them can well estimate. They would plainly be incomplete by themselves, they do not admit, taught in this manner, of the careful study of detail, the minute and painstaking work and *drudgery*, that makes every science so valuable as an instrument of education. But these subjects claim to enter into the schemes of literary and scientific education, to form a common ground between them, to be science to the men of literature, and literature to the men of science.

The most important question that arises out of the suggestions I have made is this: Is education in science—by which, of course, I mean a real training in chemistry and physics—incompatible with the existing classical education?

As far as my experience goes, it is in the later years of school life. There are always some boys of sufficient general ability to do pretty well, even to the end of their school course, in all the subjects, and it might be said that these, at any rate, gain from the extension of their education. But I have good grounds for thinking that many of them lose strength, as I have explained before, and go up to the University rather wearied, and with a cessation of growth, at what has been called an *stagnation*, or *wit-stand*. There are many more who can do one or the other well, but from trying to do both well, fail in both. I think it will be admitted that some of these are sufferers. Others are large gainers, finding in science the stimulus and intellectual food they need, and even making progress in classics far more satisfactorily than they would if they devoted themselves to classics. If our Rugby experience is worth anything, it proves this—that there exists a considerable proportion of boys who, after the age of sixteen or thereabouts, gain far more from the study of mathematics and science than they do from language. In literature and history they can hold their own against the best scholars, and continue to derive much culture from these parts of their classical work, but most of their work in language is unproductive. It is equally undeniable, on the other side, that there are some boys whose *forte* is language, and whose minds seem hermetically sealed against scientific ideas. After a time, I think they ought to be left to cultivate their own genius on the side on which it exists. We must respect facts.

The problem, then, of bifurcation, not only in schools but in universities, is distinctly involved in the subject before us. If the universities do not admit on an entire equality the one branch and the other, the modern or scientific sides of our schools will consist of boys not going to the universities, and will be a sort of refuge for failures, or for boys whose education is to stop at an early age. Nor, on the other hand, will it be enough for the universities to admit students of both classes, unless our great schools do the same. It may be urged, let some schools admit one and some the other class, and let boys go to one school or to the other, according to their taste. But the taste is not of ten ascertained till a boy is sixteen, and up to that time

the education ought to be nearly the same; and every one knows how impossible it would be, in practice, to turn a boy out of his school at sixteen. I know that our Rugby boys would rather live on the bread and water of grammar than leave at such an age.

Further, the leaving examinations must be organised with a view to bifurcation and not encyclopædism. This is a matter of immediate importance.

Such, then, is the problem before reformers in education,—to modify our existing schemes and institutions till they admit of boys obtaining a groundwork of education, fitting them for progress equally in literature and science, and in itself, so far as it goes, sound, stimulating, and refining, till they admit of boys continuing the study of literature and history simultaneously, while some of them are concentrating themselves on the study of language, and others on that of science; and till they admit of boys of both these classes being equally welcome at all our universities.

## 2.

**THE OBSTACLES TO SCIENCE TEACHING IN SCHOOLS.**—A Paper read before the British Association at Edinburgh, Tuesday, August 8th, 1871. By the Rev. W. TUCKWELL, M.A., late Fellow of New College, Oxford, and Head Master of Taunton College School.

Seven years have passed since the first Public School Commission revealed to us the fact, that from the higher English education natural science was practically excluded, that while in the preceding generations science had extended her empire, explored and annexed new provinces, and made them accessible to all men, education had become narrower than it was three centuries ago. A statement so startling, and made on such authority, could not but bear fruit. The schoolmasters felt the reproach; the press urged reform, full discussion was facilitated by this association, and a most valuable report was made public with its authority, till, in 1868, a second School Commission felt itself able to declare that the majority of the teachers whom it had examined had accepted natural science as part of their school work. But this announcement became less cheering when the evidence supporting it was mastered. It was found that in the opinion of many head masters the needs of the new subject were fully met by the visits of an occasional lecturer, and by the optional attendance of the boys, or that it was delegated to some assistant of no great mark, who, in addition to the subjects which he professed to know, was expected to get up and to teach without thoroughness or aptitude some one branch of natural science which it pleased him to select; that chemistry was taught without a laboratory; mechanics without models or apparatus; physiology without a skeleton, a scalpel, or a microscope. Where this commenced, school science has naturally languished; hesitation and misgiving have marked from the first the utterances of the masters who introduced it. In some cases it has been condemned and dropped, in many others it has made no progress, and I believe that at the present moment the first-class English schools which teach it fairly and systematically, which honour it with separate masters and with due appliances, and which accord to it its proper time and worthy rank in relation to other subjects taught, can be counted on the fingers of one hand.

I do not think that we can bestow much blame on the head masters. They have inherited, we must remember, an order of tuition some hundred years old, fortified with unbroken venerable traditions, looked upon for ages past as the supreme instrument and test of intellectual power, whole and complete in itself, supported by immense experience, worked by tried machinery. Into the midst of their well-mapped, well-proved system is thrust a strange and foreign subject, comprising many branches and demanding multifold appliances, whose value as a mental weapon they have had no means of testing. They are called upon to surrender to this a portion of the time which already seems too short for other work, and to inaugurate a department of school labour over which they can exercise no sort of supervision or control. They ask for guidance in the new arrangements which they are called upon to form, whether any one department is educationally fundamental to the rest; whether sciences of experiment should precede or follow those of observation; what portions of the old course are to be abandoned; how far the Universities, which in many cases stamp the practical value of their work, will recognise such abandonment. They look round for accredited teachers and approved text-books, for enlightenment as to the amount of apparatus and its cost, for details of teaching and of testing, and they look in vain.

They must fall back upon their moral consciousness, for no help is tendered to them from without. I place this helplessness of head-masters first on the list of obstacles which we have to chronicle, and I plead, for the moment, in their behalf almost more than in behalf of science. For their attitude is frank and cordial, they are prepared, as a body, to meet the demands of the scientific public loyally and with all their might. If those who are pressing modern subjects on them will entertain their just appeal, and try to understand their difficulties, they will prove the best auxiliaries science can hope to gain, for they will bring to this new department of their work the same energy and wisdom, the same self-sacrificing impartial zeal, which have already won for them the deserved esteem of the community, but if we fail to work in harmony with them, their want of sympathy and interest will be simply fatal to our schemes.

The fact that our head-masters, mainly appointed to their posts because of excellence in other subjects, cannot themselves teach science, brings into prominence the next great difficulty with which we have to deal, namely, the training and appointment of science masters. In Germany, the candidate for a school-teachership, already bristling with certificates and testimonials, passes a strict examination in his general culture, in his chosen subject, above all in his practical power of imparting knowledge and in managing large classes of boys, nor, however successful under this ordeal, can he be appointed to any mastership, high or low, until he has spent a "trial-year" in the practice of teaching and of governing at some large school under able superintendence. In England, an university degree is the sole and single test, and though a distinguished position in the honour list is undoubted evidence of high intelligence and extensive knowledge, yet that without which these will be useless in his profession, the power of infusing intelligence and communicating knowledge, clearness of delivery, voice, manner, dexterity of manual illustration, ability to attract and to sustain attention—in a word, *teaching power*—is not only not attested, but is in no way provided for or ensured, and thus we are driven to fear that of the few University men whom the present slight demand for masters has induced to graduate high in science, with a view to scholastic life, a small proportion only is qualified to make it attract and flourish in the class-room.

Further, were the supply of science masters unlimited and unexceptionable, their cost is another heavy item for our consideration. They involve in every case entirely fresh outlay, no modification of the existing staff is possible, no master can be detached from other work, or have science tacked on to his own, without sore and manifest injustice on all sides. Yet the first condition of scientific, as of other teaching, is, obviously, the teacher. He must be a man thorough in his special knowledge, and, if his special knowledge is to stick, of the widest general culture. He must not spend all his time in teaching, but must have leisure to prepare his subjects and experiments. He must possess or he must acquire the delicate art of handling many pupils, the force of manner which attracts them, the enthusiasm which puts and keeps them *en rapport* with him; the insight which reads their minds, the tact which can preserve discipline without checking inquiry; the art of adjusting experiment to information, of glancing at that which is obvious, of dwelling on that which is difficult; and, possessing all this and more, he must be well and highly paid. It is fortunate that we should have the opportunity to urge this point at a moment when all the school endowments in the country are melting in the crucible of a school commission. Its commissioners, like the witches in Macbeth, have thrown strange things into their cauldron, may their incantations, like those of Heate and her sisters, bring to birth a line of kings.

"Who two-fold balls and double sceptres carry,"

teachers who shall rule in years to come over the empire of things as well as words, over the operations and the phenomena of nature as well as over the history and the workings of the human mind.

If the cost of the teacher can be got over, the remaining unavoidable expense is trifling. It ought to be more widely known for how very small a sum sufficient apparatus can be obtained to teach natural history and experimental science. A laboratory can be fitted up for 20 boys at a cost of little more than 20*l.*; while each boy's private stock of glass and test solutions need not cost him more than 8*s.* per annum. Botanical flower-trays, containing 18 bottles, may be bought for half-a-crown, electrometers, telescopes, polariscopes, models of pumps, and pulleys, can be made, after a little instruction, by the boys themselves, who will learn in their construction far more of the principles which they involve than could ever be instilled into their minds by the choicest produce of the shops. And this leads to one word upon the immense value of workshops in a school, not only as bearing upon practical science, but as distinctly fostering mental growth. The class-room is not the only field of culture; nor need bodily activity reign undisputed

over the many hours of leisure. Excessive athleticism is one amongst many causes which are threatening to paralyse University life, and during the months when cricket is impossible, or the hours in which it is superfluous, the forge, the turning-lathe, the sculpture-room, the photographic shed come in not only as preventatives against listlessness and mischief, but as revealing to the boys that they have minds as well as muscles, as imperceptible development of taste and the exercise of unlabouring discipline. And what is true of workshops applies also to those other charming accessories of science teaching, museums, botanic gardens, natural history societies. Let it only be remembered that in all these things the hand of the master must guide and not supplant the labour of the boys themselves, that their growth must be organic, springing naturally from scientific work to meet the wants that work suggests, that their creation and their sustenance by the workers is at once a condition of their vitality, and an elevation of their character from playthings into educators.

The action of the Universities upon science teaching is a question of the deepest moment. For good or evil their influence in many schools is paramount. Possessing supreme educational prestige, and dispensing enormous educational rewards, their power is absolute to determine the grooves in which school work shall run. How their influence has been exerted in the past no one requires to be told; those least familiar with their politics cannot but be aware how great a change has passed over them of late. We may not venture to assume, but we shall all rejoice to learn, that in their future legislation, more especially in the important change to which they have been of late invited by the Committee of Head Masters, they will accept suggestions and even invite assistance from those whom science may depute to watch her interests and to urge her claims.

I pass to a grave item in our catalogue of difficulties. Granting that scientific teaching is essential to a perfect education, the anxious question meets us, how is it to be inserted in the curriculum of an established school? We are told that to meet the demands of University competition the highest pressure is already put upon the time and brains of boys, and that if four hours a week are to be accepted as the minimum demand of science, classical work must suffer. And in order to solve this problem, some well-known schools have instituted a system of bifurcation, separating their senior boys into two departments, whereof one learns classics only, the other learns modern subjects, as they are called, quite or almost exclusively. Of course such a separative process does not really help us. If linguistic training is bad without the rationalising aid of scientific study, no less is exclusive science bad, when divorced from the refining society of literature and philology, and an admission that certain institutions stunt particular faculties is oddly followed by a device which causes each to work unchecked. The difficulty must be met fairly, and on premises which scholars as well as savans can understand. It must be met by asking whether, in purely classical schools, no time is wasted, why it is that in the lower forms a boy takes years to master what a clever tutor teaches in a few months at home: why the weapon of analysis, which opens every other chamber of human knowledge, should be discarded in the case of scholarship alone, whether unattractiveness is an inherent vice in Greek and Latin only, or whether, if judicious method wakens pleasure and keeps alive attention, that of itself is not economy of time, whether, lastly, the day has not arrived when Greek and Latin verse-making has not, like many other sweet and graceful things, passed from vitality to survivalism, and may not be allowed to disappear. Shall I shock the taste of any whom I address, if, after having written some thousand Greek or Latin verses in my own school days, I pronounce them waste of time, and protest against them altogether? They do not cultivate the taste, for reverent enjoyment of the beauty of an author's thoughts is excluded by the labour necessary for a feeble imitation of his diction. They do not train the intellect, for all chance of analysing words and sentences is lost in the necessity of wedging lifeless blocks into the forms of a Hexameter or Iambic verse. Except in the case of those in whom the sacred faculty is innate, and whose genius would find fitter scope in exploring the poetical resources of their own literature and language, they constitute a mere mechanical process, exercising hardly more effect on taste, refinement, imagination, than the compilation of a Chinese puzzle. Their elimination from our school systems will be clear gain in itself, and will set free at once a much larger time than is demanded for the prosecution of natural science.

What that time should be I have already ventured from my own experience to hint. The question may continue open till it shall finally settle itself in the gradual adjustment of science to other subjects, but we shall probably all feel that we cannot demand for it at starting less than four hours a week. Of course, also, if it is to be fairly started, it must be compulsory on all the boys; it must involve no

extra charge beyond the actual waste of materials in its experimental branches, it must take rank not as subordinate or alternative to what are called the main subjects of a school, but as being itself one of those main subjects, affecting in due proportion the school marks of the half-year, liberated from all those slight but telling signs of inferiority which prescription is skilful to inflict. Nor must the teacher forget that the victory of science over prepossession, and so its rapid establishment as a settled branch of teaching in the future, depends in a great measure upon him. It will have been introduced and accepted on *a priori* grounds; accordingly as it is borne in mind that things, not words, are its subject-matter—that observation and reasoning, not memory and imagination, are its field of work—it will approve itself experimentally, and stand by its results.

The character of those results I cannot for a moment doubt. Its practical value, its endless resources, its cultivation of those faculties which no other discipline can reach, will assert for it at once its place as an essential branch of youthful culture. Rooted and flourishing in the schools, it will overflow into their surrounding neighbourhood. It will give birth to local museums, provincial lectures, science classes. It will lay hold of the tradesmen of our town and counteract the tendency which their life exerts to the exclusive worship of material prosperity. It will light up the minds of our women, too often doomed to pass through the years of so-called education with accomplishments exclusively mechanical, and with intellects absolutely untrained. It will invade the intelligence of our clergy, hostile to its conclusions through ignorance, not through conviction, and will teach them how to bridge, by sympathetic knowledge and by common intellectual interests, the gulf which widens day by day between themselves and the community; far from diluting their religious feeling or undermining their religious faith, it will place on broader grounds and sink in deeper foundations their knowledge and their love of God.

I have detained you long enough, and yet I have but scratched the surface of this great subject. But the summary of what I have to say is this: that our schools, in their readiness to establish science, must be aided from without. All questions of funds, of apparatus, of teachers, of selected text books, of co-ordinated subjects, of University influence, of united action, come to the same point at last. We must have central leadership, at once commanding and intelligent, if the introduction of science into our schools is to be simultaneous and effective. The question has passed out of the realm of general discussion, it is ripe, if ever question was, for detailed and practical settlement. There must be within this association, there must be within this room, men qualified in all respects to appreciate the nature of our difficulties, to formulate rules for our guidance, to press our pecuniary needs on those who are for a time the bursars of our educational endowments, to watch and influence the action of the Universities, as on other points, so especially in the projected "leaving examinations." To them I confidently appeal. I appeal on behalf of countless schools, which, ready to admit reform, are helpless to initiate it. I appeal on behalf of those few schools which *have* initiated it, and are endeavouring courageously and honestly, but with little of useful concert, with much of wasted force, to work it out. Let it once be announced to the educational community that a committee of distinguished men, having at heart not merely scientific interests, but the interests of the Universities and schools, has been armed by this association to counsel, to assist, to recommend and to accredit, to harmonise and to combine, to become, in short, the recognised representatives and controllers of scientific education, and they will not lack grateful clients or attain inadequate results. If science is to flourish in the land, preliminary knowledge and training, bestowed with care upon our boyhood, must leave our manhood free for original research. If our English education is to be abreast of continental teaching, one half of our mental faculties must no longer be suffered to lie dormant. To have removed this great reproach, and to have helped this great reform, will be an achievement worthy to take high rank even amongst those splendid services to science and to the community which give glory to the British Association.

## 3.

ON THE TEACHING OF PHYSICS. By Professor G. C. FOSTER, F.R.S. [Extracted from the "Educational Times," Feb. 1, 1872.]

I do not suppose that it is needful for me to take up any part of your time this evening in trying to prove how desirable it is that the study of Physics should be introduced into schools as part of the regular school-work. If I have rightly understood the task that has been entrusted to me

by the Council, it is not that I should advocate the teaching of Physics in schools, but that I should point out, as far as I may be able, how it can best be taught. But, although probably it may be safely taken for granted that all here are agreed that the science of Physics is an important and valuable subject of study, and one which may with advantage occupy some considerable share of the attention of young people during their school course, it will nevertheless, I think, be useful, before attempting to discuss the way in which the subject may be most successfully taught, to give a few moments to the consideration of what the precise advantages are which may reasonably be looked for, as resulting from the study of it; for it is plain that the first step towards deciding what is the best course to adopt in order to attain any object, is to get a clear idea of what it is we want to attain. Moreover, if my judgment with respect to the reasons why Physics is deserving of general study should unfortunately differ from that of any of my audience, the statement of my own opinions on the point will, I trust, help to show that what I may have to say with regard to the mode of studying it is justifiable from my own point of view.

First, then, I think it may be asserted that whatever useful results proceed from an early study of Physics, are due much more to the mental discipline which is needful for the successful prosecution of the study than to the value, for practical purposes, of the facts stored up in the memory. Indeed, even in the case of the comparatively small number whose special occupation in after life consists in the practical application of physical principles, it is certain—so far as the two things can exist independently, and can be estimated separately—that a scientific habit of mind is of far more value than a knowledge of scientific facts, in proof of which it is sufficient to call to mind that ascertained facts can nearly always be found recorded in books of reference, while only a trained intellect can interpret the lessons conveyed by any new combination of them.

Nevertheless, when we are considering the way in which Physics should be taught, it is essential to remember that the instrument of intellectual discipline, which this study affords, consists in processes of reasoning whose only basis is our knowledge of individual concrete facts, and hence that the teaching of facts must form a great part of our occupation, even when our principal aim is, not to stock the memory with them, but to train the mind by the study of the methods by which they have been demonstrated, and of the inferences that can be drawn from them.

But the relation which it is desirable to maintain between the two essential parts of the teaching of Physics—that is to say, the relative prominence that should be given to what we may roughly call the teaching of facts, and the teaching of theories—will probably become more apparent if we next inquire as to the precise nature of the mental training upon which the educational value of the study of science in general, and more particularly of Physics, depends. Here, however, notwithstanding the importance of the subject, I fear I shall not succeed in being very systematic, or be able to do more than express very imperfectly the ideas which have struck me as being chiefly worthy of consideration in reference to it. For the question is one of great difficulty and complexity—one in relation to which we have rather to estimate tendencies than definite clearly marked results. We do not, for example, find, as a matter of fact, that scientific men, as a class, possess one invariable set of mental characteristics, or that the intellectual differences between them—even when we compare together those who cultivate the same branch of science—consists in the varying degree in which they possess any special habit of mind. But yet it is unmistakably true that there is a considerable difference between the habitual mental attitude of men of science, and that of those who do not usually occupy themselves with scientific pursuits, although it is much easier to recognise the existence of this difference than to say with precision wherein it consists. An additional difficulty, moreover, attending any attempt to estimate the educational value of scientific studies arises from the fact, that the effect of a systematic and long-continued course of training in any scientific subject, except pure mathematics, has never hitherto been tried in this country, so that our scientific men exhibit the results of individual predilections, and what we must call accidental circumstances, rather than the effects of a special system of education. An "educated" man, in the technical sense, has been hitherto, of necessity, a man educated either by means of the so-called "classical" studies, or of pure mathematics. Hence, in trying to put into as definite language as possible an estimate of the educational advantages derivable from the study of Physics, I shall be obliged in the main to be guided by what seems to be probable *a priori*, in view of the nature of the study itself. Proceeding in this way, and without attempting to treat the matter exhaustively, I venture to draw your attention to the following points.

One most important effect, which this study can hardly fail to promote, is the habit of taking general and more or less abstract views of whatever subject is under discussion, whereby I do not at all mean the habit of being content with vague notions, or of being inattentive to details, but rather the contrary habit of taking account of the general condition which results from the co-existence of all the partial conditions of a phenomenon, instead of concentrating the attention upon one or more of them to the exclusion of the rest. The habit of mind that I am referring to may perhaps be described as the generalization and universal application of the notion of a *resultant*, a notion which, at first purely geometrical and confined to direction and velocity, acquires a physical meaning in dynamics, and re-appears over and over again in all departments of Physics, whenever we have to deal with the superposition of actions or effects. This habit, applied to questions of politics or of social economy, leads men, instead of wishing to see their own views at once triumphant over those of their opponents, to inquire what part of the truth it is which appears so plainly to others as to obscure what is so evident to themselves, but unfortunately, while in Physics the test of experiment can in general be readily applied, to show whether we have rightly estimated the resultant tendency, it is far less easy to check our conclusions by a similar appeal in the case of the more complex problems of social existence.

Another closely allied mental habit, namely, that of distinguishing among the details, which a particular phenomenon may present, those which are essential to its nature, from those which are merely the accidents of a special case, can hardly fail to be developed by the frequent exercise which the study of Physics affords in tracing the operation of a general law throughout a multitude of different phenomena, many of which at first sight do not seem to present any common element. The same effect is no doubt produced, in a greater or less degree, by the study of any science, but none tends to produce it to the same extent as the study of Physics, since in no other department of knowledge do we meet with ascertained laws at once as definite and as various as those of Physics.

The strict quantitative character of the principal physical laws, moreover, renders the study of Physics a very valuable discipline in the strict and careful use of language. In fact, it would be difficult to conceive anything which tends more directly to counteract the habit of using words without attaching definite meanings to them, than practice in the description and explanation of physical phenomena, or in the solution of well-chosen physical problems, where every word used loosely or ambiguously is almost sure to lead, before long, to manifest confusion or contradiction. Again, the habit—quite as much moral as intellectual—of taking care not only that our language shall agree accurately with our meaning, but also that our meaning shall correspond, as closely as we can make it, with the truth of nature—or, in other words, that our records of observation shall be strictly faithful accounts of what has been witnessed—is absolutely essential for the successful prosecution of original investigations not only in Physics, but in all departments of science; and a satisfactory method of teaching will make this necessity as apparent to the student of the elements of Physics as to the original inquirer.

The only other point of which I want to speak specially, in connexion with the educational effects of the study of Physics, is its value when considered as a means of *educating the judgment*, or the faculty of drawing true conclusions from the direct observations of our senses. Probably the habit of making minute and accurate observations is likely to be cultivated to even a greater degree by the study of some branches of biological science than by that of Physics, but probably no science affords so good a discipline as Physics in the right interpretation of our observations, or, in other words, in judging of the true nature of their object. For in no other science is it possible to draw such definite conclusions, or to test them so rigorously by experiment, as it is in this.

If we now try to include all that has been said respecting the study of Physics, considered as a mental discipline, under a single statement, we may put it into some such form as the following—This study tends specially to *develop the power of thinking definitely and correctly*; and this general statement is perhaps better adapted to serve as a guide in the discussion of the method of teaching Physics than the individual illustrations of it that I have tried to give previously. A word or two upon the relation between science and other studies, considered as instruments of mental education, may, however, still be useful.

The power of thinking in general, or mere mental activity, is, like bodily activity, probably more a matter of constitution than of education, and any pursuit which furnishes the mind with ideas seems as likely to stimulate it as any

other. The function of education, it seems to me, is not so much to excite increased mental activity as to discipline that which exists, and direct it to the attainment of profitable ends. And the means available for this purpose may be broadly distinguished as two—first, the power of thinking rightly may be cultivated by the study of the greatest and best thoughts of other men, which is the classical or literary method of education; or, secondly, it may be cultivated by actual practice in cases where the truth or falsehood of our thoughts can be unerringly tested, and this is the scientific method of education. Whether, or to what extent, or in what cases, one of these methods is preferable to the other, are questions not now before us.

Taking, then, as our fundamental principle, that Physics is to be so taught as to make it furnish a series of exercises in thinking correctly, it is clear that this implies that it must be so taught as to make the learners *think about physical questions*, and from this it further follows that the first object of the teacher must be to impart clear physical ideas, which can be made the subject of thought. This, however, can only be done by making the pupils get at any rate some part of their knowledge of physical facts through their own personal observation of phenomena. Not only is the knowledge which a boy gets from what he does and sees for himself, far more distinctly impressed upon his memory than that derived from what is told or shown him by another, but it is altogether of a more ultimate and personal kind, he feels himself on terms of familiarity with it, so that he can turn it about and apply it to any use that suggests itself, instead of being, as is often the case with what he knows only on the authority of others, afraid to meddle with it lest he should spoil it, or get it wrong side up and be unable to put it right again. In fact, personal observation and experience naturally produce living ideas, whereas our attempts to communicate knowledge by mere statements and descriptions often result in a form of words being committed to memory quite apart from the acquisition of any corresponding ideas by the mind. Moreover, the mere fact of the application of the mind in making observations and experiments ensures its being actively directed to the matter in hand, while listening to authoritative statements is apt to produce a merely passive and receptive state of mind that is by no means favourable to independent thought.

If these views are correct, it follows that a teacher of Physics should not endeavour chiefly to make his pupils receive and remember his statements of facts, but that he should try, as far as he possibly can, to make them learn the facts for themselves, as matters within their own experience. And it is also evident that the facts to which attention should be directed are not what may be called the curiosities of science, about which little more is as yet known than their mere existence, but the facts which have been of most importance, as serving for the foundation of other knowledge, and whose relation to other facts is therefore most fully known. And here it may be noted, that facts which can be brought into relation with what is familiarly known only by processes of mathematical reasoning that are beyond the reach of beginners, are, for the purposes of elementary instruction, to be classed among the curiosities, the value of physical knowledge for such purposes depends entirely upon the completeness with which it can be understood. We should therefore make the smallest possible demands upon the faith of our pupils, and shun as much as possible all necessity for using such phrases as, "It can be shown," "It may be proved," &c. Our object should be, not to try to convince them of the truth of physical principles, but to help them to convince themselves by reasoning upon the facts they have themselves observed. Hence, in choosing practically the particular subjects to be included in the course of instruction, the two following considerations must be kept in mind—first, the greater or less extent to which the fundamental facts of the several departments of Physics can be demonstrated by such experiments as can be performed by the pupils themselves; and secondly, the extent to which the pupils are able to follow the processes of mathematical reasoning needed for the discussion of the experimental results. The first of these considerations is mainly a question of the amount of time and money that can be devoted to the study of Physics; and the second also is to a great extent a question of time, for when we can afford to go slowly enough, it is possible, even for pupils whose knowledge of mathematical technicalities is very small, to make very considerable progress.

It remains for me to attempt the most difficult part of my task—namely, to contribute something towards the application, in the actual practice of teaching Physics, of the principles which the general consideration of the matter seems to show are those which ought to be kept in view. But I do so with great diffidence; for never having had experience in teaching Physics under exactly the conditions

which obtain in schools, I cannot but feel that many of my audience would be able to speak upon this part of my subject with greater authority than I can claim. I must, therefore, ask that what I may say upon it may be considered in the light of suggestions merely, and as liable to correction from those who have a fuller knowledge of the conditions of the problem.

Probably the first question which a schoolmaster, who wishes to introduce the teaching of Physics into his school, asks himself, is, in most cases, how much and what kind of apparatus will be wanted? And this question, serious enough when it is only intended that the master should show experiments to the boys, becomes much more important, if the method I have advocated, of letting the boys make most of the experiments for themselves, is to be adopted.

If a whole class of boys are to perform the same experiments at the same time, it is of course necessary to have a sufficient stock of apparatus to be able to give to every two, or to every three boys at most, the things needed for making each experiment. This, however, it would probably, in most cases, be impossible to do, or would be possible only by restricting within very narrow limits the range of work given to the boys. On the other hand, by adopting the system practised, I believe, in some of the American laboratories, the necessity for multiplying very greatly apparatus of the same kind is to a great extent got rid of. Upon this plan, the boys working at the same time are engaged upon different experiments, and, therefore, use different apparatus. Previous to each lesson each working place is supplied with the apparatus wanted for some particular experiment, and the boys, as they come into the room, are told which place they are to go to for that lesson, the place of each batch of two or three boys being changed from lesson to lesson, till all the boys have made all the experiments provided. These may then be replaced by a new set, which again will remain permanent until all the boys have gone through them. The advantage of making the boys circulate instead of the apparatus is obvious.

It is clear that, by this method of working, a given outlay on apparatus will suffice for a much greater variety of experiments than it would provide for upon the first-mentioned method, according to which all the pupils simultaneously make the same experiment. On the other hand, it greatly increases the labour of teaching a given number of boys, for it excludes the possibility of collective class instruction in the details of each experiment. To make it practicable at all, when one master has to deal with any considerable number of pupils, it would probably be needful to give to each group minute written or printed instructions as to the precautions and manipulatory details required for making the experiments assigned to them. Broadly stated, the difference between these two methods of instruction may be said to be, that the first involves the greater expenditure on apparatus, and the second on teaching power. The choice between them must be decided according to the special circumstances of individual schools.

But whatever arrangements may be adopted for the actual work of the boys, it will be found to be a very useful rule, with regard to the expenditure for apparatus, to confine it almost exclusively to the purchase of what may be called scientific tools, that is, apparatus of general utility, such as balances, air-pumps, thermometers, galvanic cells, galvanometers, &c., as distinguished from apparatus contrived to show only special experiments, like most of the things that figure in instrument makers' catalogues. For it should be remembered that, when a result is to be witnessed only by two or three observers close at hand, there is no need for producing it upon a large scale, and the expensive contrivances of the instrument maker may generally be replaced by less elegant but equally serviceable substitutes put together from such things as are usually accessible. And this leads me to remark parenthetically, that a master who wishes to teach experimental physics with success must not be above learning how to solder, to use a file, to drill holes and cut screws, and to use joiners' tools with such skill as he can acquire, nor must he neglect the simpler arts of boring corks and bending and sealing glass tubes. Some kind of workshop, however modest, is a necessary adjunct of a physical laboratory.

Even more important than a judicious choice of apparatus is that of the experiments to be made with them when they are bought. With regard to this point, my own experience leads me to think that merely qualitative experiments are of little use in practical instruction; they do not afford sufficient occupation for either hands or head, and are, therefore, apt to degenerate into play. Simple physical measurements, on the contrary, give plenty to do, and yield far more instruction. For instance, if a boy is told to form an image of a flame upon a screen by means of a convex lens, he will have finished the experiment in less than two minutes, and want to know what he is to do next, but if he is told to measure the distances between flame and lens, and between lens and screen, at which sharp images can be formed, for half a dozen prescribed positions of the screen, and also to measure the size of the image in each case, he has got work enough to keep him attentively occupied for a full hour, and at the end of it he has acquired data from which, with a little guidance, he cannot help deducing the principal laws of the action of lenses.

With a little thought there can be no difficulty in finding abundance of easy and instructive measurements of this kind in connexion with each of the main departments of Physics. But in order to make sure that the pupils know clearly what they are intended to do, and also to train them in methodical habits of working, it will probably be found useful to give them, with each exercise that is set them, with each exercise that is set them, a blank scheme or schedule, to be filled up with the results of their measurements, and with whatever further results it is intended that they should deduce by calculation from these. For example, in the case of the experiment referred to above, the schedule to be filled up might be as follows:—\*

Distances from					Size of Image.		$\frac{P}{A_1 + B_1}$	$\frac{Q}{A_2 + B_2}$	$\frac{P}{P+Q}$	$\frac{I}{I_1}$	$\frac{P}{Q}$
Lamp to Screen = L	Lamp to Lens = A <sub>1</sub>	Lens to Screen = B <sub>1</sub>	Lamp to Lens = A <sub>2</sub>	Lens to Screen = B <sub>2</sub>	I <sub>1</sub>	I <sub>2</sub>					

The first column of this table would be filled up beforehand with the distances to be employed, and the actual measurements would be entered in the next six columns, headed respectively A<sub>1</sub>, B<sub>1</sub>, A<sub>2</sub>, B<sub>2</sub>, I<sub>1</sub>, I<sub>2</sub>. The other columns would be filled up by calculation from the experimental results in the way indicated by the formulae at the top, and the degree of accuracy obtained would be indicated by the greater or less constancy of the values deduced for the principal focal length of the lens, entered in the column headed F, and by the amount of agreement between the numbers in the last two columns. As a general rule, it should be required that all the measurements should be finished before the calculations are begun.

Although it appears to me to be almost, if not quite, a matter of necessity that some amount of practical work, of which the above may serve as an example, should form part of the course of instruction in Physics, it does not seem to me possible to say, with any approach to precision, how much work of this kind is essential; all that can be said upon this point is, the more of such work the better, for there is no likelihood of what is found to be the practicable maximum being ever as much as is desirable. On the other hand, I think it of the utmost importance that the attempt

to introduce practical teaching should not be given up in despair on account of the difficulty or impossibility of introducing it, otherwise than on a very limited scale. For boys who have gone carefully and systematically through even only one or two sets of experiments, are far better able than they were before to understand and profit by experiments which they see performed by their teacher, or of which they merely read or hear descriptions. They have, as it were, become intimately acquainted with one member of a family, and, therefore, do not feel that any of the rest are entirely strangers to them.

\* The letters and formulae at the head of the several columns of this table are meant for the guidance of the teacher rather than for that of the pupils, to whom it is easy to explain the calculations they are desired to make without ever mentioning a general formulae. But one of the incidental though not least important results of making boys go through the calculations needed for comparing the results of simple measurements of this kind, is the insight it gives them into the meaning and use of general algebraical formulae. When they have been made to see that a general relation holds good with regard to the numbers resulting from each of several similar measurements, they begin to want some more general language than that of arithmetic for expressing what they have learnt, and are pleased, instead of being puzzled and disgusted, when they are shown that all possible individual cases can be included under a single algebraical formulae.

But even with the most complete equipment in the way of apparatus, it does not seem to me to be practicable to teach Physics properly by means of laboratory experiments only. A great deal of additional instruction is needful in order to point out the full meaning of each experiment and the bearing of different experiments on each other, as well as to show what the general laws of physical phenomena are, and how they can be established. This is, in fact, the most important part of physical teaching, and it is rather for the sake of giving reality to it, than for its own sake, that practical work appears to me to be of such very great value. I do not see any way of giving it satisfactorily except the method of experimental lectures, or the reading of a text-book, accompanied by the exhibition of the most important experiments referred to, and by very copious oral comments and explanations. In such lectures it is desirable that there should be as little formality as possible, the teacher should always bear in mind that the first object of all for him to aim at is to get his pupils to think for themselves about what he is telling them, and in this case he will welcome all serious questions and interruptions as his best helps. Dogmatism should give place entirely to demonstration. The relation of the teacher to his class should resemble that of a guide, who knows better than the rest of a party the ground that all are to traverse—not that of a traveller, who comes back to show to an admiring audience the wonderful things he has brought from places that they have never seen. The way in which he will best enable his pupils to accompany him will be suggested to him by the recollection of the difficulties which chiefly impeded his own progress in the early stages of his career. Much may no doubt also be learned as to methods of teaching by studying those employed by teachers of experience and of acknowledged success, but no course of previous training can supply the place of actual experience in teaching, without this a man can never know the immense difficulty of imparting to others a clear idea of what is perfectly plain to himself. Nor can he become aware of the difficulties which his own mode of presenting a subject tends to produce in the minds of his pupils. But although I am, therefore, strongly of opinion that anyone who tries to teach according to prescribed rules, instead of being guided by his own experience of success or failure, will never be a thoroughly good teacher, I still venture to ask your attention to a few points, the importance of which—self-evident as it may seem—was not so fully obvious to myself when I first tried to teach Physics as it has now become.

- (1) The most essential of all the conditions for successful teaching is that the teacher himself should have an absolutely clear idea of what is to be taught. It is far from being enough for him to have "got up" the subject carefully from books, and to know exactly what they say about it, he ought to have such a thorough understanding of it as will make him independent of the manner in which it has been presented by others, and will enable him to place his pupils at whatever point of view shows most plainly the connexion between the new subject and their previous knowledge. If the teacher's own knowledge is of the merely "adhesive" kind that exercises the memory apart from the reasoning powers, he cannot expect that his teaching will ever get below the surface of the minds of his pupils, or be of any use for the purpose of training them to think.
- (2) In teaching a subject which depends so completely as Physics upon experimental demonstrations, it is needful to be on our guard against letting experiments occupy the place of the principles they are employed to establish, and letting the mechanical details of apparatus obscure the perception of the experiments that are made with them. The kind of fault I refer to is far too common in most of the elementary text-books. For instance, in treatises on electricity, we almost always find one or more chapters devoted to the electrical condenser and Leyden jar, where the construction and action of these apparatus are elaborately described, but in which very often there is no clear statement of the nature of electrical capacity, and of the conditions which determine its amount in any special case. Again, we often meet with descriptions of comparatively complex apparatus—such, for instance, as the induction coil, in which the mechanical details of construction are dwelt upon at such length as almost to prevent the reader from recognising the usually simple principles on which the action depends. It is of course needful that the con-

struction of apparatus should be explained so fully that pupils may know what the things that are shown to them really are, and what it is that is done with them when they are used for making experiments, but time spent in discussing mechanical arrangements, which might equally well be modified in a score of different ways, is worse than wasted—it not only hinders, it prevents the comprehension of more important matters.

- (3) In teaching a subject in connexion with which so many ideas and phenomena are met with that do not occur in every day life, and, therefore, are not provided for in every day language, as is the case with Physics, the frequent use of technical terms cannot be avoided, but we ought always to remember that the use of the study of Physics is not to explain such terms, but that the use of the terms is to facilitate the study. In beginning each new subject, we ought to keep completely out of sight all the technical terms relating to it, and should explain in common language, even at the risk of considerable circumlocution, the ideas that these words are intended to express. For instance, we should not begin by talking about *specific heat*, or *electromotive force*, or *indices of refraction*, and then proceed to explain what the term means, but we should first demonstrate the existence of the property in question, and then, after the idea has been grasped, we should give a name to it. In this way, when the word follows the idea, it is understood at once and felt as a help by the learner, instead of being regarded, as it often is when the opposite order is adopted, as something even more difficult to understand than the idea which it ought to convey.

In conclusion, I cannot help saying how fully conscious I am that my lecture has been to a great extent wanting in the practical character which I was wishful to give to it. While avoiding details, which it did not seem possible to discuss with advantage without being wearisomely minute, I fear that my generalities may have degenerated into vagueness, and that I shall not have succeeded in suggesting anything likely to be practically useful to those who have really to do what I have been talking about. However, I have striven to be true to the principles I have advocated. I have tried to give good reasons for whatever opinions I have ventured to express; and, by presenting the problem before us in the clearest way I could, I have endeavoured to make it show the way to its own solution. And if what I have said should lead to a discussion of the methods of teaching Physics among those actually engaged in the work, useful results cannot fail to follow.

## 4.

ON THE PLACE OF GEOGRAPHY IN EDUCATION.\*  
By the Rev. E. HALE, M.A., F.R.G.S., Assistant Master at Eton.

"I am a schoolmaster—seeking rather for information than able to give it—hoping to awaken such interest in others who are skilled in scientific learning, that they will give the benefit of their ideas and more impartial judgment to its professional teachers, who are the obscure pioneers of what is probably a great educational movement.

"Every man from his birth is brought into contact with his fellow-men and with Nature. Nature and Man should be, and are intended by the Creator to be, in harmony with each other. The great aim of education should be to teach the relations in which each man stands to Man and Nature, —to teach each man in such a way that he should be best fitted to fulfil his social duties, best fitted to understand and employ advantageously the forces and powers of Nature.

"Since the days of the Greek philosophers until quite recently, all those who have taught, have (some perhaps unconsciously) had in view the idea of teaching the pupils their duties as citizens by means of a classical education, a system of education which, including not merely the languages, but also history and human philosophy, was, indeed, a liberal education, although a one-sided one. This was the original aim, but having to commence by teaching

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Latin and Greek before the great fathers of philosophy could be studied, their education degenerated into a mere teaching of two languages. A teaching, too, not carried on in a scientific or original manner, but by enforcing arbitrary rules of (so-called) grammar, and by exercises in a forced and artificial style of composition, a system which (at any rate where education is confined to it) I contend is calculated to dwarf the mind and impair the reasoning faculty. For the young are naturally inquisitive and eager for knowledge. In our intercourse with our own little children we see that daily. Now, this teaching of grammar—irksome to the majority of teachers, irksome to the majority of learners, preventing freedom of thought or play of intellect—was all the education afforded in our chief schools some 40 years ago. Here and there mathematics were added, but modern languages and science were entirely ignored.

"Recurring again to the aim of education to teach the young their relations to Man and Nature, or rather so to train them that they may be able to learn them for themselves, we see a system of education dividing itself into two branches—Human and Natural Philosophy—the one taught by Literature and History, the other by Mathematics and Physics and Science. Whether Latin and Greek are the best means for teaching the former of these is not my business now to discuss. But we must bear in mind that school education can be but rudimentary, but must be sound. Boys (and girls, too) should not be turned into superficial scientists, but should have a good solid foundation given them on which to build their future knowledge. Certain rudiments should be taught them, knowing which, they should be able, branching one way or the other as their faculties or inclinations lead them, to devote themselves to their own peculiar study.

"And these rudiments should be—a Language, either ancient or modern, besides their own, a certain amount of Mathematics, principally Arithmetic and elementary Geometry, or rather, perhaps, Geometrical Drawing—the Arithmetic to give quickness and readiness, the Geometrical Drawing to teach form and shape, and Geography, Political and Physical,—the former being absolutely necessary to the study of the History of Man, the latter—Physical Geography (Erdkunde, as the Germans and Professor Huxley call it, Natural History as Mr Wilson names it)—being nothing less than the History of Nature, the term by which I, with all due deference, would prefer it to be designated.

"With this groundwork a pupil should afterwards be able to devote his attention more particularly to his own special study. But these things should be taught *thoroughly*. It is impossible to expect a boy of average abilities to learn well many things—it is injurious to him mentally and bodily to attempt it. And yet this is attempted. For I cannot too prominently bring before you the fact that in very many schools where science is taught, it is added to other studies—it has been pushed in forcibly—and often in a most perfunctory manner. One term a boy has a course of *Mechanics*, the next of *Astronomy*, the next of *Chemistry*, and so on. I hold that this is a great evil, injurious to all concerned, pupils as well as teachers. I wish to maintain that a good solid, common foundation—some such a one as I have sketched out—should be given to all, and that then there should be two great divisions in a school,—the one Literary, the other Scientific and Mathematical.

"I hold, then, the first object of school education should be to ground the young thoroughly, not superficially, in those elementary studies which may best fit the pupils afterwards to pursue their investigations into the History of, and the Laws which govern, Man and Nature. And I consider Geography in its broad sense, Political as well as Physical, to be one of these elementary studies, absolutely essential to the proper study of the History of Man and Nature. The upholders of the old system of education admitted this partly. For they made a point of teaching the political divisions of the world in the days of the supremacy of Greece and Rome, and they were glad if, in the nursery or under a governess, a boy had learned the different countries of the world at the present time, and the names of their chief cities. But having myself for many years been a teacher of Modern History, I found boys absolutely ignorant of the commonest geographical facts, unable therefore to understand the political importance of treaties altering the boundaries of countries, or of the exchange of colonies, in fact, so badly grounded that they were unable to use with any advantage Historical Atlases, such as that of Spruner. Obviously a knowledge of Political Geography must precede the study of History.

"But that Physical Geography should be the groundwork of science teaching is not so obvious to all teachers. I ought, perhaps to have said before, that in all matters of ~~school teaching~~ I advocate nothing that I have not my-

self personally tried. I spoke before of the inquisitiveness of children, every parent knows it well, and must have observed also how, after school life begins, this inquisitiveness seems to vanish. My own opinion is, that it is generally stifled by the evil genus 'Latin and Greek Grammar.' Be that as it may, I know that this disappearance of inquisitiveness does not prove that it is dead. 'With warmth and gentle rains it sprouts afresh.' This stimulating power is afforded by Physical Geography. The first things the teacher will teach are the first principles of Astronomy,—the earth, its position in the solar system, the phenomena of day and night, summer and winter, eclipses and the changes of the moon. Boys generally become interested at once, the intellectual cravings of their very childhood again revive and are being satisfied. At the end of the very first lecture boys will remain behind, asking for further information—'Why is it?' Having then taught the first principles of Astronomy, the teacher will proceed to the first principles of Heat, to the effect of solar heat on the earth, tides, winds, and currents, evaporation and rain. Thence he will proceed to the first principles of Geology,—to the changes in the physical features of the earth, to rivers and ice and volcanoes, to the formation of chalk and coral, to the distribution of plants and animals. And if at first the inquisitiveness of the learners is excited, at the end they first feel their intellectual powers. They see how, from the knowledge of certain facts, the great laws of nature are deduced,—the spirit of the inquirer, of the discoverer, is aroused in them,—their reasoning faculties are now excited and strengthened.

"Of course, generally speaking, boys who are the best in Classics and Mathematics are best also in Physical Geography, because they are boys whose natural abilities are above the average. But there are many exceptions. Boys whose early training has been deficient, or who from some intellectual cause are unable to appreciate the refinements of grammar, suddenly awake, as it were, when first taught the principles causing the phenomena of Nature. And a great moral good is effected in them. I am one of those who hold that sports—athletics—are of use as a means of moral as well as of bodily training, that many a thick-headed, strong-limbed boy, by his excellence in sports is enabled to recover or maintain the self-respect he may have lost, or be in danger of losing; so, in like manner, the boy finds in the study of Nature, and in the fact that he may hold his own in this study, a means of preserving his self-esteem. An objection strikes me may be made against the study of Physical Geography, that it is too discursive. I have insisted on a boy's training being thorough, and at the same time have praised the study of Physical Geography as being introductory to so many sciences. But there is nothing really contradictory in this. The want of thoroughness is seen when boys are successively put through courses of Astronomy, Chemistry, Mechanics, &c. Anything like a thorough knowledge of these sciences, or of any one of them, cannot be imparted to a boy. Astronomy and Mechanics, for instance, if exhaustively studied, require a large knowledge of Mathematics,—much larger than that possessed by the great majority of boys. But the first principles of those sciences necessary to the study of Nature, such as Astronomy, Heat, Geology, Zoology, may be thoroughly taught, and can be perfectly understood by a boy of fair intelligence. Again, discursiveness is not opposed to thoroughness, and the discursiveness of Physical Geography is a positive advantage to the teacher. One of the great benefits which a large school affords to boys, is that they are brought into contact with so many different minds, they are subjected to the influence of so many different teachers. So the sciences teacher who is instructing his boys in Physical Geography will naturally dwell at greater length on his own speciality, will bring much peculiar knowledge to bear in illustrating all those natural phenomena which relate more particularly to his own branch of science. And on this I found another reason for making Geography or the History of Nature the foundation of all science teaching in schools.

"I will briefly mention the method I employ in teaching Physical Geography, premising that I by no means insist on it as the best method. I have had good results from it, but doubtless a better method would have produced still better results. At the same time, I must claim this indulgence for science teachers from adverse criticism. Classical teachers have the experience of centuries to guide them. The method of science teaching in schools must be regarded as tentative; as I before said, the teachers of the present day are but the pioneers of the educational army which will eventually, I believe, overcome the ignorance of 'common things' displayed so universally, and put to flight the host of Philistines who rejoice that their children's intellects are kept in the same state of bondage as their own.



"My class consists of about 30 boys. I give them no text book, and on this, I may say, I place great importance. Each boy has one of Keith Johnston's School Atlases of Physical Geography, price 10s 6d. The teacher, I presume to be conversant with Humboldt, Herschel, Tyndall, Murchison, and Reclus, and to know Sir C. Lyell's 'Principles' thoroughly. My references are principally to these authors, and my 'stock-in-trade' consists of wall maps, photographs, and a microscope in my study for the more eager pupils. I ought to have also a good geological museum. This is at present in course of formation, and when the school authorities will grant a suitable room, will be speedily in working order. I require each boy to bring in a large note-book, with each page folded in the middle. I commence my lecture by stating first what is the more immediate subject of my lecture, then I dictate from my own notes an abstract of the first division of my lecture—this abstract each boy writes on one half of the folded page. I then enlarge and illustrate by facts, putting at the same time frequent questions to the boys. On the other half of the page each boy takes as many or as few notes as he pleases. At the end of the lecture, which lasts somewhat less than three quarters of an hour, I refer the pupils to authors, and the chapters of their books which treat more at length of the subject. Only the more industrious boys refer to these. If possible, I show a photograph or picture of some well-known or often described place, which may serve to illustrate the lecture. After my two lectures (two lectures are given weekly) I require each boy to bring an abstract of the lectures, not copied verbatim from his note-book. I give marks for these, and also additional marks for good diagrams. After every eight or ten lectures an examination paper is set, and I give a prize to the boy whose aggregate marks for abstracts and papers are highest.

"I feel that a most valuable addition to my lectures would be some kind of field instruction—such as I hope to hear mentioned by the President—which should include the teaching, practically the use of instruments—and also should admit of those excursions, geological, botanical, or zoological, so common in German schools.

"Now, I believe, that independently of the knowledge acquired by the boys, the mental training is by no means despicable, which shows them, first, how to analyse a lecture or a book, as the abstract dictated to them does; and secondly teaches them, as their original abstract does, how to reproduce in their own language the lectures they hear. And this is part of the thoroughness of teaching which I insist on.

"One other objection I have heard urged against Geography, that it is a subject easily 'crammed up.' I may here answer. The result of competitive examinations is doubtless to encourage a system of cramming. If a pupil is not intended for a competitive examination, I hold that my method is the farthest possible removed from cramming; but if a pupil be intended for a competition, the question arises will he be able to pass well. I have faith that he would, and the only two competitive examinations pupils of mine have gone in for they have done satisfactorily. But I hold that Geography, if the examination papers are set with the same discrimination as those set in the Royal Geographical Society's examinations, cannot be crammed up. There are two great desiderata in an examination paper: first, to give problems; secondly, to give full marks for a certain portion of the paper answered well, &c., to encourage a thorough knowledge of some parts of a subject. Fortunately, then, Geography is so discursive; and fortunately problems can be set.—Given certain conditions, what will result?—Given certain facts, what laws would you deduce? But my own experience teaches me this—that Mathematics admit of more 'cramming' than any other study; and yet who would refrain from examining in Mathematics, because they admit of being crammed? I trust the time is not far distant when every boy in those schools professing to lay the foundations of a liberal education will be at least as conversant with Geography, both Political and Physical,—the one the necessary introduction to the History of Man, as the other is to the history of Nature—will, I say, be as conversant with Geography, as they now are supposed to be with the Latin Grammar."

5.

PRACTICAL REMARKS ON THE TEACHING OF PHYSICAL SCIENCE IN SCHOOLS. By the Rev. W. TUCKWELL, M.A., Head Master of the College School, Taunton, and late Fellow of New College, Oxford; with Letters from Charles Daubeny, M.D., F.R.S., late Professor of Botany, and late Professor of Chemistry in the University of Oxford, Henry W. Acland, M.D., F.R.S., Regius Professor of Medicine; and John Phillips, M.A., F.R.S., late Professor of Geology.

Ought Physical Science to be taught in schools? and if so, under what conditions, as regards the age of the pupils taught, the proportion of time assigned, the apparatus and accessories required?

The claims of science to be regarded as a necessary element of education have been urged by every scientific man of eminence in the kingdom. The one-sidedness of existing culture, and the manifold defects which this one-sidedness involves, the injury inflicted by it on those many minds which display peculiar aptitude for physical science rather than for languages and mathematics, and its neglect of those faculties of all minds which only physical science can call forth, the peculiar excellence of science as cultivating in a way attainable by no other means the habit of observation, of reasoning on external phenomena, of classification, arrangement, method, judgment; its power of exercising the memory at the same time that interest is excited and knowledge gained, its practical value as a preparative for professional or general life; to the medical man, the engineer, and the agriculturist, as bearing directly, in one or another of its branches, on their daily work; to the soldier as creating in him the power to appreciate and to record the phenomena which beset him in the distant countries which, at one time or another, he is sure to traverse, to the clergyman, as diminishing that dangerous want of sympathy between the clergy and the working classes which is due chiefly to the absence of a common ground of feeling, to mutual ignorance, and disregard on either side of those subjects which each severally knows and values, to all men, of whatever rank or occupation, as furnishing an endless resource of exquisite enjoyment; as lighting up the dirt on which they tread, the weeds and the insects of their walks, the daily phenomena of the sky and air, with a beauty, a history, a suggestiveness, which educates, refines, and purifies as much as it refreshes and delights. All these points are pressed upon as eagerly by the leaders of education and of thought, while the opposing arguments of critics unacquainted with the subjects which they denounce, appear calculated to cause amazement rather than to enforce assent.

But while all whose opinion is valuable are agreed upon the educational worth of science, and lament the injury inflicted on the country by its omission from the curriculum of our schools, no one, so far as I am aware, has come forward to furnish information as to those questions of detail whose settlement is of necessity preliminary to any practical effort at amendment. At what age, for instance, ought the study to be commenced? In what sequence should its various branches be taken up? How much time in each week must be allotted to it? What apparatus is necessary for its prosecution? It is with unfeigned diffidence that I offer suggestions on these several points. My acquaintance with school teaching, and my studies of physical science, have been long enough to teach me, amongst other things, my own exceeding ignorance, but having for some years included physical science in my course of teaching, and being about to introduce it systematically into my present school, I offer to all whom it may concern the results of personal experience.

As regards the age suitable for commencing scientific studies, I can affirm that I never met a schoolboy too young to derive enjoyment and benefit from them. The faculty of observation is perhaps the earliest faculty developed, the habit of inquiry concerning things observed the earliest habit formed. I know a child of six years old who can pull a flower to pieces and tell the names of its component parts, and who pronounces unhesitatingly the titles of the larger portion of the insects, plants, and minerals which present themselves in her daily walks. We have heard of the classes taught by the late Professor Henslow, in his Suffolk parish, where boys and girls of humble life, from eight to twelve years old, gained under his instruction, readily and voluntarily, a respectable knowledge of botany, and many persons must have witnessed the intense delight perceptible in quite young children, while the common objects of a country walk have been judiciously explained and illustrated by a well-educated governess or friend. I

can say without hesitation that a boy's scientific studies may begin from the time when he is first sent to school.

The order in which scientific subjects are to be taken, and the time to be assigned to them, may be discussed together. It is generally considered that these three subjects, Natural Philosophy, Chemistry, and Physiology, are educationally fundamental to all organic sciences. The first of these may be considered to include the properties of bodies, mechanics, hydrostatics, hydraulics, and pneumatics, optics, and acoustics. I have never found the slightest difficulty in teaching these subjects, treated not mathematically but experimentally, to boys of twelve years old, and I have known many boys of eleven quite capable of understanding and remembering my lectures. For boys, then, younger than eleven, I would form a junior class, which should devote one hour in the week to some such book as the well-known "Guide to Knowledge," or to some "Catechism of Common Things." The text book chosen is of no great importance, if the teacher can be trusted to expand and illustrate each lesson by verbal explanation, or by the assistance, if necessary, of a microscope and air-pump, or other interesting instrument.

With a considerable knowledge of facts, and a keen appetite for information and experiment of a higher kind, a boy would at eleven or twelve years old enter the Natural Philosophy class, spending on this new topic two hours in each week, and completing in the next two years the course of subjects ranged under this head. At thirteen or at fourteen years he would be ripe for the chemistry class. He would now witness and perform experiments in the laboratory, and would study the laws of heat, of the non-metallic elements, of the atmosphere, and of water. By attendance during two hours in the week, with opportunities of repeating or verifying experiments out of school hours under the master's eye, he would in the course of a year have completed his course of inorganic chemistry, and be prepared at fourteen or fifteen to enter the Physiology class. He would here be first taught the physiology of man and of the higher mammals, and thus familiarized with the principal organs and their functions, would start from the lowest point of animal life, and ascend by a course of comparative anatomy once more to the highest.

He will by this time be 16 or 17 years old, a period at which many boys leave school. Should he stay till 18 he will have an opportunity of studying either geology, mineralogy, vegetable physiology, or botany, or of entering upon organic chemistry; but even if he leaves school at the age of 16, he will have acquired in five years, at a cost of less than two hours a week, a body of information and a practical familiarity with the fundamental laws of science which will have furnished him with lifelong resources, and developed, as I believe, to an amazing degree his mental powers. And side by side with his severer studies the less laborious pleasures of science will have been presented to him. In many a country walk or half-holiday excursion he will have learnt the delights which wait upon the enthusiastic naturalist; and as years go on, the crowded shelves and cases of the school museum, the well-stored botanic garden and herbarium, the carefully-compiled and published Fauna and Flora of the district, will bear witness to the judgment that has won to innocent and refined enjoyment the restless natures which, if left unguided, might have been wasted and lounged away in the billiard-room or stable-yard.

For the effective teaching of these various subjects an extensive apparatus is essential; without models, instruments, and specimens, nothing whatever can be done. If bought in the shops the cost of these accessories is alarming, but with the help of a dexterous carpenter and glazier the great majority of them can be manufactured at a trifling cost. In my own school a class-room with an area of about six hundred feet has been set aside for our small museum, the walls will be lined with deal cases between seven and eight feet high, having moveable shelves, and divided into compartments for rocks and fossils, anatomical and zoological specimens, philosophical instruments, and models. A working table for the microscope, with a microscopic cabinet, and drawers for insects and mollusca, will be added as our funds permit. An adjoining room will form our laboratory, while half an acre of ground has been laid out as a botanic garden so as to hold about six hundred plants. I calculate that the necessary cost incurred at starting, for cases and shelves, for instruments and models, and for the laying out and labelling the garden, will be covered by 60*l.*, a sum which I have little doubt that the kind liberality of the neighbourhood will principally furnish. The pleasure of collecting plants and specimens, of mounting preparations and preserving objects, will be reserved for the boys and masters, and by their help and by the assistance of our friends, I have no doubt that we shall possess in a few years' time a collection numerous enough to be completely typical, but whose limited extent will enable the individual specimens to exhibit extraordinary excellence and beauty

Amongst the first and kindest contributions to our scheme are the interesting letters from distinguished Oxford teachers which I am permitted to append to this short paper. The time to come will show whether the predictions which they utter, and the hopes which I have built upon my own experience, are founded well or ill. Without their warm support I should not have ventured to come forward, and I have the satisfaction of feeling that those who find my own remarks uninteresting will thank me for eliciting theirs.

I will presume, in conclusion, to express a hope that the nascent study of physical science in our schools may be fostered by the labours and the recommendations of the present Educational Commission. The results of those labours are awaited by a very different class from that which owned an interest in the *Public Schools Commission*, and will be criticised in a very different temper. The Prussian system of our public schools is viewed with languid disapproval at the most by those who entrust their sons to them in order that certain tangible prizes may be won, or by that far larger class who reckon extravagance, exclusiveness, and idleness not hard conditions towards the attainment of gentlemanlike manners and the acquisition of fashionable acquaintances. But thousands of hard-working anxious parents, who know the wealth of knowledge and of mental training, and whose worldly and professional experience has led them deeply to distrust a plan of teaching which they consider narrow, partial, unelastic, and unpractical, will eagerly expect and thoughtfully peruse the opinions which shall be expressed, and the verdict which shall be delivered, by those to whom the regeneration of the great mass of English education is committed.

#### LETTER FROM DR. DAUBENY.

MY DEAR SIR, April 15th, 1865.

I AM glad to learn that you are designing to introduce the study of physical science and of natural history into the school under your superintendence.

I am persuaded that a certain acquaintance with these subjects might be imparted generally to boys, without interfering with those classical acquirements which had heretofore constituted the staple of an English education.

Different heads of study are to the mind what different kinds of exercise are to the body, and by bringing into play new faculties enable the student to refresh his mind with intellectual occupation of another sort, even when wearied and disgusted with the ordinary routine of school-boy employments.

Besides, since the great object of classical study, as an element of general education, is to develop the faculties, it must be apparent that similar effects will be produced by the acquisition of a knowledge of the laws and phenomena of the external world, especially in quickening the sources of observation, inducing habits of method and arrangement, exercising the power of induction, &c.

Moreover, as it must be admitted that only a certain proportion of any number of youths are capable of appreciating the meeties of scholarship and the higher beauties of the classical writers, it will be well that an opportunity should be afforded them of acquiring other kinds of knowledge, which may take the place of that for which they possess neither the genius nor the inclination.

It is, therefore, not without reason that physical science has of late been allowed a place in the curriculum of our universities, and that scholarships as well as fellowships have been instituted for its encouragement.

Judging from those which have been established in my own College at Magdalen, I should pronounce that the experiment has hitherto proved eminently successful.

At any rate, there can be little doubt that through those influences, and that of the honours now held out at Oxford for proficiency in these studies, a knowledge of the physical sciences will become more extended and more generally appreciated amongst the educated classes than has been the case hitherto.

The encouragement given to these branches of learning at our universities has indeed already begun to act upon the public schools; and many private academies and colleges also, throughout the country have, with great advantage to themselves and to their pupils, introduced these branches of knowledge into their courses of study. And as only a part of the boys therein educated commonly resort to the universities, it is evident that acquirements which admit of so many important applications to the purposes of life must be well worthy of being cultivated, by all at least who profess any natural bias or aptitude for them.

I am persuaded that if physical science and natural history were introduced more generally into schools, side by side with the classics, we should hear much fewer complaints as to the number of dunces sent into the world after the completion of the ordinary years of study.

Botany especially seems adapted for a school recreation, for one does not see why boys should not exercise that quickness of sight and observation which is characteristic of their age, in the discovery and discrimination of the flowers that present themselves to their view, as well as in the ordinary sports in which they indulge.

On every account, therefore, I wish you all success in your proposed scheme, considering it conducive both to the general interests of education and to the credit and prosperity of the school itself, both as a preparative for the universities and for other walks of life.

I remain, dear sir,  
Very truly yours,  
To the Rev. W. Tuckwell  
CHARLES DAUBENY

## LETTER FROM DR. ACLAND

DEAR MR. TUCKWELL, Oxford, April 24th, 1865  
I HAVE great pleasure in sending a small donation towards your projected collection of apparatus for teaching the elements of natural science in the Taunton School.

No one conversant with the state of culture in Europe can doubt, I think, that the youth who have in early life some sound training in the direction of science are placed in a situation more advantageous than those who have not. The chief difficulty appears to be in deciding what they should learn at school, and who shall teach them.

Both these questions are no doubt in some cases (and as yet in country schools in England in the majority of cases) insoluble. In the case of Taunton neither difficulty arises. In you the school has a master himself accurately instructed in some departments of natural knowledge, and, therefore, not only capable of selecting what shall be taught, but of teaching himself, and judging of teachers.

My general feeling on the whole question as you are kind enough to ask it is that the *matter* taught is very secondary in importance to the *manner*. The essence of science lies in observation, comparison, and classification; in precision of data and precision of argument.

These several qualities can be more or less elicted from every department of natural science by a competent person imbued with the scientific spirit in any branch.

For boys, of course, the simpler subjects are the best. The ordinary laws of Physics come first no doubt in order of study, then Chemistry, then the several departments of Biology. Some boys would prefer chemical subjects and experiments, some botany or British zoology, with the physiology of plants and animals. Indeed, if I were to venture to suggest a course for any school, it would be to have on hand one of the inorganic and one of the organic class of subjects at different times of the year, and to let the boys choose their class. It is probable they would choose both.

I hope you will be successful in obtaining the "plant" you consider to be necessary for starting, and I shall hear at any time with gratification of your progress.

I am, dear Mr. Tuckwell,  
Ever yours faithfully  
To the Rev. W. Tuckwell.  
H. W. ACLAND.

## LETTER FROM PROFESSOR PHILLIPS

MY DEAR SIR, Oxford, May 1st, 1865  
THOSE who knew and profited by your zealous cultivation of natural science in Oxford, will hear without any surprise, but with great pleasure, that your thoughts have been turned to the introduction of this order of study into the course of instruction in your grammar school. Even if you were not moved by considering the actual inducements now held out by your university and several colleges for the advancement of physical science, the singular local advantages of your beautiful district—the garden of England—would surely lead you to indulge your own love of botany and zoology and palæontology, and to fill the minds of your pupils with the delightful images of natural beauty and divine wisdom and goodness which these branches of study call up. Remembering how marked an influence on my own life a few words addressed, a small microscope given to me at school, really exercised, I resume with pleasure my old status of a student, and will try to explain how, according to my experience, schoolboys may acquire with least pressure, with most pleasure, and with the greatest profit, that kind of knowledge of natural science which will be of great value in after life, and, if they come to the university, will give them a place among their rivals from which to spring to higher grades.

The knowledge to which I refer is the knowledge of *things*, not a store of reading about plants and animals, or chemical wonders, or astronomical vicissitudes, but

recognition of animal and vegetable forms; some idea of the peculiar adaptations of teeth and bones to the diet and movements of animals; experiments tried with the air-pump, minute objects seen by the microscope; planets and stars and sun and moon examined with the telescope. In short, that which is the most important for the efflorescent mind is the opportunity of observation.

"Give him to see, the schoolboy asks no more!"

But to furnish this opportunity, so that the boys may have frequently before them the objects most worth observing, you must have a museum. Yes, a museum! Not such a collection as many busy towns and many idle gentlemen possess—"spoils from every land, trifles from every sea"—but a small, well-arranged selection of natural objects—minerals, rocks, fossils, skeletons, skulls, insects, &c., all preserved with respectful care from mischief, decay, and dust. More than this, a very small laboratory—that is to say, a work table and a couple of drawers for tools and chemicals, and a few instruments for experiments, such as thermometer, air-pump, electrical machine. I would hunt these treasures to a single room, and would give in that room not anything like a lecture, but easy and familiar explanations in answer to questions, or as a necessary accompaniment of experiments. How much more is learned of plants by gathering them with a botanist at hand, than by hearing dissertations on "botany" from the professional char! How much fitter for a boy is the guinea and feather experiment than the "theory of gravitation;" one peep through a telescope, than the "laws of dioptrics and catoptrics," the burning of iron in oxygen, than the "atomic theory!" These laws and theories they may fully master in after years, and all the more easily, that they have seen some of the characteristic phenomena while the eyes are bright and the doors of memory are open to new impressions.

Yes. You must have a museum, and it will be in your hands an instrument of power, a means of permanent good as well as an ever-renewed pleasure to your pupils. You ought not to refuse aid in filling it, for your purpose is of more than local or personal interest. I beg permission to offer you three little contributions: a fossil, typical of natural history, a thermometer, representative of experimental science, and a sovereign, which may help to glaze your drawers or cabinets.

And now I resume cap and gown, and go to teach my own class, amongst whom in future years, perhaps, I may count one or two of your pupils.

Ever yours most truly,

JOHN PHILLIPS.

The Rev. W. Tuckwell, M.A.,  
College School, Taunton.

THE METHOD OF TEACHING PHYSICAL SCIENCE IN SCHOOLS.—A Paper read before the British Association at Exeter, August 21st, 1869. By the Rev. W. TUCKWELL, M.A., late Fellow of New College, Oxford, and Head Master of the Taunton College School.

The claims of Physical Science, on *a priori* grounds, to a fair place in the course of school work, have been abundantly vindicated, and are, I suppose, established. But the method and details of its teaching, the books and apparatus which it requires, and the amount of time which must be given to it, are points which can be decided only by experiment, and have not yet been decided at all. I cannot premise too distinctly that the aim of this paper is practical. Of the necessity for teaching science to their boys many good schoolmasters are convinced, as regards the machinery by which it is to be taught, they mostly confess their ignorance, and cry aloud for guidance. In my own school it has been taught systematically for the last five years, and I offer the fruit of this experience, very humbly, to all who are interested in education.

The subjects to be taught, the time to be spent upon them, the books and apparatus necessary, and the mode of obtaining teachers, are the points on which information seems to be required. I will take them in order.

The subjects which naturally suggest themselves as most essential are Experimental Mechanics, Chemistry, and Physiology. But it has been urged by high authority, familiar to the members of this Association, that between Chemistry and Physiology, Systematic Botany should be interposed, as well because of the charm this science lends to daily life, as from its cultivating peculiarly the habit of observation, and illustrating a class of natural objects which are touched indirectly or not at all by the other sciences named. Whether all these four subjects can be taught depends upon the period to which school education is protracted; but, at any rate, let these, and none but these, employ the hours

assigned especially to Physical Science, in the scheme of actual work in school. Abundant opportunity will remain for less direct instruction in many other branches of science. The geographical lectures, if properly treated, will include the formation of the earth's crust, with the classification and distribution of its inhabitants, both animal and vegetable, both extinct and recent. The possession of meteorological instruments, whose observations are regularly taken, and their computations worked by the boys, will almost insensibly teach the principles of atmospheric phenomena, while such books as "Maury's Physical Geography of the Sea," "Arry's Popular Astronomy," and "Herschel's Meteorology," may be given as special matter for annual scientific prizes. The laws of light and heat will be taught as prefatory to chemistry. Electricity attracts boys so readily that with very little help they will make great progress in it by themselves. The mathematical master, whose best boys are well advanced, will not be satisfied till he has obtained a transit instrument and a mural circle. And the wise teacher, living in the country, will not disdain to encourage a knowledge of natural history. He will know that it is not only ancillary to severer scientific study, but in itself a priceless and inexhaustible resource. By country walks, by well-chosen holiday tasks, by frequent exhibitions of his microscope, he will not only add to the intellectual stock of his boys, but will build up safeguards to their moral purity. Indeed, even without such encouragement, boys who are trained thoroughly in certain sciences will of their own accord seek to become acquainted with other and collateral ones. Cases multiply in my own experience where pupils of a chemistry class have taken up electricity, pupils of a geography class mineralogy, pupils of a physiology class microscopy, and I need hardly say that boys make nothing their own so thoroughly as that which they select themselves.

The time to be given to science should not be less than three hours a week. At this rate two years may be given to mechanics, two years to chemistry, one year to botany; while the rest, if any remain, will be free for physiology. We need not be afraid of beginning early. A boy of 11 years old, fresh from an intelligent home, where his love of observation has been fostered, and his inquiries have been carefully answered, is far more fit to appreciate natural laws than a much older boy, round whose intellect, at an old-fashioned school, the shades of the prison house have steadily begun to close. Most schools are now divided into lower, middle, and upper. I would commence the study of mechanics with the junior class in the middle school. For the first year the teaching may be *swad voce*, with easy problems and abundant experiment, care being taken that each week's lectures shall be reproduced on paper, and great attention being paid to correct drawing. In the second year the teaching will be more minute and more extended, and a good book will be mastered. At the end of this time the class is fit to pass creditably the Oxford Local Examination for juniors, and has done with mechanics for the present. The third and fourth years will be given to inorganic chemistry. The third year will include only lectures in the class room, a text book being used, experiments being shown by the master, but no laboratory work being done by the boys. The fourth year's work will be conducted entirely in the laboratory, each boy manipulating with his own instruments at his own table. At the expiration of these two years the class will be qualified for the chemistry examination in the London University Matriculation. The fifth year is given to botany. If a good book is used, if each boy works for himself with lens and knife, if "Henslow's Schedules," or a modification of them, are regularly filled up, above all, if plates are not made to do the work of living plants, the pupils will at the year's end thoroughly understand the principles of classification, will know the characteristics of at least all the British orders, and will be able with the help of Bentham or Babington to make out almost any English flower. The boys who have completed this course will be from 16 to 17 years old. Some of them will now be leaving school; those who will remain will give the rest of their time to physiology. They will begin with human and will pass to comparative physiology, using in the first Professor Huxley's valuable little book; dependent for the second, of which no school manual exists, on the skill and method of their teacher. But whether at the earlier or the later age, they will pass out into the world immeasurably superior to their contemporaries who know not science, with doors of knowledge opened which can never again be closed, with a fund of resource established which can never be exhausted, with minds in which are cultivated, as nothing else can cultivate them, the priceless habits of observation, of reasoning on external phenomena, of classification, arrangement, method, judgment.

The subject of books and apparatus, involving as it does

the question of expense, is of the highest practical importance. Apparatus need not cost much, but it may, and, if possible, it should cost a great deal. While poor and struggling schools may begin cheaply and proceed gradually, institutions which can spend money on racket courts and gymnasiums ought not to grudge it on museums and botanic gardens. We have taught mechanics efficiently; that is to say, we have passed our classes for the last three years in the Oxford Local, with a good air pump, a set of pulleys, models of the force pump, and the common pump, with Keith Johnston's scientific maps, and with the diligent use, during the second year, of "Newth's Natural Philosophy." But we have lost no opportunity of making the boys acquainted with machinery, from the crane and the water-mill of our daily walks, to the steam engine and the spinning jenny of the manufactory; for he who has not examined engines at work will never understand them clearly, or describe them correctly. For teaching chemistry a laboratory is absolutely essential; no matter how rough or shabby a room, so that it be well ventilated, have gas and water laid on, and will hold from 16 to 20 boys. I hold in my hand the model of a cheap laboratory table, on the scale of two inches to a foot. It is about 9 feet by 3, and contains eight compartments, each 2 feet by 16 inches, with two slight shelves, and a special recess for the teacher. It costs about 4l.; if made for twice the number of boys, it may be made at about 9s. per boy. The general laboratory stock, including a still, a stove, or furnace, gas jars, a pneumatic trough, a proper stock of retorts, crucibles, tubing, &c., and the necessary chemicals, will cost under 12l. Each pair of pupils must have also between them a set of test tubes, a washbottle, a spirit lamp, a waste basin beneath their table, and 24 bottles of test solutions, while each boy has his own blow-pipe, tripod and stand, pestle and mortar, and three beakers. These will cost each boy about 8s. He will replace everything that he breaks, and will receive the value of his stock from his successor when he quits the class. The text book used should be Roscoe's or Williamson's, and a large black board is quite indispensable. In botany the book for the boys' use is Professor Oliver's Lessons; but the teacher will find great advantage from Le Maout's *Leçons de Botanique*. An excellent modification of Henslow's Schedule is published by Professor Babington for the use of his Cambridge classes, and Lindley's *Descriptive Botany*, price 1s., is a most useful help. Every boy should be furnished with a small deal board, a lens, and a sharp knife. The botanical microscope which I exhibit, including a lens fixed or moveable, a black glass stage, two dissecting needles and a forceps, is made by Mr. Highley, of Green-street, Leicester-square. If they are ordered by the dozen, he will furnish them at 6s. each. Flower trays, such as I hold in my hand, should be kept constantly in use, the boys being encouraged to bring in wild flowers, and to place them in their appropriate niches. Their cost per tray, holding 18 bottles, is under 2s. Fitch's diagrams, designed for the Committee of Council on Education, which cost 2l. 9s. the set, are a valuable help to the lectures; and for schools which have large purses or liberal friends, Dr. Auzoux's models of plants and plant organs, ranging in price from 20 to 100 francs, and 10 times the size of life, form a luxurious assistance to beginners, which only those can appreciate who have worn out their eyesight and their temper over a composite floret or the glume of a small grass. The same excellent modeller, whose catalogue is on the table, provides every organ necessary for the study of comparative and human physiology; and his prices ought not to be beyond the reach of any prosperous school. In any case a skeleton will be necessary, and will cost about 5l.; and if the Committee of Council were to authorize the reproduction of such typical physiological cases as, from the skilful hands of Mr. Charles Robertson of the Oxford Museum, drew so many admirers in the Exhibition of 1862, these would find immediate purchasers in many of our schools. At present teachers want the skill or the leisure to make their own preparations, and they cannot buy them. A good set of meteorological instruments costs from 16l. to 20l., but these, with astronomical apparatus, are a costly luxury, and may be left out of the list of indispensable necessities. I cannot think that any school, professing to teach science systematically, will be long satisfied without a typical museum. As scientific work proceeds, specimens of all kinds, some purchased for lecture work, others given by friends or collected by the boys, will gather and increase, till the class-room cupboards and shelves are choked, and a special room must be devoted to them. Here will be arranged, in one place rocks and fossils, in another trays of minerals, in a third zoological specimens, in a fourth physiological preparations. The driest corner in the room will be assigned to the Herbarium, a small library of scientific references will give promise of the future. Everything not typical will be rigorously

excluded, every case will be so carefully arranged and so plainly labelled as to tell the history of its contents to the eye of the least instructed observer. And it will be hard if some corner of the playground cannot be laid out as a botanic garden. In the crowded school premises which we are happily leaving I have found room for nearly 400 plants, and at the new school to which we are about to migrate I shall not in two acres of garden ground, with a pond for water plants and a sheltered rockery for ferns.

It remains only to examine the mode of obtaining teaching power; a point which presses heavily on many head masters who have themselves no knowledge of science. That all head masters should have such knowledge, is a fact which, if science is to be taught at all, trustees and governing bodies must come to recognise before long; meanwhile every school which teaches science thoroughly, is training skilled teachers for a not distant generation. Institutions which can give so high a salary as to command a London bachelor of science or a first-class Oxford or Cambridge man, will find no more difficulty than attends the choice of all masters: where this is not the case, it is sometimes possible, by combining mathematics with physical science, to tempt a superior man with a sufficient income; and if only a small salary can be given, the ordinary pass B.A. of the London University will sometimes make a fairly good teacher. But one point has struck me forcibly in my own experience, namely, the unexpected value of general culture in teaching special subjects. The man who knows science admirably, but knows nothing else, prepares boys well for an examination, but his teaching does not stick. The man of wide culture and refinement brings fewer pupils up to a given mark within a given time, but what he has taught remains with them, they never forget or fall back. I am not sure that I understand the phenomenon, but I have noted it repeatedly.

I cannot end this paper without a word as to the educational results which our five years' experience has revealed. The system has brought about this result first of all, that there are no dunces in the school. In a purely classical school, for every promising scholar, there are probably two whomake indifferent progress and one who makes no progress at all, and a certain proportion of the school, habitually disheartened, loses the greatest boon which school can give, namely, the habit and the desire of intellectual improvement. By giving importance to abstract and physical science we at once redress the balance. Every boy progresses in his own subject, some progress in all; no one is depressed, no one thinks learning hateful. Secondly, the teaching of science makes school work pleasant. The boy's evident enjoyment of the scientific lesson rouses the emulation of other masters. They discover that the teaching of languages may become as interesting as the teaching of science. They realise—a point not often realised—the maxim of Socrates, that no real instruction can be bestowed on learners "κατὰ τοῦ μὴ ἀπαικροῦς," by a teacher who does not give them pleasure. Lastly, the effect on the boy's character is beyond all dispute. It kindles some minds which nothing else could reach at all. It awakes in all minds faculties which would otherwise have continued dormant. It changes, to an extent which we cannot over-estimate, the whole force and character of school life both to the learner and the teacher. It establishes as matter of experience what has long been urged in theory, that the widest culture is the noblest culture, that universality and thoroughness may go together, that the system which confines itself to a single branch of knowledge, does not gain, but loses incomparably, by its exclusiveness, that observation, imagination, and reasoning may all be trained alike, that we may, and so we must, teach many things, and teach them well.

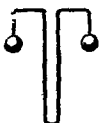
II.—CATALOGUE OF APPARATUS FOR THE TEACHING OF PHYSICS AND OF INORGANIC CHEMISTRY, WITH PRICES ATTACHED.

(See § 20.)

PHYSICS.		£ s. d.		£ s. d.	
SOUND.					
Apparatus					
1 table air pump	-	2	0	0	13 0 0
4 receivers, of which	-				
1 open at top, ground flat	-	0	12	0	3 15 0
1 shallow	-				
A true brass plate for receiver of air-pump, with straight adjustable rod through it	-	0	10	6	0 15 0
1 musical box, small size	-	0	10	6	1 1 0
A double square case, padded, 1 ft. x 1 ft. x 1 ft.	-	0	18	0	1 0 0
12 soft-iron balls	-				
1 grooved board for do.	-	0	12	0	0 15 6
A tuning fork on resonance box. Prongs of fork, 1 ft. long	-	2	10	0	5 0 0
Box of musical glasses	-	0	5	0	—
12 varnished pith balls	-	0	1	0	0 2 6
1 tin funnel with side tube, 1 pint	-	0	2	0	0 2 6
Sounding box, 1½ ft. x 1 ft.	-	0	12	0	0 15 0
8 bars of equal length, of glass, brass, and woods, each 5 ft. long and ½ in diam., with 1—	-				
3 glass	1 mahogany	0	15	0	3 0 0
3 brass	1 larch				
1 deal	1 oak				
Tinned iron tube, 15 ft. long, 9 in wide, in three pieces, to fit one another	-	1	0	0	2 0 0
A whirling table, with screw clamps to fasten on table	-	2	10	0	6 10 0
Harmonic toothed wheels to fit on whirling table	-	1	1	0	2 10 0
Brass collar to fit on whirling table (to clamp perforated cardboard disks)	-	0	2	6	0 10 0
3 wooden laths, 6 ft.	-	0	2	0	0 7 0
1 rectangular steel wire, 4ft. long, ½ in square	-	0	2	6	0 5 6
2 forks for antennae with scratchers	-	0	16	0	1 5 0
6 selected forks on resonance boxes	-	5	0	0	5 10 0
1 set of Wheatstone's rods and bent rod	-	1	5	0	1 10 0
Barrett's compound spring	-	0	5	0	2 0 0
1 kaleidobow	-	1	5	0	1 10 0
4 Lussan's forks with compensator	-	10	10	0	12 0 0
A 4-keyed wind box	-	5	10	0	10 0 0
1 table blow-pipe, complete	-	5	0	0	6 6 0
1 monochord on sounding box, with moveable spring balance attached to pull, 4 cwt	-	2	2	0	7 10 0
1 brass alarm bell	-	0	6	0	1 10 0
A set of Chladni's plates with clamp, two bows	-	2	2	0	3 3 0
Brass bar clamped in centre, with suspended ivory ball (18 in long). For longitudinal vibration	-	1	16	0	3 0 0
3 hoops of gutta serena, 18 in diam. 4 in. deep	-	2	0	0	—
2 blackened brass disks, 1 ft. in diam., with connecting brass tube, ½ in thick, 4 ft. long	-	0	15	0	1 7 6
5 resonant zinc tubes, from 3 ft. to 6 in. in length, 2 in diam	-	0	7	6	0 15 0
1 spiral steel spring (close spiral, 2 ft. long, 1 in diam.)	-	0	2	0	—
A Baden-Powell's wave apparatus	-	3	0	0	6 10 0
A double gas jet. (Singing flames)	-	0	12	0	1 10 6
2 pressure gas bags, with pressure frames and nozzles 4 gallons' capacity	-	2	0	0	7 0 0
6 organ pipes corresponding with forks—An organ pipe fitted with glass side	-	1	15	0	2 2 0
Organ pipe fitted with gas side cell and membrane (nodes)	-	1	15	0	—
1 pitch pipe	-	0	5	6	0 7 6
3 reed pipes	-	0	15	0	1 5 0
Dissected embouchure of organ pipe	-	0	5	0	1 4 0
1 trumpet organ pipe	-	0	10	0	0 15 0
A model of human larynx	-	0	7	6	1 0 0
A single syren	-	4	0	0	4 4 0
An anatomical model of human ear	-	4	4	0	—
<b>Materials</b>					
½ oz Lycopodium	-	0	3	0	—
2 lb. white sand	-	0	1	0	—
2 lb. black sand	-	0	9	0	0 18 0
3 blades with stop-cocks	-	0	7	6	—
160 yards steel pianoforte wire, selected of three kinds	-	0	7	6	—

HEAT

Apparatus.		£	s.	d.	£	s.	d.
2 brass and iron gages and holes		0	10	0	1	0	0
1 hollow brass sphere and ring (for expansion)		0	9	0	0	15	0
Ferguson's pyrometer		1	15	0	4	10	0
Trevolyan's rocker		0	12	0			
Apparatus for comparative expansion of liquids, viz., a tin trough 18 in. long, 6 in. wide, 6 in. deep		0	5	6	0	7	6
1 air thermometer		0	1	6	0	15	0
1 differential thermometer		0	17	6	1	18	0
1 model of Siemen's pyrometer		0	0	0	0	0	0
1 ditto Danell's ditto		5	0	0	5	10	0
Compound band of copper and iron rivetted (for unequal expansion), 18 in. long, 2 in. wide		0	7	6	0	15	0
Compound ribbon of silver and platinum		0	7	6	1	0	0
Apparatus for breaking cast-iron pin by contraction of iron		0	7	6	0	15	0
12 Rupert's drops		0	1	0	0	2	0
14 selected thermometers, viz.							
1 alcohol from 50° to + 120° F.	}	3	5	0	5	0	6
2 mercury from 50° to + 100° C							
2 mercury from 50° to + 360° C							
6 mercury from 0° to + 360° C							
1 maximum and minimum							
1 maximum							
1 minimum							
An iron bar 2 ft. x 1 in. x 1 in.		0	5	0	0	7	6
A copper bar 2 ft. x 1 in. x 1 in.		0	15	0	0	18	0
12 wooden balls, 2 in. diameter		0	4	0	0	10	0
Cylinders for conduction of heat, viz.							
2 copper	}	1	in	diam.,	1	m.	high
1 iron							
1 lead							
1 zinc							
1 bismuth							
1 antimony							
1 box wood							
1 marble							
1 ivory							
Ingenhous's bars (for conduction) with trough		0	15	0	1	5	0
Apparatus for showing conduction of heat by liquids (Guthrie's)		1	10	0	11	0	0
2 copper-cone bottles on stand, with screw adjustment							



Spiral bulb thermometer, mercury, of thin glass for calorimetry, from 20° C. to 200° C. - 0 10 0 to 1 5 0  
 Pure silver evaporating dish, 4 oz., 5 in. diam. - 1 10 0,, 2 7 6



6 porous capsules for freezing under air-pump - 0 4 0,, 0 6 0  
 1 condensing syringe - 0 6 6,, 0 15 0  
 1 Daniell's hygrometer - 1 17 6,, 2 2 0  
 6 barometer tubes - 0 6 0,, 0 15 0  
 A copper well for barometer tubes, with wide mouth - 1 0 0,, 1 15 0



A wooden stand for a series of six barometers (vapour tension) - 0 15 0  
 1 Marceot's boiler - 4 10 0,, 6 0 0  
 1 water hammer, with constricted neck - 0 3 0,, 0 4 6  
 1 cryophorus, 2 ft. long - 0 6 0,, 0 8 6  
 1 copper boiler, silvered inside, to expel cork (spheroidal state), with handle, 4 in. high - 0 12 0,, 0 15 0



Model of Savary's pump - - - - -  
 A pair of silvered reflectors, 15 in. diameter, on stands - 2 2 0,, 10 0 0  
 4 Leslie's cubes, 6 in. x 6 in. x 6 in., with assorted surfaces, one with glass window 3 in. x 3 in. in one face - 0 16 0,, 1  
 2 tinned iron plates, 1 ft. x 1 ft., on stands, with 2 bismuth bars soldered on centres - 0 15 0,, 1 6 0  
 4 saucepans, cylindrical, 1 quart - 0 8 0  
 Double screen with opening for diathermancy, and support - 0 10 0  
 1 plate of alum - 0 2 0  
 1 plate of rock salt - 0 5 0  
 1 plate of glass, square, 3 in. x 3 in. x 1/4 in. - 0 1 0,, 0 5 0  
 1 hollow copper tube for hot oil, 5 in. x 5 in. + 5 in. - 0 2 0  
 Wide open iron tube for gas diathermancy, with opening and stop-cock in middle, 4 ft. long, 6 in. diam. - 0 12 6,, 1 10 0  
 Model of Joule's mechanical heat equivalent apparatus - - - - -  
 A pyrheliometer - 3 0 6,, 4 4 0  
 1 lb. asbestos - 0 3 6,, 0 5 0

LIGHT

Apparatus

Argand lamp and lantern, with condenser and reflector diaphragm, &c. (Ladd's model) - 4 0 0,, 4 10 0  
 Electric lamp with fittings. Dubosq's electric light - 12 0 0,, 21 0 0  
 Ivory balls, from the size of a billiard ball to 1/2 inch diameter, pierced through - 1 5 0,, 2 10 6



	£	s	d.	£	s	d.
2 quires tissue paper	-	0	1	0	-	-
60 yards stout covered copper wire for full force of 50 cells Grove	-	0	18	0	1	10
5 lbs mica in cakes	-	2	10	0	-	-
5 lbs selenite in cakes	-	-	-	-	-	-
1 pint glycerine soap solution	-	0	3	0	0	10
1 lb bone ash	-	0	0	6	0	1

ELECTRICITY.

Frictional Electricity Apparatus.

12 agate cups for support	-	1	10	0	-	-
Size, about.						
3 circular brass plates, rounded edges	-	-	-	-	-	-
(1.) 1/2-in. thick, 12 in diam	-	-	-	-	-	-
(2.) 3/4-in. thick, 8 in diam	-	0	18	0	2	2
(3.) 3/8-in. thick, 4 in diam	-	-	-	-	-	-
2 gold-leaf electrosopes, with tops, each 18 in high	-	0	15	0	6	0
1 Thompson's electrometer	-	-	-	-	-	-
1 small electrophorus	-	0	7	6	0	15
1 Coulomb's electrometer, with mica plate, and glass for sulphuric acid	-	3	3	0	3	10
1 Fish ball electroscope	-	0	8	6	2	2
A mahogany stool, with glass legs, 1 ft. square	-	0	10	0	0	18
2 cylindrical conductors, on varnished glass legs, 18 in. long, with holes and plugs	-	2	10	0	-	-
3 wooden balls, covered with foil, 9 in diam	-	0	10	6	2	0
4 wooden ditto ditto 4 in. diam	-	0	6	0	1	5
1 ice pail	-	2	5	0	-	-
2 brass balls on bent wire and stand	-	0	7	6	2	2
1 ball 4 in diam.	-	-	-	-	-	-
1 ball 1 in diam.	-	-	-	-	-	-

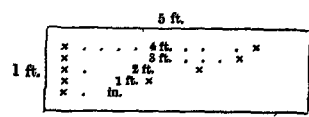


Ball and covers, with insulating handles, viz., ball, wooden, covered with foil	-	2	10	0	4	10
Covers, brass (distribution), diam 1 ft.	-	-	-	-	-	-
Electric wheel	-	0	4	0	0	10
1 cylinder machine (Cylinder, 18 in long, 12 in diam.)	-	4	0	0	10	0
1 plate glass machine (plate 2 ft. diam) with hoop condenser	-	6	0	0	12	0
1 Holt's machine (plate 20 in diam.)	-	7	10	0	21	0
1 brass plate condenser (plates 9 in. diam.)	-	1	0	0	2	0
1 electrophorus, 15 in. diam	-	1	0	0	1	15
1 dissected jar	-	0	10	6	0	15
4 jars, 1 ft. high, 8 in. diam	-	1	1	0	6	0
4 insulated table stands, 6 in. diam., adjustable for height	-	1	4	0	2	0
1 spiral ebonite jar, Guthrie's	-	1	0	0	1	18
1 unt jar, about 5 in. long, 1 in. diam.	-	0	18	0	1	6
1 model of Wheatstone's revolving mirror	-	1	10	0	-	-
1 table for spark discharge for ditto	-	1	10	0	-	-
1 disk, with black cross, to revolve. (Duration)	-	1	0	0	-	-
A table universal discharger	-	1	0	0	2	5
Tube for exhaustion and electric discharge, to screw on to air-pump, 3 ft. long, 4 in. diam.	-	2	5	0	3	8
Discharging rod, jointed	-	0	5	0	0	11
Jar, with foil device, 9 in. high, 5 in. diam.	-	0	12	6	1	1
Franklin's plane, 1 ft. x 1 ft.	-	0	5	0	0	10
Open Leyden jar, of thick glass, for self-discharging, 9 in. high, 6 in. diam.	-	0	10	0	1	0
4 Gasmot's tubes, viz.:	-	-	-	-	-	-
1 air vacuum	-	-	-	-	-	-
1 nitrogen ditto	-	-	-	-	-	-
1 hydrogen ditto	-	1	10	0	2	0
1 carbonic acid ditto, 9 in. long	-	-	-	-	-	-
3 tourmaline crystals, 2 in. long (for pyro electricity)	-	-	-	-	-	-

3 flat coils for induced spark	Thin covered copper wire coils, 1 ft. diam.	3	0	0	4	0
1 steam boiler (1 gallon), with nozzle and valve, on tripod stand, and ring burner	-	5	0	0	-	-

Voltac Electricity Apparatus.

1 galvanometer, Astatic needles, flat, 8 in. long, with screws, stops, shade, &c., complete	-	3	0	0	3	10
Thomson's galvanometer, with mica plate (Barrett's modification)	-	3	0	0	-	-
2 commutators	-	0	12	0	2	3
1 large astatic needle, with coil (for strong currents), needles 6 in long	-	1	17	6	2	10
3 large wire models of open coils. Iron wire painted white, 3 ft. long, viz.:	-	-	-	-	-	-
(a) right-handed	-	0	7	6	0	12
(b) left-handed	-	-	-	-	-	-
(c) conical	-	-	-	-	-	-
1 magnetic needle, horizontally supported (agate), 6 in. long	-	0	10	6	1	10
Large hoop coil of covered copper wire, 18 in. diam.	-	0	18	0	2	0
2 bobbins of copper wire, with ebonite tube core (for electro-magnet), 2 in. internal diam, 8 in. long	-	3	0	0	10	10
1 horse-shoe core for ditto	-	-	-	-	-	-
3 soft iron cylindrical cores for ditto	-	0	10	0	2	10
1 suspended helix, with terminals in mercury cups (thin copper wire), 9 in. long	-	0	10	0	0	12
2 floating helices, one cylindrical, the other loop, with zinc and copper terminals (to float in acid).	-	0	12	0	1	0
1 Volta's pile	-	0	18	0	1	10
1 Wollaston's cell	-	0	5	0	0	15
5-cell Bunsen's battery	-	1	15	0	2	12
14-cell Daniell's battery	-	3	10	0	8	10
60-cell Grove's battery (A)	-	25	10	0	30	0
1 Smee's cell	-	0	5	0	0	10
1 Grove's gas cell for gas battery	-	1	0	0	1	5
6 thin silver plates for polarized battery, 6 in. x 8 in.	-	0	7	6	1	7
1 tangent galvanometer hoop, 18 in diam, accurate, with screws, shade, &c., complete	-	3	10	0	6	6
4 platinum spatulas, each to weigh 1/2 oz.	-	2	16	0	3	0
1 rectangular glass cell, blown, 6 in. x 5 x 3	-	0	15	0	-	-
1 pillar stand for hot platinum spiral	-	1	15	0	-	-
Goodeve's modification of Wheatstone's bridge	-	3	3	0	6	6
Resistance coils, 10 selected from 1,000 to 1	-	15	0	0	-	-
Board with metal screws	-	1	0	0	1	6



1 accurate balance, in case, weigh to 50 grammes turn to 0005 grammes	-	8	10	0	19	0
Agate supports, release, to weigh 500 grammes turn to '005 grammes	-	12	12	0	14	10
4 sets of gramme weights from 500 grammes	-	3	3	0	-	-
A Wheatstone's rheostat	-	3	3	0	15	15
Faraday's balanced wire, to show attraction and repulsion of current	-	0	6	6	0	10
2 flat coils for attraction and repulsion	-	0	12	0	0	15
6 mercury cups, ebonite, 1 in. diam.	-	0	7	6	0	18
1 glass cell for electrolysis of water and salt, 1 ft. x 6 in. x 2 in.	-	1	0	0	-	-
4 cells, glass, for electrolysis of metallic solutions, to fit in lamp, with screw clamps for fine platinum wire	-	3	0	0	5	0
1 Faraday's voltammeter	-	4	15	0	5	5
1 Guthrie's voltmeter	-	2	0	0	3	10
A small magneto-electric machine, with Siemens' armature	-	2	10	0	2	12
1 dissected coil, 8 in long	-	1	10	0	2	10
1 Ruhmkoff's coil, with separated condenser	-	5	5	0	25	0
Model of Morse's make break and relay	-	2	0	0	4	0
Contact breaker and reverser in one	-	0	18	0	2	10
Faraday's balanced wire	-	0	8	0	0	12
Faraday's rotating frame	-	0	7	6	4	0
Spark from Ruhmkoff's coil, revolving in vacuo around electro-magnet (reversible)	-	2	2	0	4	10



	£	s	d.	£	s	d.
1 Barlow's wheel	-	-	0 8 6	to	0 12	'0
Disk of copper, to revolve beneath needle.	-	-	-	-	-	-
9 in diam., $\frac{1}{4}$ in thick	-	-	0 18 0	"	3 12 0	
A slab of uranium glass	-	-	1 1 0	"	1 15 0	
Goodeve's model to illustrate telegraph	-	-	0 15 0	"	1 10 0	
Model of Wheatstone's relay	-	-	10 0 0	"	-	
Morse's telegraph	-	-	9 10 0	"	10 10 0	
Electric alarm	-	-	1 0 0	"	1 10 0	
Electric thermometer	-	-	0 7 6	"	1 10 0	
2 bars	-	-	-	-	-	
(1) Bismuth	-	-	0 12 0	-	-	
(2) Antimony	-	-	3 3 0	"	5 10 0	

	£	s	d.	£	s	d.
12 agate caps	-	-	0 14 0	to	3 0 0	
2 pairs of bar magnets bored through centre, 1 ft. in length	-	-	1 1 0	"	1 10 0	
1 large Ferriant magnet, 9 in. high, on wooden stand	-	-	0 7 6	"	3 0 0	



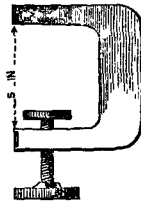
Size.

APPARATUS AND MATERIALS, GENERAL.

Materials, Frictional and Voltaic Electricity

book, gold leaf	-	-	0 1 6	"	0 2 6	
book, Dutch metal	-	-	0 0 2	"	0 1 0	
1 lb tinfoil	-	-	0 1 6	"	0 3 0	
1 piece of amber, $\frac{1}{4}$ oz	-	-	0 0 6	"	0 2 6	
8 sticks, sulphur	-	-	0 0 6	"	0 6 0	
1 cat's skin	-	-	0 2 0	"	0 6 0	
1 fox's brush	-	-	0 2 6	-	-	
3 yards best black silk	-	-	1 1 0	"	1 16 0	
3 lb. electrical amalgam	-	-	0 18 6	"	1 13 0	
4 yards best white flannel (all wool)	-	-	0 10 0	-	-	
8 glass tubes, closed at one end, $2\frac{1}{2}$ ft. long, $1\frac{1}{2}$ in. external, 1 in. internal diameter	-	-	0 7 6	"	0 15 0	
1 Ditto ditto partly ground	-	-	0 2 6	-	-	
3 yards gutta serena ribbon	-	-	0 1 0	"	0 5 0	
1 skein China silk	-	-	0 1 0	"	0 3 6	
1 skein cocoon silk	-	-	0 2 0	"	0 5 0	
1 skein silk braid without cotton	-	-	0 3 0	"	0 4 6	
60 pith balls	-	-	0 7 6	-	-	
2 square feet vulcanized india-rubber, sheet, $\frac{1}{4}$ in thick	-	-	0 7 6	-	-	
4 lbs shellac	-	-	0 8 0	"	0 12 0	
2 square feet sheet ebonite, $\frac{1}{16}$ in.	-	-	0 7 0	-	-	
6 yards brass chain	-	-	0 2 0	"	0 4 0	
Bars of.—						
Magnesium	} 6 in. long, $\frac{1}{4}$ in. diam.		6	10	0	
Zinc						
Tin						
Iron						
Lead						
Silver						
Copper						
Platinum						
Bismuth						
Antimony						
12 lbs iron filings	-	-	0 5 0	"	0 10 0	
20 yards copper covered wire, No. 12	-	-	0 5 0	"	0 7 0	
20 ditto ditto No 16	-	-	0 3 0	"	0 3 6	
6 plates of tin plate	-	-	0 2 0	"	0 3 0	
1 square foot thin platinum foil	-	-	3 0 0	-	-	
12 feet hardened ornolune steel	-	-	0 9 0	-	-	
4 copper balls, with eyes, on stands, 3 in. diam.	-	-	2 0 0	-	-	
4 iron balls, with eyes, on stands, 3 in. diam.	-	-	0 10 0	-	-	
6 cubes of nickel, $\frac{1}{4}$ in.	-	-	0 1 0	-	-	
1 lb of bismuth	-	-	0 15 0	"	0 18 0	

1 iron pestle and mortar	-	-	0 2 6	"	0 10 0	
12 papers of needles, from darning to finest	-	-	0 2 0	"	0 3 6	
20 knitting needles	-	-	0 1 6	"	0 2 0	
6 square feet of iron wire gauze, from very coarse to finest	-	-	0 6 0	"	1 0 0	
20 sheets stout white card board, 2 ft. x 2 ft.	-	-	0 12 0	"	0 14 0	
3 photographic dishes, 1 ft. x 9 in	-	-	0 7 6	-	-	
Porcelain	-	-	0 4 0	"	0 10 0	
2 test tube stands for 24 tubes	-	-	0 10 0	"	0 14 0	
1 gross test tubes, assorted	-	-	0 10 0	"	0 14 0	
24 cylindrical wooden blocks	-	-	-	-	-	
12, $\frac{1}{2}$ in. high	} 9 in diameter		0	18	0	2 5 0
6, 2 in high						
4, 3 in high						
2, 6 in. high						
6 brass table clamps	-	-	1 4 0	"	2 10 0	



12 table stands	-	-	2 8 0	"	4 10 0	
to stand 18 in. high						



MAGNETISM.

Apparatus

4 soft iron bullets, from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. diam.	-	-	0 10 0	"	0 18 0	
1 bar of soft iron, same dimensions as bar magnets	-	-	0 1 6	"	0 5 0	
1 small vertical test needle	-	-	0 10 0	"	0 15 0	
1 wooden sphere, with copper coil, on stand (Barlow's), with binding screws to show earth's magnetism	-	-	3 15 0	"	4 0 0	
Cylindrical bar of soft iron in glass tube, in copper coil, for magnetic expansion, 3 feet long	-	-	0 15 0	"	1 0 0	
1 dipping needle	-	-	1 1 0	"	1 5 0	
1 compass needle	-	-	0 2 6	"	0 15 0	
Box of small magnets for consequent poles	-	-	0 7 6	-	-	
1 steel horse-shoe for magnetisation and demagnetisation	-	-	0 10 0	"	0 12 0	
1 iron bar for earth's magnetism, 5 ft. long, perfectly soft	-	-	0 7 6	"	0 10 0	
4 lode-stones	-	-	0 10 0	"	1 10 0	
6 flat magnetic needles bored through centre, from 9 in to 1 in long	-	-	0 9 0	"	0 15 0	
6 needle stands for magnetic needles, from 1 in. to 6 in. in height	-	-	0 15 0	-	-	

6 universal wooden holders	-	-	1 16 0	"	3 15 0	
6 iron retort stands, with 4 rings each (heavy footed)	-	-	2 2 0	"	2 10 0	
1 gross circular and square glass plates, average 5 in diameter, and diagonal	-	-	0 12 0	-	-	
100 lbs mercury in iron bottle	-	-	17 0 0	"	20 10 0	
1 lb. sulphide of calcium	-	-	0 3 6	"	0 4 0	
1 lb. sulphide of strontium	-	-	0 10 6	"	0 15 0	
1 lb sulphide of barium. In sealed tubes	-	-	0 5 6	"	0 6 0	
20 lbs. fluor spar	-	-	0 5 0	"	0 10 0	
2 oz platinum wire of selected thicknesses	-	-	2 16 0	"	3 0 0	
4 oss. precipitated silica	-	-	0 4 6	"	0 6 0	
$\frac{1}{2}$ lb magnesia "usta"	-	-	0 1 0	"	0 2 6	
20 lbs. quick lime	-	-	0 1 0	-	-	
5 lbs. oxide of mercury	-	-	1 15 0	"	2 10 0	
2 lbs ammoniac alum	-	-	0 2 6	-	-	
2 oss. solution sulphate of indigo	-	-	0 0 6	"	0 1 0	
1 lb tetrachloride of carbon	-	-	0 10 6	"	0 13 0	
10 lbs chlorate of potash	-	-	1 5 0	"	1 6 0	
1 lb gum arabic	-	-	0 2 0	"	0 2 6	
20 lbs oxide of manganese	-	-	0 4 6	"	0 12 6	
5 lbs nitre	-	-	0 3 6	-	-	
2 lbs. cyanide of potassium	-	-	0 6 6	"	0 7 0	
5 oss. nitrate of silver	-	-	0 19 0	"	1 4 0	
10 lbs. chloride of calcium (fused)	-	-	0 15 0	"	0 18 6	
1 oz hitmus	-	-	0 0 4	"	0 0 6	
2 lbs. acetate of lead	-	-	0 2 6	-	-	
1 lb. sulphate of iron	-	-	0 0 6	-	-	

	£	s	d.	¢	d
6 yards muslin, 3 kinds -	-	0	10	0	-
1 carboy of sulphuric acid -	-	0	0	1½	per lb
1 carboy of nitric acid -	-	0	0	7	"
1 carboy of hydrochloric acid -	-	0	0	1½	"
1 pair bellows -	-	0	7	0	-
1 lb iodine -	-	1	16	0	to 2 6 6
10 lbs bisulphide of mercury -	-	2	14	0	" 3 16 0
6 ozs iodide of mercury -	-	0	12	0	" 0 16 0
5 lbs chloride of ammonium -	-	0	4	6	" 0 5 0
20 lbs sulphate of soda -	-	0	4	6	" 0 16 0
8 lbs sulphate of copper -	-	0	4	0	" 0 5 0
1 lb sulphuric ether -	-	0	6	0	" 0 8 0
10 lbs paraffine (solid) -	-	0	15	0	" 0 18 6
1 gallon turpentine -	-	0	4	0	" 0 6 0
1 gallon olive oil -	-	0	6	0	" 0 9 0
4 bolt heads, 2 gallons -	-	1	0	0	-
12 ebony penholders -	-	0	3	0	" 0 6 0
1 glazier's diamond -	-	0	16	0	" 1 5 0
1 gallon methylated spirit -	-	0	4	6	" 0 7 6
30 yards india rubber tubing, ½ in. -	-	2	0	0	" 8 10 0
30 yards ditto ditto ¼ in. -	-	1	2	0	" 1 7 6
2 iron pans with wooden handles -	-	0	7	6	-



½ lb. flowers of sulphur -	-	0	0	8	" 0 0 6
2 ozs red lead -	-	0	0	8	" 0 0 6
1 lb starch -	-	0	1	0	" - - -
½ oz iodide of potassium -	-	0	1	6	" 0 2 0
A box of wafers -	-	0	0	6	" - - -
½ lb gunpowder -	-	0	0	4	" 0 1 0
6 square feet thin sheet glass -	-	0	4	6	" 0 5 0
6 ½-lb. round-bottomed flasks -	-	0	2	0	" 0 6 0
½ ream white blotting paper -	-	0	7	6	" 0 12 0
2 funnels, from 2 pints to ½ pint -	-	0	4	6	" 0 7 6
24 silvered glass beads, from ¼ in. to ½ in. diameter -	-	0	2	0	-
6 Bunsen burners, small size -	-	0	9	0	" 1 4 0
10 lbs soft German glass tubing, ½ in. -	-	0	15	0	-
5 lbs. ditto ditto ¼ in. -	-	0	7	6	" 0 8 6
5 lbs. ditto ditto ⅜ in. -	-	0	7	6	" 0 10 0
6 wooden trays, 2½ ft. x 1½ ft. -	-	1	16	0	-
1 set cork borers -	-	0	0	1	" 0 12 0
1 cork knife -	-	0	1	0	" 0 2 0
1 bottle collodion -	-	0	2	6	" 0 6 6
12 dozen selected corks -	-	0	8	6	" 0 6 0
A box of carpenter's tools -	-	1	0	0	" 2 0 0

## INORGANIC CHEMISTRY

### ELEMENTARY STAGE.

1 *Bunsen Burner, with Rose*—For burning a mixture of coal-gas and air, the latter being admitted through the small holes at foot. The rose is used for gently heating a glass or porcelain vessel, as in Exps 55 & 91; without the rose, a long, narrow, intensely hot flame is produced, suitable for ignition, as in Exp. 1, but not for direct application to glass or porcelain vessels. From 2s. 1d. to 7s. 6d.

2 *A Dozen Test Tubes*—(Exps. 2, 36, 36, 39, 45.)—For exposing various substances to a moderate degree of heat 8d. to 2s. per doz.

3 *Three Test Glasses on Feet*—(Exps 7, 8, 23, 34, 47, 48, 65, 73, 74, 78, 80, 81, 82, 103, 109.)—For showing the effect of mixing various solutions. 6d. to 3s. each.

4 *Two Small Strong Cylinders, 6 in. x 2 in.*—For showing the formation of hydrochloric acid (Exp 6) One is led with hydrogen, the other with chlorine, both being lead with glass disks; they are then placed mouth to mouth, chlorine uppermost, the discs withdrawn, the gases allowed to mix perfectly, and the jars separated, when the application of a flame to the mouth of each cylinder causes an explosion, with production of hydrochloric acid. 3d. to 2s. each.

5 *Two Cylinders on Feet, 12 in. x 1 in.*—(Exps. 2, 12, 15, 16, 17, 19, 24, 40, 52, 53, 54, 57, 58, 62, 67, 70, 77, 85, 89, 94, 95, 96, 99, 101, 102, 106.)—For demonstrating the properties of gases. 1s. to 2s. each.

6 *Two Cylinders on Feet, 15 in. x 2 in.*—(Exps 21, 27, 49, 69.)—For similar purposes. 1s. 6d. to 5s. each.

7 *A Cylinder on Foot, 30 in. x 3 in.*—(Exps 25, 69, 84.)—For demonstrating the solubility of certain gases in water. The cylinder must be filled with dry gas and closed with a stout glass plate, grasped firmly, and the mouth dipped into water, the plate held off so as to allow a very small jet of water to enter the cylinder as the absorption proceeds. 5s. to 32s.

8 *Two-necked Woulff's Bottle, fitted with Thistle Funnel and Delivery Tube*—For the preparation of gases not requiring the application of heat, as hydrogen, carbonic anhydride, nitric oxide, and sulphuretted hydrogen. (Exps. 13, 34, 50, 54, 68, 92.) The tube of the funnel must dip into the liquid in the bottle. 1s. 9d. to 4s.

9 *Two-necked Woulff's Bottles fitted up as Wash-bottles for washing Gases*—For freeing gases from traces of the acids used in their preparation, by passing them through water or alkaline solutions. The inlet tube should just dip beneath the surface of the liquid. By placing strong sulphuric acid instead of water in these bottles, any gas passed through will be freed from moisture. (Exps. 26, 34, 50, 54, 68, 92.) 1s. 4d. to 3s.

10 *Three-necked Woulff's Bottles fitted up as Wash-bottles, with Third Tube as Safety Tube*—(Exps 18, 22, 26, 41, 55, 61, 98, 100, 106.)—For similarly washing very soluble gases, as hydrochloric acid and ammonia. The inlet and safety tubes should just dip beneath the surface of the washing liquid. The safety tube permits of the entrance of air, in case of any running back of water through absorption of gas, and so restores the equilibrium of pressure. 1s. 9d. to 4s.

11 *Large Flasks fitted with Cork, Thistle Funnel, and Delivery Tube*—For the preparation of gases from liquids by the aid of heat. Flame should not be allowed to come in contact with the glass, a piece of iron-wire gauze or a sand-bath being interposed between the flask and the source of heat. (Exps. 18, 22, 26, 41, 55, 56, 61, 98, 100, 105.) 1s. 3d. to 5s.

12 *Smaller Flasks, fitted up as No. 11, and used for similar purposes.* (Exps. 14, 107.) 10d. to 1s. 6d.

13 *Small Flask fitted with Cork and Delivery Tube*—(Exps. 60, 72, 76, 104.)—For heating substances, generally solids, and collecting products of decomposition. Without the tube this may be used as a receiver to condense nitric acid, in Exp 76. 7d. to 1s. 6d.

14 *Large Flasks with Wide Necks*—For burning phosphorus in oxygen, &c. (Exps 28, 66, 71.) 1s. to 4s.

15 *Three Florence Flasks with Corks and Delivery Tubes*—(Exps 26, 55, 79, 83, 86.)—For use when the naked flame must be applied to a glass vessel being cheap, the fracture of these flasks is of slight consequence. 4d. to 1s. each.

16 *Flask with Cork and Two Tubes, used for washing Gases*—(Exps. 26, 41.)—For purposes similar to those described in No 9. Specially, as in Exp 26, for passing a gas through hot water, so as to mix it with steam. 1s. to 2s.

17 *Large Beaker*—(Exps. 42, 43, 90, 108.)—For use when hot solutions are required in open vessels, or when substances are mixed which by their action evolve heat. To be heated upon gauze or a sand-bath. 10d. to 2s.

18 *Retorts, one large, one smaller*—(Exps 76, 90.)—For use in distillation, as of nitric acid. 9d. to 3s.

19 *Large Flask, 1-2 Gallons, with Cork and Five Tubes passing into it, one reaching just through the Cork, the remainder to the Centre of the Flask*—To illustrate the manufacture of sulphuric acid: oxygen or air, nitric oxide, sulphurous anhydride, and steam being admitted through the longer tubes, and an aspirator attached to the shorter one, to maintain a constant current. (Exp 107.) 2s. 6d. to 6s.

20 *Two-necked Bottle fitted as Wash-bottle, but with wide inlet tube*—(Exp. 61.)—For decomposing ammonia by chlorine. A deposit of sal-ammoniac is formed, which would choke a narrow inlet tube. 1s. 9d. to 4s.

21 *Voltmeter to decompose Water and collect the Gases separately*—(Exps. 11, 20.)—May be used also to electrolyse aqueous hydrochloric acid and ammonia. The battery, No. 49, is employed for this purpose. 2s. to 60s.

22 *Bell-jar with Stop-cock, and Glass Vessel for Bell-jar to float in*—(Exp. 30.)—To be filled with a mixture of two volumes of hydrogen and one of oxygen. The gas can be transferred by downward pressure of the jar and opening the stop-cock into a bladder or collodion balloon, which is then exploded by contact with flame. 7s. to 60s.

23 *Stopped Cylinder on Foot*—(Exp. 33.)—For the preparation of ozone, by leaving a piece of freshly cut phosphorus for 30 or 40 minutes in a shallow layer of water at the base of the cylinder. The phosphorus should rise above the water, so as to be partly in contact with the air enclosed in the cylinder. 2s. to 10s.

24 *Long Throat Funnel Tube*.—(Exp. 40).—For conveying sulphuric acid to the bottom of a glass of water, so as to procure the combustion of phosphorus in contact with potassic chlorate. Used also for pouring liquids into non-tubulated retorts without wetting the insides of the necks. 2d to 1s. 9d.

25 *Glass Tube and Silk Rubber*.—(Exp. 4).—For producing electricity. 1s to 7s. 6d.

26 *Large Tubulated Bell-jar*.—(Exp. 59).—The jar being closely stoppered is placed over a capsule, floating on water, containing ignited phosphorus. When the phosphorus ceases to burn, the jar is depressed, so as to equalise the level of the water within and without. The stopper being then removed, the residual gas can be tested and shown to be nitrogen. 2s. 2d. to 10s.

27 *Tubulated Aquarium*.—(Exp. 51).—To be filled with carbonate anhydride through the tubulure at bottom, until the gas overflows. Soap bubbles filled with air will float when they are allowed to fall into the glass vessel. 4s. 6d. to 5s.

28 *Shallow Glass Dish*.—(Exp. 46).—For exposing a large surface of lime-water to the air of the room wherein a lesson is being given, to prove the presence of carbonic anhydride therein. 1s to 2s. 6d.

29 *Series of Two-necked Bottles*.—For passing SH through various solutions of metallic compounds to produce sulphides. (Exp. 97). The bottles should contain aqueous solutions of arsenious anhydride, cupric sulphate, plumbic acetate, tartar emetic, manganous chloride, and zinc sulphate. 2s. 6d. to 10s.

30 *A Tube with Stopcock at Bend surrounded by Glass Vessel to contain Freezing Mixture*.—(Exp. 100).—For the liquefaction of sulphurous anhydride by a mixture of ice and salt. 4s to 12s.

31 *Combustion Tube containing Spongy Platinum*.—(Exp. 105).—Through the heated tube is passed a mixture of two volumes of sulphurous anhydride and one volume of oxygen. They combine to form sulphuric anhydride, which produces dense white fumes when it issues from the tube into moist air. 1s. 6d. to 11s. 1d.

32 *Globe with Two Platinum Wires for passing a Stream of Electric Sparks through Air*.—(Exp. 63).—Under the stimulus of the intense heat of the spark, the constituents of the air in the globe combine to form ruddy fumes of nitrous anhydride and nitric peroxide, which redden moist litmus paper. 1s. 6d. to 17s. 6d.

33 *Clock Glass*.—(Exp. 44).—To contain an alcoholic solution of boric acid, which, on ignition, burns with a characteristic green-edged flame. 4d. to 1s.

34 *Tube for Heating Mercurial Oxide*.—To show its decomposition into mercury and oxygen. (Exps. 10, 26).—The mercury condenses in the bend, the gas passing onwards to a pneumatic trough. 6d. to 1s.

35 *Jet from which to Burn Hydrogen*.—(Exps. 21, 31).—To be attached by a flexible tube to a hydrogen apparatus (No. 8), and, the gas being lighted, lowered into a jar of chlorine or oxygen. 4d. to 1s.

36 *Gas-holder*.—(Exps. 29, 105, 107).—For storing gas for some time, or supplying it in considerable quantity when required for experiment. May be used also as an aspirator. (Exp. 19). 16s. 6d. to 80s.

37 *Porcelain Capsule*.—(Exp. 59).—For use with the bell-jar, No. 26, in the preparation of nitrogen from atmospheric air. 3d. to 1s.

38 *Platinum Fil and Wire*.—(Exp. 38).—The foil serves to show the fixedness or volatility of substances when exposed to a red heat, the wire is used for preparing coloured beads with metallic oxides and fused borax. 1s. to 2s. 6d.

39 *Two Deflagrating Spoons*.—(Exps. 28, 66, 71).—For showing the combustion of sulphur, phosphorus, sodium, &c., in oxygen and chlorine. 9d. to 1s. 6d.

40 *Pestle and Mortar*.—For pulverising various substances.—1s to 6s. 9d.

41 *Broad Camel-hair Brush*.—(Exps. 37, 38).—For brushing a solution of hydroxyl over discoloured white paint, so as to restore its original whiteness. 6d. to 1s. 6d.

42 *Iron Tripod Stands*.—For supporting flasks, &c. over lamps. 9d. to 5s.

43 *Two Retort Stands*.—For a similar purpose. 2s. to 16s. 6d.

44 *India-rubber Tubing, assorted*.—For making connections between the tubes of various pieces of apparatus, as in Exp. 54, where Nos. 8, 9, 45, and 10 are used. It may be cut into lengths of two or three inches for this purpose. 6d. to 2s. per yard.

45 *Clay Furnace for Burning Coke, with Iron Tube to pass through*.—(Exps. 26, 54, 86).—For exposing a gas to a red heat. 10s. to 40s.

46 *Blowpipe Jet*.—(Exp. 29).—Fitted to the gas-holder No. 36, a powerful blast of oxygen may be obtained, and used to show the burning of a bundle of steel wires, by allowing the jet of gas to blow through the flame of a spirit lamp. 1s. 6d. to 7s. 6d.

47 *Pneumatic Trough*.—1s to 15s.

48 *Porcelain Tube to pass through Furnace*.—(Exp. 26).—For use instead of the iron tube in No. 45 in cases where, as with chlorine, the use of iron is inadmissible. In heating a mixture of steam and chlorine the tube should be packed with broken porcelain or pieces of pumice, so as to afford as large a surface as possible. 4d. to 6s.

49 *Five-cell Grove's Battery*.—(Exps. 11, 20).—For electrolyzing water, hydrochloric acid, and ammonia. The full power is needed for this work. When used with an induction coil, the number of cells should be adapted to the size of the coil. 30s. to 90s.

50 *Induction Coil*.—(Exps. 63).—For effecting the direct combination of nitrogen and oxygen by the intense heat of the electric spark. Also for decomposing ammonia gas and marsh gas by the same agency. A coil of the size exhibited will work well with five cells of the battery No. 49. 21s. to 25l.

#### APPARATUS FOR SPECIAL IMPORTANT ILLUSTRATIONS.

1 *Apparatus to decompose Steam by Stream of Electric Sparks*.—Consisting of a five-cell Grove's battery, a Ruhmkorff coil, a globe fitted with platinum wires for the passage of the spark, and a leading tube for gas, mounted upon a flask, in which to generate steam. The flask is half filled with water, which is made to boil, and the steam driven slowly through the globe, led into the pneumatic trough, and condensed. When the air is completely displaced from all parts of the interior, the platinum wires are connected with the coil, which is then set in action. A portion of the steam passing through the globe is thus decomposed, and the mixed oxygen and hydrogen gases can be collected over the pneumatic trough. 4l. 12s. to 13l.

2 *Apparatus for Gas Analysis*.—Intended to submit a mixture of gases to the successive action of absorbents, and so to determine its composition volumetrically. The *modus operandi*, divested of minor details, is simply this. The gas to be analysed is placed over mercury in the reservoir I, then drawn by the descent of a column of mercury into the measuring tube C, where its volume is determined. Being returned into the reservoir I, into which an absorbing agent is thrown, which deprives it of one constituent, the gas is brought back to the tube C and measured again, and this process is repeated until the composition of the mixture is ascertained. An equable temperature is maintained in the measuring tube C by the vessel H being filled with water, which can be agitated, if necessary. The pressure is regulated by the mercury column E, which is raised or lowered as may be necessary, and it is measured by the column of mercury in the tube A. 5l. 5s.

#### Instructions for using the Apparatus

Let the gas to be analysed be common air, or the gas evolved by ebullition from natural waters, consisting usually of carbonic anhydride, oxygen, and nitrogen. First, the gas is carefully transferred without loss to the jar I, and thence drawn by lowering the mercury reservoir and opening the stop-cocks into the tube C, where the apex of the mercury is brought to coincide with any graduation mark. Suppose the following observations to be made:—

Height of mercury in C	-	-	250 mm.
Corresponding volume of gas as per calibration table	-	-	19.2 c.c.
Height of mercury in A	-	-	130.4 mm.
Temperature of water in H	-	-	16.4° C.
Height of barometer	-	-	763.1 mm.
From these data the pressure upon the gas is calculated as follows:—			
Height of barometer	-	-	763.1 mm.
Deduct height of mercury col. in A	-	-	
from height in C, viz., 250—	-	-	119.6
130.4	-	-	
Plus tension of aqueous vapour (the interior of C being moist)	-	-	13.9
at 16.4° C.	-	-	133.5
Pressure on dry gas	-	-	629.6
Hence we have 19.2 c.c. of dry gas at 16.4° C. and 629.6 mm. pressure.			

**Absorption of Carbonic Anhydride.**—This is effected by passing up into the jar I, by means of a small pipette, two or three drops of a concentrated solution of caustic potash. The gas is driven from the measuring tube C into contact with the potash solution by raising the mercury reservoir and opening the stop-cocks. A few minutes' exposure secures the absorption of the carbonic anhydride, and the residual gas, a mixture of oxygen and nitrogen, is drawn back into C and measured as before.

**Absorption of Oxygen.**—A few drops of a concentrated solution of pyrogallic acid are added to the solution of caustic potash in the jar I, and the gas driven from C as before. The alkaline potassic pyrogallate immediately absorbs oxygen, becoming of a deep blood-red colour. By careful manipulation, the jar I may be slightly agitated, so as to promote the absorption, which is known to be complete when the dark-coloured liquid thus thrown upon the sides of the glass runs off again without leaving a dark blood-red stain.

The remaining operation is to determine in C the volume of the residual nitrogen, and the analysis is finished.

Three uncorrected gaseous volumes are thus obtained, viz. —

- A = volume of three mixed gases,  
B = volume of mixed oxygen and nitrogen;  
C = volume of nitrogen.

By the formula given below these volumes may be reduced to 0° C and 760 mm pressure, and then from the corrected volumes A', B' and C', so obtained, the quantity of each gas in the mixture may be deduced

- A' - B' = volume of carbonic anhydride.  
B' - C' = volume of oxygen.  
C' = volume of nitrogen.

The centesimal composition of the mixture is then very easily calculated.

The following formula may be used to bring the observed volumes to standard temperature and pressure:—

$$(1 + 003665 t) 760.$$

V = observed volume of gas in cubic centimetres.  
P = pressure upon the dry gas  
t = temperature at the time the volume was measured.  
For further details, see *Chemical Society's Journal*, vol. xxi p. 109.

**3 Apparatus for the Determination of Vapour Densities by Gay-Lussac's Process, and by Dumas' Process**

**Gay-Lussac's Process.**—The principle of this method is to convert a known weight of a substance, confined over mercury, into vapour, the volume of which being measured at known temperature and pressure, can be readily reduced by calculation to that at standard temperature and pressure. 11 10s to 11 10s 5d.

**Dumas' Process** is the reverse of the preceding. A known volume of a vapour is first measured, and its weight then ascertained; from these data the vapour-density under standard conditions is calculated.

Further details may be found in Miller's *Chemical Physics*

**4 Apparatus for showing that Hydrogen and Chlorine do not contract when they unite to form Hydrochloric Acid.**—This consists of a glass tube having a stop-cock at each end, and filled with a mixture of hydrogen and chlorine in equal volumes. By opening one end of this tube under mercury it is proved to be completely full of gas. Then, either by the light of burning magnesium wire, or by an electric spark passed between two platinum wires fused into the tube, the gases are caused to combine. On opening the tube a second time under mercury, after cooling, the volume of the contained gas is shown to be the same as before combination, and solution of the hydrochloric acid gas in blue litmus-water proves that no hydrogen or chlorine is left. (See Hofmann's *Modern Chemistry*, Lecture III) 5s. 5d to 10s 6d

**5 Apparatus for the Decomposition of Ammonia by Electric Sparks, and for the subsequent Combustion of the liberated Hydrogen by Cupric Oxide.**—A certain volume of dry ammonia gas is confined in the closed limb of the tube, and the height of the mercury therein, after equalisation of pressure in both limbs, carefully marked. Electric sparks are then passed for some minutes between the two platinum wires; the high temperature of the spark decomposes the gas, which expands to exactly double its original volume. Then the voltaic current from five or six cells of a Grove's battery is passed through the spiral of platinum wire, so as to ignite some included pieces of cupric oxide. The hydrogen is thus gradually removed, and nitrogen alone is left to the amount of one half in bulk

of the ammonia originally taken. Hence it is proved that two volumes of ammonia gas are composed of one volume of nitrogen and three volumes of hydrogen. In noting the volumes, the level of the mercury must be equalised in both limbs of the tube. 7s. 6d. to 9s.

**6. Apparatus for the Decomposition of Marsh-gas.**—A convenient volume of marsh-gas is introduced into the closed end of the tube, and, after equalising the pressure, its bulk is marked. It is then decomposed by sparks from an induction coil, with an occasional reversal of the current. Carbon is deposited upon the platinum terminals, and the gas, after decomposition, occupies double its original volume. This product of decomposition can be shown to be hydrogen by igniting it at the jet, when it burns with a flame, which is, however, more or less luminous, on account of the formation of a small quantity of acetylene during the process of decomposition. 6s 6d to 16s 6d

**7. Apparatus for showing that when Carbon or Sulphur burns in Oxygen no Alteration of Volume takes place.**—This consists of a U-tube with a bulb blown in one limb, capable of being closed with a stopper, through which are passed copper wires sustaining a deflagrating ladle of bone-earth to contain charcoal or sulphur, which may be ignited by the transmission of a galvanic current through a fine platinum wire. The bulb being filled with dry oxygen, and the level of the mercury being marked, ignition of the charcoal or sulphur is effected, and on the cooling of the gas it will be observed that no change of volume has occurred on conversion of oxygen into carbonic or sulphurous anhydride. 10s. to 25s

**8. Ozone Apparatus.**—This is intended to ozonise oxygen by induction. It consists of a glass tube coated outside with tinfoil; within this is placed a narrower tube lined with tinfoil or silvered inside. The two metallic coatings are connected with the two ends of the secondary wire of an induction coil, and while a "silent discharge" is made to pass between the two tubes, a current of dry oxygen is slowly driven through from a gas-holder. A portion of the oxygen is converted into ozone, which can be detected by means of iodised starch paper at the exit end of the tube. It is important that the oxygen should be perfectly dry, otherwise the quantity of ozone formed will be very small. 6s. to 25s.

**9. Galvanometer.**—The action of this instrument depends upon the fact that a magnetic needle, freely suspended at its centre, and placed in the neighbourhood of a wire or other conductor along which a current of electricity is passing, tends to place itself at right angles to the line of the current. In practice two parallel needles are mounted the one above the other upon the same pivot, with their poles in contrary directions, so that the action of the earth's magnetism upon them shall be reduced to a minimum. The lower needle is then adjusted within a coil of silk-covered copper wire, and the upper one above a cardboard disk on which is marked an arc graduated into degrees. On a current of electricity traversing the coil of wire, even though it be the feeble current produced by a slight variation of temperature on the face of a thermopile, the motion of the upper needle at once indicates the existence, and to some extent the force of the current. 6s. to 5l. 5s.

**10. Thermopile.**—An instrument for producing feeble currents of electricity by warming at their points of junction bars of bismuth and antimony soldered together. A number of couples of this kind are packed in a brass case, so that half the joints may be on one side and half on the other. The slightest variation of temperature between the two sets of joints is enough to excite a current of electricity, which may, by means of wires attached to the terminal bars, be conducted to a galvanometer, and measured. The heat given off by the human body at a distance of 10 yards is sufficient to affect a delicate instrument 10s 6d to 5l 10s

**11. Daniell's Hygrometer.**—This is an instrument for determining the "dew-point," or the temperature at which the aqueous vapour contained in the air begins to be condensed. It consists of a glass syphon connecting two bulbs. One of the bulbs is blackened, and contains ether, into which dips a small thermometer for the determination of the temperature of the liquid. The instrument is mounted on a stand bearing another thermometer to take the temperature of the surrounding air. The empty bulb is covered with muslin tied tightly round it. To use the hygrometer, a little ether is poured upon the muslin, and the cold produced by its rapid evaporation condenses the ether vapour inside the empty bulb as fast as it is formed in the blackened bulb. By this action the temperature in the blackened bulb is lowered. As soon as the dew-point is reached, aqueous vapour from the air condenses as dew on the black bulb, and at that instant the readings of the two thermometers must be observed. 12s. to 2l 12s. 6d.

12. *Eudiometer to estimate Oxygen in Air*—This instrument is first filled with water. The air to be examined is then introduced, and the level of the water adjusted to the zero of the scale marked on the tube. A few drops of water being now removed from the open end of the eudiometer by a tube, their place is supplied by an equal quantity of solution of potassic pyrogallate, or, what is the same thing, solutions of caustic potash and pyrogallic acid are separately used to refill the open end. The instrument is now closed with the thumb and violently shaken to promote absorption, and then opened under water so that the liquid may rise and its level be ascertained. All measurements must be taken after the eudiometer has been immersed in a glass cylinder containing water, so as to counteract the expansion caused by the warmth of the hand, and while the water is standing at the same level both within and without the tube. 6s to 16s 6d.

13. *Diffusion Tube*—This is a tube closed at one end by a porous plug of plaster of Paris, and open at the other. In using it the plug must on no account be wetted. Hydrogen is the gas usually employed in diffusion experiments, owing to its greater rapidity of motion. The tube may be filled with hydrogen by displacement, first closing the top of the tube by a cork so that no gas may escape through the plug. On then placing the open end of the tube in coloured water, the rise of the liquid on removing the cork shows that the hydrogen escapes through the porous plug more rapidly than the air enters the tube in the opposite direction. Or the open end of the tube may be dipped into water, and a cylinder of hydrogen lowered over the plugged end. The diffusion of hydrogen into the tube is so much in excess of the diffusion of air out of it, that bubbles are forced through the water as if they were violently blown out of the tube. 1s to 2s.

14. *Oxyhydrogen Blowpipe and Gas Bags*—The use of these is sufficiently understood. The chief precaution to be observed is, that the hydrogen must always be ignited before the oxygen is turned on, and an excess of oxygen is to be carefully avoided. Twice as much hydrogen as oxygen (by measure) should be burned. 16s 6d. to 8l. 10s.

15. *Cavendish's Eudiometer*.—This is used for demonstrating the production of water by the explosion of a mixture of oxygen and hydrogen. It is filled by first exhaust-

ing it of air at the air-pump, turning off the stop-cock, and then connecting it with a receiver standing over water and containing a mixture of hydrogen and oxygen in the proportions requisite to form water. The stop-cock being first opened and then closed, the mixture is exploded by the electric spark. After the explosion, the interior will be perceptibly moistened by minute drops of water. 35s to 50s.

16. *Apparatus to prepare Acetylene from Hydrogen and Carbon*—This is a globe, designed to contain hydrogen, with two carbon electrodes nearly meeting in the centre. A Grove's battery of 20 cells is to be connected with these electrodes, which must first be pushed together and afterwards separated so as to produce the voltaic arc. Under the influence of the heat thus generated, combination ensues between the carbon and hydrogen, and acetylene in small quantity is formed. 5s to 15s.

17. *Twenty Cells of Grove's Battery*.—To be used with the preceding 5l to 16l, 16s.

18. *Apparatus for preparing Acetylene from Coal-gas by a Stream of Electric Sparks*.—This much resembles No. 16, a current of coal-gas being substituted for one of hydrogen, and the sparks obtained from the coil No. 1. 3s to 12s.

19. *Model Apparatus for Coal-gas*.—Intended to illustrate the manufacture of coal-gas. The copper retort is to be charged with coal and heated to redness in a charcoal furnace. The Woulff's bottle is intended to arrest fatty matter, the gas is then conducted through slaked lime or ferric hydrate to remove sulphuretted hydrogen, and is afterwards collected in jars or in a gasholder, from which it may be burnt at a jet. Care must be taken that all the air is expelled from the apparatus before the gas is collected. 15s to 2l 2s.

20. *Apparatus for exposing equal Volumes of Hydrogen and Marsh-gas to various Temperatures and Pressures*.—Equal volumes of two gases are placed in the two limbs of the U-shaped tube. The pressure may be increased by addition of mercury in the open tube, or diminished by running off mercury from the pinchcock at the bend. A glass cylinder surrounding the U-tube containing the gases forms a steam jacket, and affords the means of rapidly raising the temperature of the enclosed gases to 100° C. 14s to 35s.

### III.—SKETCH OF EXPERIMENTS IN PHYSICS AND IN INORGANIC CHEMISTRY.

See Memorandum on Science Programmes (page 62).

SKETCH OF EXPERIMENTS IN SOUND, HEAT, LIGHT, ELECTRICITY, AND MAGNETISM. By Professors FRANK GUTHRIE and WM. GOODEVE.

#### SKETCH OF EXPERIMENTS.

##### SOUND.

A body in a state of vibration produces sound.  
A glass goblet set in vibration in contact with pith balls.  
A tuning fork set in vibration in contact with pith balls.  
A large tuning fork struck and waved exhibits its vibrations.  
Alarm or musical box under the receiver of the air pump.  
The end of a long wooden rod scratched by a pin.  
One prong of a tuning fork is armed with a cork cone, which is plunged in water contained in a tube, one end of which is fastened to a sounding board.  
All bodies are compressible.  
Bending of solids. Elasticity of air in syringe. Boyle's Law.  
Propagation of force through a row of solitaire balls.  
A tin funnel covered with a membrane is inserted into a tube filled with smoke, and struck.  
Baden Powell's apparatus for transverse vibrations.  
A thin vulcanized india-rubber tube 30 feet long, stretched (best vertically), shows transverse pulse and its reflexion, also the simultaneous existence of several pulses.  
A thin tube as above, loaded with sand, and marked with tape, shows the passage of longitudinal vibrations, and their reflexion.  
The same experiments with increased tension.

34734.

Baden Powell's apparatus employed to show that separate particles are in different phases.

Speaking tubes.  
Ticking of watch heard through a long tube.  
The same assisted by reflector behind the watch.  
Refraction of sound through a collodion balloon filled with carbonic acid.

Reflexion of sound.

Refraction of sound.

N.B.—The reflexion and refraction of sound may be made manifest by a sensitive flame.

A hand bell ceases to be sonorous when heated over a Bunsen burner.

A glass goblet or funnel ceases to be sonorous when it contains an effervescing liquid.

Dotted line formed on slats by pencil when a note is produced.

The same with brass tubing scraped with a knife.

Trevelyan's rocker.  
Electric syren.

Toothed wheels on whirling table with card.  
Perforated disk of cardboard on whirling table produces notes when air is blown upon the holes.

Preliminary experiments to determine pitch of fork and organ pipe by coincidence with notes of syren (without beats).

A whistle connected with an inflated india-rubber bladder is fastened to the whirling table. The note is graver during approach than during recession.

Vary length of very long rod swinging transversely in vice, and obtain law of vibration according to length.

Wheatstone's kaleidophane and figures (may be reflected and focussed on screen).

Effect of loading the rod.

Imperfect elasticity and mechanical dispersion.

Notes.

Syren.

Rate of sound in air.

Transverse vibrations of elastic rod.

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	<p>A — Lissajou's figures 1 1, 1 2, 2 3, 3 4, &amp;c.</p> <p>Graphic analysis of vibrations exhibited by moving lamp-blackened surfaces across points fastened to selected forks</p> <p>Vary length of stretched wire          .. tension .. ..          .. thickness .. ..          .. material .. ..          and deduce law of vibration</p> <p>Examine actual motion of a vibrating string by means of a light bead fastened to it</p> <p>Nodes on long elastic rod held in the hand          Nodes in struck bar vibrating transversely          Musical glasses and sonorous bars          Harmonics on tuning fork when the bow is drawn near the root exhibited by strewn sand          Chladni's figures on round and square plates, exhibited by sand and lycopodium          Nodes on bell, exhibited by suspended pith balls and water in inverted bell-glass          Multiple nodes in stretched india-rubber tubing, one end being held in the hand          Nodes formed in elastic ring on compressing and extending opposite sides          Silk cord stretched across the mouth of a bell jar or bell exhibits nodes          Silk cord stretched between vibrating forks shows nodes.          A.—Large fork (not sonorous) worked by electric "make and break," and fastened to a stretched silk cord, develops nodes</p> <p>Production of nodes by damping various points of a stretched steel wire Test for nodes by rulers          Experiments with spiral steel wire stretched spring, such as —</p> <p>(1) Vibration when upper end is fastened and lower end is loaded Compare with elastic rod fastened at one end          (2) Fasten at both ends and vibrate longitudinally and transversely          (3) Fasten as (2). Damp the centre and obtain the same nodes for transverse and longitudinal vibrations.          (4) Increase number of nodes</p> <p>Longitudinal vibrations in a brass bar clamped in its centre exhibited upon a suspended ivory ball touching its end          Longitudinal vibrations in a bar of wood          Longitudinal vibrations in a rod of glass, exhibited by the creeping of a paper ring          Compound longitudinal nodes on a strip of glass or metal</p> <p>Air nodes in wide glass tube with moveable piston set up by longitudinal vibrations of an inserted brass bar (lycopodium)</p> <p>Compare above with single resonant cylinder          Resonance of closed cylindrical tubes with selected forks          Closed tubes of lengths 1, 3, 5, &amp;c., resound to the same fork, say C          Closed tubes of lengths 2, 6, 10, &amp;c., resound to lower octave of C</p> <p>Open tube of length <math>l</math> vibrates to fork C          .. .. <math>2l</math> .. .. C and C'          .. .. <math>3l</math> .. .. C not C'          .. .. <math>4l</math> .. .. C and C', &amp;c., &amp;c</p> <p>N B — For closed tubes, glass cylinders tuned with water may be used Numerous telescopic tubes of cardboard both closed and open should be constructed</p> <p>Compare notes of open and closed tubes of equal length          Examine nodes and segments in an organ pipe with a paper tray          A.—Examine nodes in organ pipe by extinguishing gas jets in side chamber for fundamental note and octave.          Cardboard disks are loaded and hung up by double wires of various lengths Another card giving rythmical puffs of air sets one or other of the hung cards in oscillation          A jet of hydrogen, when lighted beneath a glass tube, gives a resonant pop          A rustling flame is converted into a sonorous one by a selected resonant tube          Examine noise of embouchure with and without organ pipe          Blow across open end of closed tube or jar with contracted neck or plial          Sonorous goblet with resonant tube          Metal bell with resonant box, closed and open          Series of forks with resonant cylinders          Use of sounding boxes with forks</p>	<p>Alteration of law of resonance by spreading cavities          Vowel spheres and forks          Jews' harp          India-rubber model of larynx          Reed, with and without pipe          Trumpet stop-pipe.          Trumpet          Willis's "maura tube"          Compare closed pipe with a longitudinally vibrating spring with one end fixed          Length of closed pipe is one quarter of the wave length.          Know or determine the number of vibrations of a fork resounding to a closed jar Measure depth of jar, and so deduce the velocity of sound in air          Make the same determination by means of an open tube, the length of an open tube being one half the wave length          Show how the closed tube must be altered in length when filled with hydrogen or carbonic acid in order to resound to a given fork          Bars of brass, glass, and wood of equal length, when in longitudinal vibration, require resonant air columns of different lengths hence deduce sound rate in these solids          Compare notes by transverse and longitudinal vibrations in brass and iron wires          Sympathetic vibrations of forks in air.          Sympathy of tuned strings on monochord exhibited by rulers on segments and nodes          Sand or drum with organ pipe          A bar held vertically is fastened to two blackened brass circular disks, upon which sand is strewn, the bar is ribbed with resined leather. The arrangement of the sand exhibits the transformation of longitudinal into transverse vibrations          The above apparatus is held above a drum strewn with sand.          The sounding board is attached to a stretched string or fork.          The musical box is placed in the double felt case A wooden rod with sounding board is introduced          Sympathetic vibrations in a piano, violin, &amp;c          Concord of forks          Beats of forks on boxes and above a resonant cylinder.          Loading of forks          Beats with organ pipes          Beats between organ pipe and syren          Beats between tuning fork and syren.          Determination of the number per second of the vibrations of several tuning forks by means of the elimination of beats          A.—Beats by double syren.          Dissonant forks          Lissajou's forks, parallel and vertical, to show interference by sinusoids on screen by consonant, harmonic, and dissonant forks          Turn fork over resonant jar to detect lines of extinction at corners          Interference in organ pipes illustrated by membranes, gas jets, and vibrating mirror          Various sensitive flames affected by different vowels, and by hissing, rustling, &amp;c          Analyze singing flame in tube by means of a mirror          Set up vibration in flame by an organ pipe or tuning fork          Sympathy between two pipes when tuned by a moveable casing          Balanced card disk attracted by tuning fork          Cotton wool attracted by tuning fork          Balance card attracted by disks on rod in longitudinal vibration          Hydrogen in collodion balloon repelled by tuning fork</p>	<p>Human vocal pipes and other wind instruments.          Rate of travel of sound          Communion of vibrations</p> <p>Interference beats.          Singing at various flames.          Approach caused by vibrations</p>
<p>Transverse vibrations of strings.</p>			
<p>Nodes</p>			
<p>Further inquiry into wave motion</p>			
<p>Longitudinal vibration of a column of air (a) closed tubes.</p>			
<p>(b) open tubes</p>			
<p>Selection of vibrations by resonant column</p>			

HEAT

Lengthen a stretched platinum wire by heating it by a galvanic current  
 Fergusson's pyrometer, used with various metals through a fixed range  
 Water, alcohol, mercury, oil, &c., completely filling equal flasks (2 oz.), provided with narrow tubes, are heated  
 Air in a flask is expanded by heat, and a portion is expelled through a tube and collected over water  
 A wide-mouthed balloon is held over a gas flame till it rises  
 An air-tight, somewhat shrivelled bladder, becomes tense on heating  
 The air thermometer and differential air thermometer constructed and explained.  
 A compound band of copper and iron rivetted shows by its curvature when heated the superior expansion of copper.

Sim per exp solid liquid gases  
 Inequality and equal of expan

	<p>A—Complete galvanic circuit by the expansion of brass before the same is effected by iron</p> <p>Compound metal ribbons, as of silver and platinum, curl when heated.</p> <p>Equal flasks of water, alcohol, oil, mercury, &amp;c, full and furnished with narrow tubes, are equally heated. The liquids are found to expand unequally.</p> <p>Equal flasks of air, nitrogen, oxygen, hydrogen, carbonic acid, &amp;c., are equally heated by hot water, and the volumes of the gases expelled through narrow tubes and collected over mercury are the same.</p>	
Force of expansion and contraction.	<p>Break cast-iron pin by the contraction of a cooling rod of iron.</p> <p>Rupert's drops</p> <p>Break flasks of water quite full by expansion</p>	
Thermometers.	<p>Make thermometers (alcohol and mercury) and determine fixed points</p> <p>Danielli's pyrometer.</p> <p>A—Make and use a model of Siemens' pyrometer</p>	
Maximum density of water.	<p>Bring a cylinder of ice-cold water into a warm room, and test the temperature above and below</p> <p>Allow a full flask of ice-cold water with a narrow tube and inserted thermometer to become warm</p>	
Conduction, solids.	<p>Wooden balls are stuck with soft wax at equal intervals along two bars of iron and copper placed end to end, heated at the place of contact. The superior conductivity of the copper causes the balls on it to fall off soonest.</p> <p>Equally long cylinders of ivory, glass, clay, and various woods and metals are placed on flat top of air thermometer, and receive heat from above</p> <p>The same arrangement, substituting thermo-pile for air thermometer.</p>	
Liquids.	<p>Apparent passage of cold by the above arrangements.</p> <p>Boil water at top of test-tube held in the hand</p> <p>Boil water in test-tube over loaded ice.</p> <p>Surround bulb of air thermometer with a cup containing water whose level is above the bulb, and pour hot water on the cold</p> <p>Examine conductivity of mercury, water, oil, oil of turpentine, tetrachloride of carbon, &amp;c; by Guthrie's liquid conductivity cones</p>	Latent heat.
Isaac.	<p>The hand, covered with asbestos, supports a red-hot ball.</p> <p>Quenching of red-hot spiral of platinum by hydrogen.</p> <p>Put out flame of candle by thick copper coil of wire</p> <p>Burn gas above wire gauze.</p> <p>Davy's lamp.</p>	
Illustrations of conduction.	<p>Test sensation of cold on plunging the hand into various liquids of the same temperature, as mercury, water, oil, &amp;c.</p> <p>Compound cylinder of brass and wood with serpentine division to scorch paper.</p> <p>Melt a spherical leaden bullet in paper envelope</p> <p>Burn or shreds of paper in round-bottomed flask heated over gas flame, show convection currents.</p> <p>Sreaks of water produced by descending currents of cold water from ice.</p> <p>Sreaks of ascending currents in water from heated platinum spiral (heated by galvanic current)</p> <p>Same in flask of water when near boiling</p> <p>Show by two flasks and connecting tubing hot water circulation.</p> <p>Ventilation exhibited by candle burning in a bell jar carrying a chimney divided by a diaphragm. The air current tested by smoke.</p> <p>Heat platinum wire by current and show the ascending air on screen (fore-shorten).</p> <p>Project on screen the hot currents from a candle and gas jet.</p>	Relation of heat to change of state.
Convection.	<p>Test sensation of cold on plunging the hand into various liquids of the same temperature, as mercury, water, oil, &amp;c.</p> <p>Compound cylinder of brass and wood with serpentine division to scorch paper.</p> <p>Melt a spherical leaden bullet in paper envelope</p> <p>Burn or shreds of paper in round-bottomed flask heated over gas flame, show convection currents.</p> <p>Sreaks of water produced by descending currents of cold water from ice.</p> <p>Sreaks of ascending currents in water from heated platinum spiral (heated by galvanic current)</p> <p>Same in flask of water when near boiling</p> <p>Show by two flasks and connecting tubing hot water circulation.</p> <p>Ventilation exhibited by candle burning in a bell jar carrying a chimney divided by a diaphragm. The air current tested by smoke.</p> <p>Heat platinum wire by current and show the ascending air on screen (fore-shorten).</p> <p>Project on screen the hot currents from a candle and gas jet.</p>	
Capacity for heat.	<p>Project on screen the currents from a hot poker, &amp;c</p> <p>Compare the capacities of three glass cylinders of different diameters for water. Show how the withdrawal or addition of equal quantities of water affects the level.</p> <p>Cylindrical slabs of metals of equal weight heated to the same temperature, melt different quantities of ice or wax. (Iron, zinc, lead, copper, bismuth, &amp;c.)</p> <p>Balls of the above metals of equal size heated in oil bath to 130° C. penetrate a cake of wax to different degree</p> <p>A ball or cube of copper heated to different degrees heats a given weight of cold water (Siemens' copper cube pyrometer)</p>	
Unit of heat.	<p>Burn gunpowder mixed with sand in a copper vessel under water, and show that the same amount of heat is absorbed in heating two weights of water one degree as in heating one weight two degrees.</p>	
Specific heat.	<p>Equal weights of various hot metals are plunged into cold water of given weight, and the specific heats of the metals deduced</p> <p>Known weights of various hot metals are treated as above</p> <p>Known weights of cold metals are plunged into known weights of hot water to obtain confirmatory results.</p> <p>Model of calorimeter for solids.</p>	
	<p>Mix 1 lb. of ice cold mercury with 1 lb. of water at 100° C.</p> <p>Mix 1 lb. of ice cold water with 1 lb. of mercury at 100° C.</p> <p>Perform the same experiments substituting oil of turpentine for mercury</p> <p>Vary the quantities, temperature, and nature of the substances, and deduce their specific heats</p> <p>Weigh a penny and a half-crown, boil them in water, place them in a cavity of ice covered with an ice slab, and weigh by means of blotting paper the quantities of ice they melt, and so deduce their specific heats</p> <p>Determine the latent heat of water by pouring a pound of boiling water on a pound of dry powdered ice, and determining the temperature of the mixture</p> <p>Vary the temperature of the water and the quantity of the ice and water</p> <p>Weigh a cake of wax or paraffin just beginning to melt in hot water, melt a part of it by a known weight of boiling water, and determine its latent heat from the resulting temperature.</p> <p>Pass low pressure steam into a known weight of ice cold water till the latter is at 100°, from the increase in weight of the water, deduce the latent heat of the steam</p> <p>Substitute boiling oil of turpentine for boiling water in the above, and deduce latent heat of vapour of oil of turpentine</p> <p>Vary the quantity, temperature, and nature both of the condensing substances and the vapours to determine the latent heats of the latter.</p> <p>Surround bulbs of differential air-thermometer with cups of water, and dissolve various salts in one cup.</p> <p>A—Place shallow platinum crucible lid with water on thermo-pile, and dissolve various salts in the water. Show thermo current by galvanometer.</p> <p>Water, alcohol, ether, &amp;c, placed on bulb of air thermometer or differential air-thermometer absorb heat by their evaporation</p> <p>Cold produced by effervescence of mixed liquids.</p> <p>Gases liquefying evolve heat, e.g., ammonia and hydrochloric acid in water.</p> <p>Liquids solidifying evolve heat, e.g., a super-saturated solution of sulphate of soda poured upon the bulb of an air thermometer</p> <p>The same upon a protected thermo-pile</p> <p>Slake lime and hydrate anhydrous sulphate of copper, and so evolve heat by solidifying water</p> <p>Fuse various solids by heating them.</p> <p>Solidify " liquids " cooling "</p> <p>Vapourize " liquids " heating "</p> <p>Condense " vapours " cooling "</p> <p>A—Various experiments with solid carbonic acid, e.g., mix with ether, freeze mercury, therewith freeze water, freeze sulphurous acid, &amp;c.</p> <p>Freezing mixtures.</p> <p>Ice produced by evaporation under air pump.</p> <p>Ice formed in cryophorus.</p> <p>A—Ammonia freezing machine.</p> <p>Still or Liebig's condenser</p> <p>Air compressed and cooled in copper vessel impinges on bulb of air thermometer.</p> <p>A—Airs as above impinges on thermo-pile (compare also "mechanical heat")</p> <p>Difference of boiling points of various liquids, e.g., water, alcohol, turpentine, &amp;c</p> <p>Rectify alcohol</p> <p>Flask of boiling water corked and cooled, recommences to boil.</p> <p>Warm water boils under the air pump, also warm alcohol.</p> <p>Boil ether under air pump</p> <p>Introduce a series of liquids into a series of barometers, e.g., water, alcohol, ether, bisulphide of carbon, &amp;c, and so measure their vapour tension</p> <p>Depress the above into deep copper or glass well to show condensation.</p> <p>Surround the above by a glass cylinder of water of various temperatures.</p> <p>Experiments with Marcell's boiler.</p> <p>Crush a tin vessel by atmospheric pressure against steam vacuum.</p> <p>Syphon gauge for steam tension</p> <p>Adhesion of blocks of ice to one another and to flannel.</p> <p>Cut a block of ice by a loaded wire.</p> <p>Press ice through a wide meshed wire gauze.</p> <p>Compress snow into ice.</p> <p>Water dropped into red hot silver basin.</p> <p>Water drops held by pipette on outside of hot platinum cap. The non-contact proved by break in circuit with galvanometer.</p>	<p>Latent heat.</p> <p>Relation of heat to change of state.</p> <p>Illustrations of thermal effect of change of state.</p> <p>Heat absorbed by expansion</p> <p>Evolution.</p> <p>Variation of boiling point with pressure.</p> <p>Tension of vapours.</p> <p>Regulation.</p> <p>Spheroidal state.</p>

	Force a cork out of a copper flask (silvered internally) by the burst of steam after spheroidal state	
Steam, a true gas	Heat a steam cloud and examine its shadow. Show the transparency of steam in the constricted water hammer	
Radiant heat	(1) Radiant heat reflected A red hot ball throws heat upon a bright tin plate which reflects it on to an air thermometer or pile A candle flame at one end of a long bright tin tube and an air thermometer or thermo-pile at the other (2) Radiant heat absorbed Use of a thermometer with blackened bulb (3) Radiant heat transmitted Copper ball, thin sheet of glass and air thermometer or thermo-pile	
Radiation from various surfaces	Place boiling water in two similar saucepans, one externally blackened, the other bright. Examine after half an hour the temperatures by differential thermometer Experiments with Leslie's tubes. Compare radiation on air thermometer from lamp black, bright metal, scratched metal, isinglass, and glass sides of cubes A—As above, with thermo-pile Compare radiation from bare glass and glass surface covered with gold leaf, on air thermometer or thermo-pile Compare temperature of water placed when hot in bright metal and glazed earthenware tea-pots A bright and a lamp blackened metal saucepan are filled with cold water and placed at the same distance above a hot metal plate. The temperature of the water is compared after half an hour by the air thermometer The front of a piece of paper is partly covered with gold leaf, the back is covered with iodide of mercury. A hot iron is held over the paper A hot ball is placed midway between two vertical tin plates, one blackened, the other bright towards the ball Bars of bismuth are soldered to the outside of each plate and connected with the galvanometer Show that silvered glass reflects little heat	
Absorption of radiant heat	Determine dew point by Daniell's hygrometer Test by means of Argand lamp and thermo-pile the thermancy of (1) glass, rock salt, blackened rock salt, (2) water, bisulphide of carbon, blackened (by iodine) bisulphide of carbon, in glass cells, (3) dry air, coal gas, ether vapour, moist air, in a long tube	
Dew	Examine the distribution of heat in a solar or electric spectrum formed by a rock salt or bisulphide of carbon prism Heat-focus of burning glass with sun Heat-focus of bisulphide of carbon lens The heat of an Argand burner with mirror is sent through ice and then focussed	
Thermancy	Electric or solar radiation is analysed by passing through bisulphide of carbon and iodine, it may then be focussed on bulb of air thermometer, &c A—The emergent beam fails to melt ice but fires paper, &c	
Refraction of heat	Heated ball in focus of one of two parabolic mirrors, gun cotton or blackened bulb of air thermometer in the other Ice in focus of one of a pair of parabolic mirrors, air thermometer in the other A—Pyrheliometer, use of. Test heat produced by stropping a razor, sawing, &c, by air thermometer or thermo-pile Boil ether, fuse fusible metal by heat of friction, using whirling table. Hammer a piece of lead and examine its heat Drop a leaden ball into a wooden tray from a height of 4 ft —Experiments with Joule's apparatus syringe with German tinder or bisulphide of carbon, densation of oxygen by spongy platinum and heat-ect. dry platinum over gas, alcohol, camphor, &c rust air in receiver of air pump, show condensation, initiate by gas jets. show expansion of cool condensed air produces cold in thermometer or thermo-pile. Compare with heat produced by bellows The pendulum illustrates the conversion of potential into kinetic energy A—Illustrations of heat potential in unstable equilibrium in consequence of chemical affinity exhibited by calorimeter, e.g., sulphur carbon, iron, &c, burnt with nitre under water	
Calorescence	Heated ball in focus of one of two parabolic mirrors, gun cotton or blackened bulb of air thermometer in the other Ice in focus of one of a pair of parabolic mirrors, air thermometer in the other A—Pyrheliometer, use of. Test heat produced by stropping a razor, sawing, &c, by air thermometer or thermo-pile Boil ether, fuse fusible metal by heat of friction, using whirling table. Hammer a piece of lead and examine its heat Drop a leaden ball into a wooden tray from a height of 4 ft —Experiments with Joule's apparatus syringe with German tinder or bisulphide of carbon, densation of oxygen by spongy platinum and heat-ect. dry platinum over gas, alcohol, camphor, &c rust air in receiver of air pump, show condensation, initiate by gas jets. show expansion of cool condensed air produces cold in thermometer or thermo-pile. Compare with heat produced by bellows The pendulum illustrates the conversion of potential into kinetic energy A—Illustrations of heat potential in unstable equilibrium in consequence of chemical affinity exhibited by calorimeter, e.g., sulphur carbon, iron, &c, burnt with nitre under water	
Reflexion of heat	Heated ball in focus of one of two parabolic mirrors, gun cotton or blackened bulb of air thermometer in the other Ice in focus of one of a pair of parabolic mirrors, air thermometer in the other A—Pyrheliometer, use of. Test heat produced by stropping a razor, sawing, &c, by air thermometer or thermo-pile Boil ether, fuse fusible metal by heat of friction, using whirling table. Hammer a piece of lead and examine its heat Drop a leaden ball into a wooden tray from a height of 4 ft —Experiments with Joule's apparatus syringe with German tinder or bisulphide of carbon, densation of oxygen by spongy platinum and heat-ect. dry platinum over gas, alcohol, camphor, &c rust air in receiver of air pump, show condensation, initiate by gas jets. show expansion of cool condensed air produces cold in thermometer or thermo-pile. Compare with heat produced by bellows The pendulum illustrates the conversion of potential into kinetic energy A—Illustrations of heat potential in unstable equilibrium in consequence of chemical affinity exhibited by calorimeter, e.g., sulphur carbon, iron, &c, burnt with nitre under water	
Theory of exchanges	Heated ball in focus of one of two parabolic mirrors, gun cotton or blackened bulb of air thermometer in the other Ice in focus of one of a pair of parabolic mirrors, air thermometer in the other A—Pyrheliometer, use of. Test heat produced by stropping a razor, sawing, &c, by air thermometer or thermo-pile Boil ether, fuse fusible metal by heat of friction, using whirling table. Hammer a piece of lead and examine its heat Drop a leaden ball into a wooden tray from a height of 4 ft —Experiments with Joule's apparatus syringe with German tinder or bisulphide of carbon, densation of oxygen by spongy platinum and heat-ect. dry platinum over gas, alcohol, camphor, &c rust air in receiver of air pump, show condensation, initiate by gas jets. show expansion of cool condensed air produces cold in thermometer or thermo-pile. Compare with heat produced by bellows The pendulum illustrates the conversion of potential into kinetic energy A—Illustrations of heat potential in unstable equilibrium in consequence of chemical affinity exhibited by calorimeter, e.g., sulphur carbon, iron, &c, burnt with nitre under water	
Heat of friction	Heated ball in focus of one of two parabolic mirrors, gun cotton or blackened bulb of air thermometer in the other Ice in focus of one of a pair of parabolic mirrors, air thermometer in the other A—Pyrheliometer, use of. Test heat produced by stropping a razor, sawing, &c, by air thermometer or thermo-pile Boil ether, fuse fusible metal by heat of friction, using whirling table. Hammer a piece of lead and examine its heat Drop a leaden ball into a wooden tray from a height of 4 ft —Experiments with Joule's apparatus syringe with German tinder or bisulphide of carbon, densation of oxygen by spongy platinum and heat-ect. dry platinum over gas, alcohol, camphor, &c rust air in receiver of air pump, show condensation, initiate by gas jets. show expansion of cool condensed air produces cold in thermometer or thermo-pile. Compare with heat produced by bellows The pendulum illustrates the conversion of potential into kinetic energy A—Illustrations of heat potential in unstable equilibrium in consequence of chemical affinity exhibited by calorimeter, e.g., sulphur carbon, iron, &c, burnt with nitre under water	
		Light.
	Familiar examples of combustion, e.g., wood, wax, paraffine oil, candle, gas, &c. Test for carbonic acid with lime water Burn sulphur, phosphorus, magnesium, zinc Also in oxygen. Burn antimony in chlorine Light of resisting platinum wire Coal gas mixed with air in blow-pipe flame or Bunsen burner. Introduce platinum wire, lime powder, magnesia, silica, &c Smoky flame is luminous Lime light Loaf sugar rubbed in the dark Quartz pebbles as above Powdered flint thrown upon a hot iron plate in the dark Phosphate of lime as above Sulphides of calcium, barium, and strontium in sealed glass tubes, exposed to light and brought into the dark. Show by means of model of earth, sun, Jupiter, and its satellites the determination of velocity of light by occultation of Jupiter's satellites. Construct and explain model of Fitzinger's wheel Construct and explain model to show aberration of light Obtain small inverted image of a candle flame through a pin hole Cast the shadow of a broad lath by a flat and edge flame Show depth of water when the same quantity is poured into two tin trays of areas 1, 4. Galvanically incandescent platinum wires in ground glass globes of different diameters. Wire frame, a long square pyramid with wire frame sections at 1, 2, 4 from the apex A square frame is placed half way between a flame and a screen A square tube blackened internally with end of ground glass inclined to axis of tube Experiment to show that brightness is not diminished by recession Experiments with Wheatstone's photometer Use shadow photometer and show the use of coloured glasses for comparison. Experiments with Bunsen's photometer, e.g., equal lights at unequal distances, unequal lights at equal distances, &c Pierce tin foil in front of a candle or lamp till the images coalesce Show the formation of a round disc of light through an irregular hole A parallel beam falls at the foot of a slender white rod fastened perpendicularly to a small silvered plane mirror A small vertical mirror in the centre of a horizontal graduated semicircle carries an index and receives a horizontal parallel beam, the index and mirror are revolved Artificial horizon Compare angular motion of reflected beam with that of mirror Explain and use Hadley's sextant Single and multiple reflexion of small luminous object, the latter from parallel and inclined mirrors. Use of moveable model of an object, rods from which are hinged upon an edge representing a reflecting surface The arrangement to show the position of the image in the plane mirror Inversion of parti-coloured beam by reflexion from plane mirror Experiment with candle flame and mirror to verify the above. Write with soap on glass plates, view one side directly, the other by reflexion in a mirror, &c Compare the brightness of light reflected from silver, silvered glass, plain glass, blackened glass Powdered glass Soap suds. Cast a beam of light upon a plane mirror which throws it on a screen, breathe upon the mirror where the beam impinges, and observe the dark spot on screen The shading of an object never reaches its outline Increased reflexion by obliquity of incidence Spherical concave mirror. Focus of parallel rays nearly half way between centre of mirror and centre of curvature Exact focussing in case of parabolic mirror Conjugate mirrors with light in focus of one Spherical aberration and caustic, the latter also from cylindrical band Luminous point on axis of spherical mirror— (1) Beyond centre of curvature (2) At centre of curvature. (3) In principal focus (4) Within principal focus.	Sources of light Also in oxygen. Comparatively luminous of gases & solids Phosphor. cones Fluores. cones Insolation Velocity of light Recognition of light Intensity Photom. Sup. from lens Law of reflection Appar. positive points mirror Appar. relative to or to reflect points formal images Reflex. power surface Mixed reflected images Reflex. focus surface Positi focus from cen. in



	<p>Luminous point above or below axis of spherical mirror—</p> <ol style="list-style-type: none"> <li>(1) Beyond centre of curvature.</li> <li>(2) Near centre of curvature.</li> <li>(3) About principal focus.</li> <li>(5) Within principal focus.</li> </ol>		
Real images.	<p>Real image of flame to verify. Image of illuminated object. Use of diaphragm to diminish aberration.</p>	<p>Demonstrate anatomical model of eye. Image of a luminous body thrown upon a screen (1) behind, (2) within, (3) upon the surface of the eye; by displacement of object and variation of lenses. To illustrate long and short sight and their remedies. A double image of an object seen with one eye close to the object through two pin holes. Distinct vision within the limits obtained by a pin hole or a lens held close to the eye, which therefore acts as a magnifying glass. Determine the <i>punctum caecum</i>. Examine net work of vessels in the eye by a candle in a dark room.</p>	<p>Limits of distinct vision.</p>
Virtual images.	<p>Dispersion when luminous point is between mirror and principal focus Virtual focus and virtual image with concave mirror. Dispersion of parallel beam.</p>	<p>Examine net work of vessels in the eye by a candle in a dark room. Wheatstone's photometer. Rotate an illuminated slit above a series of slits. Apparent superior size of white objects over dark ones. Platinum wire heated by a galvanic current and viewed through coloured glasses. Explain reflecting and refracting stereoscopes and pseudoscope. Analysis and recombination of a flat beam of light by glass prisms. Recomposition of analysed beam by a lens. Interpose opaque screen or glass wedge at different ends of the spectrum before its recombination. Synthesis by rotating discs opaque and transparent. Cast a spectrum on a plane mirror and thence on to a screen; cause the mirror to vibrate. Lens of glass containing biphosphide of carbon gives different focal lengths of images for different colours. Examine the change in colour of the sheath of a conical beam after its rays cross one another. A trough prism with dividers receives different liquids, a wide flat beam of light falls upon all. Examine (1) position, (2) length of spectrum. Examine length of spectra by equal prisms of crown and flint glass. Show achromatic couple of crown and flint glass prisms. Show achromatic combination of water and crown glass prisms.</p>	<p>Duration of images and irradiation.</p>
Convex mirrors.	<p>Dispersion of beam from luminous point on axis of mirror. Dispersion of beam from luminous point above or below axis</p>		
Oblique reflection.	<p>Image, erect, virtual, diminished. Focal lines when the beam is incident obliquely. View a bright coin round the edge of a pail of water.</p>		
Transmission and refraction.	<p>Displacement of a portion of a straight line when viewed obliquely through a flat slab of glass, or shadow of line focussed on screen and the slab held near the line obliquely. Displacement of a parallel beam towards base of interposed wedge of glass.</p>		<p>Stereoscope and Pseudoscope. Analysis of white light.</p>
Inequality of refracting power.	<p><i>N.B.</i>—The angle of the wedge should be so acute that little chromatic effect is produced. Two equal slabs and wedges of crown and flint glass, displace line and shadow unequally Float line on warm water and examine the shadow focussed on screen. Pour hot water through a pipette to the bottom of cold water, focus shadow on screen. Examine vertical straight line through a cell of water and biphosphide of carbon held obliquely. Mix water with syrup and alcohol. Examine shadow of coal gas, also ignited gas jet. Examine shadow of ether vapour, red-hot poker, and red-hot platinum wire (forenhorten on screen). Semicircular bath graduated on inside, a window on diameter, and a sliding sine arm, used to prove law of refraction.</p>		<p>Chromatic dispersion of lenses. Dispersion by different media.</p>
Law of refraction.	<p>Disappearance of a glass rod or powdered glass when plunged into a mixture of biphosphide of carbon and ether. Transparency of waxed paper Total reflexion on surface of water in finger-glass of a coin in it. Compare superficial and internal reflexions by hypotenuse of right-angled prism. Inversion without lateral displacement. Use of water prism with moveable sides, showing total reflexion at one side or at surface of water. Examine test tube in water, empty and full. Air on hairy leaves. Division surface between two liquids totally reflects. A.—A jet of water curved receives a beam of light and carries it along by internal reflexion. The use of the camera lucida.</p>		
Total reflexion.	<p>Intersection of two parallel rays passing through two rectangular prisms of unequal sides put base to base; to illustrate the derivation of plano-convex lens. A.—Model of light-house lenses with prisms arranged for camera. Principal focus for plano-convex lens. Focus of point on axis of plano-convex. Three examples of distance of point from lens. Focus of point off the axis of plano-convex. Three examples of distance of point from lens. Simultaneous foci of two points and formation of images. Foci and images with double convex lens, as above. Point in axis corresponding with centre of curvature at distance 2<i>f</i>. Selected comparative experiments between lens and mirror.</p>		
Lenses.	<p>Real image in air viewed from a distance. Formation of virtual image by convex lens, erect and magnified. Dispersion of parallel beam by plano-convex lens, and double concave lens. Prolongation of focal distance by interposition of plano-concave and double concave lenses. Virtual image by concave lens. Variation in focal distance by using different parts of a lens.</p>	<p>Interpose before a source of white light a red glass and a solution of ammonio sulphate of copper in succession and together. Permanganate of potash in solution is passed along a spectrum; it appears opaque in all colours but its own. Chromate of potash, as above. Absorption bands by permanganate of potash solution. Analyse permanganate coloured beam of light by a narrow prism to show blue, red, and the purple where they overlap. Various opaque-coloured objects seen in monochromatic light as alcohol flame in lamp whose wick contains salt. Also in red and green fires. Cast disks of light on screen through solutions of permanganate of potash and ammonio sulphate of copper, and suddenly interpose opaque screen. Throw coloured light over the screen and cast shadows upon it. Decompose oxalate of iron under water by light. Cause equal volumes of hydrogen and chlorine to combine by light. Decompose iodide of methyl in presence of mercury by light. A.—Decompose nitrite of amyl by passing light through the glass end of a glass tube containing the rarefied vapour of it. Float blotting paper in succession on brine and a solution of nitrate of silver, and expose a portion of it to the light of the sun or burning magnesium ribbon. Examination of Fraunhofer's lines in solar spectrum. A.—Obtain the absorption line of nitrous oxide by interposing a flask of that gas in the spectrum. A.—Examine continuous spectrum from carbon points of electric lamp. A.—Obtain the bright bands for silver, copper, zinc, brass, sodium, &amp;c. A.—Absorb yellow band in sodium spectrum by sodium vapour. Examine in violet light uranium glass, quinine solution, turpentine dropped into water, and alcohol; also examine the above in the spectrum. Show colours when oil of turpentine or lemons is dropped upon water. Show colours of soap bubble. Cover glycerine-soap bubble with a beaker and observe spot and coloured rings. Examine the incidence of lead cones, Nobil's rings, mother-of-pearl, lammoth, ruled gold leaf, Newton's rings. Examine these also in monochromatic light. Cylinder of liquid to show internal reflexion and dispersion.</p>	<p>Colour by partial absorption of white light. Colour by reflexion. Subjective colours. Contrast colours. Chemical effect of light. Spectra.</p>
Comparison between concave mirror and convex lens.	<p>Real image in air viewed from a distance. Formation of virtual image by convex lens, erect and magnified.</p>		
Concave lens.	<p>Dispersion of parallel beam by plano-convex lens, and double concave lens. Prolongation of focal distance by interposition of plano-concave and double concave lenses. Virtual image by concave lens. Variation in focal distance by using different parts of a lens.</p>		
Spherical aberration.	<p>Use of diaphragm. Image of illuminated coin with diaphragm on lens. Cylindrical lens. Bright bullet in test tube of water. Construct model of eye by a bent lead or spherical flask of water, a lens and a luminous or illuminated object.</p>		<p>Fluorescence. Undulatory theory.</p>
The eye.			

Polarization.	<p>Two narrow slits in same plane, one at each end of a tube, to show diffraction.</p> <p>Lycopodium strewn on glass and a candle flame viewed.</p> <p>Ordinary light can be reflected at every angle</p> <p>Diminution and destruction of this power by previous reflexion</p> <p>Polarizing angle for glass</p> <p>Cast a beam of polarized light upon the apex of a square pyramid of blackened glass:</p> <p>Compare polarization of reflected ray by black, transparent, and silvered glass</p> <p>Gradual and complete polarization by repeated refraction</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p>
Polarization by double refraction.	<p>Examine light through tourmaline by tourmaline and by blackened glass, (1) glass used as polarizer, (2) glass used as analyzer.</p> <p>Introduce mica plate between polarizer and analyzer.</p> <p>Show double image by Iceland spar.</p> <p>Test by tourmaline the plane of polarization in Biot's prism</p> <p>Confirm above by reflecting from blackened glass.</p> <p>Iceland spar cut perpendicularly to optical axis shows single refraction.</p> <p>A.—Single and double image Iceland spar prism.</p> <p>Construction and use of Nicol's prism</p> <p>Show the effect on polarized light of selenite, quartz, strain, pressure, vibration in glass, heat, &amp;c.</p> <p>A.—Use of saccharimeter.</p>	<p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p>
Circular polarization detected by instruments.	<p>Examine image formed on the ground glass of a camera obscure by a magnifying lens; also examine the real image in the air by a magnifying glass</p> <p>Use of Ramsden's eye-piece for viewing cross wires and image together, as used in theodolite, &amp;c</p> <p>Huygen's eye-piece for improving the image, increasing the field, and being achromatic</p> <p>Erecting eye-piece</p> <p>Refracting telescope.</p> <p>Conversion of reflecting telescope into microscope.</p> <p>Convex object-glass and concave eye glass; give an erect and magnified image. Opera glass.</p> <p>Construction of a reflecting telescope with concave mirror and eye-piece.</p> <p>Application of polarized light to microscope.</p>	<p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p> <p>Show the difference of tension on parts of long conductor by means of the repulsion of pith balls. Test also by proof plane and electroscopes</p> <p>Test by proof plane and electroscopes the tensions on different parts of insulated, saucepan, flat metallic disk, hat, &amp;c.</p> <p>Roll up a charged sheet of tin-foil in connexion with the electroscope.</p> <p>Roll up the same placed on a sheet of varnished glass on the table</p> <p>Examine the place of the electricity when a charge insulated ball is clasped between two insulated metallic hemispheres</p> <p>Show rotation of electric wheel.</p> <p>Chase gold leaf with excited rod.</p> <p>Gold leaf kite hovering around knob of Leyden jar. The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p>
Sample attraction.	<p>Amber rubbed with flannel attracts lath balanced on glass flask, also gold-leaf, bran, feathers, &amp;c</p> <p>Brown paper (hot) rubbed with a clothes brush attracts as above</p> <p>Foreign post paper rubbed with bottle india-rubber attracts as above, also clings to wall</p> <p>Silk ribbon rubbed with vulcanized india-rubber, as above</p> <p>Collodion rubbed with the fingers, as above.</p> <p>Glass tube rubbed with electric amalgam on silk attracts as above, also paper roller, egg shells, &amp;c</p> <p>Sealing wax rubbed with flannel attracts as above</p> <p>Stick of sulphur rubbed with flannel attracts as above.</p> <p>Excited glass attracts every unelectrified body, including bar magnet.</p> <p>Excited sulphur and sealing wax attract as above.</p> <p>Excited glass and excited wax attract one another.</p> <p>Excited glass repels excited glass.</p> <p>Excited wax repel excited wax</p> <p>N B—The wax and glass when excited may be placed on little wire stirrups and hung from supports by silk tapes.</p> <p>Foreign post excited with india-rubber is cut into strips forming a tassel.</p> <p>The two halves of the silk ribbon excited with vulcanized india-rubber repel one another</p> <p>By this instrument test the nature of the electricities in the above experiments, employing proof-plane</p> <p>N B—Show that the only sure test as to the kind of electricity in the electroscope is the getting increased repulsion</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p> <p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. 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The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p> <p>Bertech's machine</p> <p>Holtz's machine.</p> <p>Cylinder machine.</p> <p>Double plate machine</p> <p>A body may be charged either by the addition or subtraction of electricity or by both combined.</p> <p>Study the method of charging a prime conductor mounted with a point by excited glass or sealing wax</p> <p>Examine the electricities in the prime conductor and rubber.</p> <p>Elementary jar made by two sheets of tin-foil separated by glass.</p> <p>Single Leyden jar charged and discharged</p> <p>Dissected jar.</p> <p>Partial discharge of Leyden jar from the glass to the inner coating</p> <p>Examine the residual charge, primary, secondary, &amp;c</p> <p>A jar cannot be charged unless its outer coating is in connexion with the earth.</p> <p>Charge a jar with both positive and negative from the same prime conductor.</p> <p>Faraday's experiment to show the gradual charging of a submarine cable.</p> <p>Show cascade arrangement.</p> <p>Measure capacity of jar by unit jar.</p> <p>Use of pith ball electroscope.</p>
Two kinds of electricity.	<p>N B—The wax and glass when excited may be placed on little wire stirrups and hung from supports by silk tapes.</p> <p>Foreign post excited with india-rubber is cut into strips forming a tassel.</p> <p>The two halves of the silk ribbon excited with vulcanized india-rubber repel one another</p> <p>By this instrument test the nature of the electricities in the above experiments, employing proof-plane</p> <p>N B—Show that the only sure test as to the kind of electricity in the electroscope is the getting increased repulsion</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p> <p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p> <p>Show the difference of tension on parts of long conductor by means of the repulsion of pith balls. Test also by proof plane and electroscopes</p> <p>Test by proof plane and electroscopes the tensions on different parts of insulated, saucepan, flat metallic disk, hat, &amp;c.</p> <p>Roll up a charged sheet of tin-foil in connexion with the electroscope.</p> <p>Roll up the same placed on a sheet of varnished glass on the table</p> <p>Examine the place of the electricity when a charge insulated ball is clasped between two insulated metallic hemispheres</p> <p>Show rotation of electric wheel.</p> <p>Chase gold leaf with excited rod.</p> <p>Gold leaf kite hovering around knob of Leyden jar. The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p> <p>Bertech's machine</p> <p>Holtz's machine.</p> <p>Cylinder machine.</p> <p>Double plate machine</p> <p>A body may be charged either by the addition or subtraction of electricity or by both combined.</p> <p>Study the method of charging a prime conductor mounted with a point by excited glass or sealing wax</p> <p>Examine the electricities in the prime conductor and rubber.</p> <p>Elementary jar made by two sheets of tin-foil separated by glass.</p> <p>Single Leyden jar charged and discharged</p> <p>Dissected jar.</p> <p>Partial discharge of Leyden jar from the glass to the inner coating</p> <p>Examine the residual charge, primary, secondary, &amp;c</p> <p>A jar cannot be charged unless its outer coating is in connexion with the earth.</p> <p>Charge a jar with both positive and negative from the same prime conductor.</p> <p>Faraday's experiment to show the gradual charging of a submarine cable.</p> <p>Show cascade arrangement.</p> <p>Measure capacity of jar by unit jar.</p> <p>Use of pith ball electroscope.</p>
Electroscope.	<p>Ground glass rubbed with flannel becomes negatively electrified</p> <p>A glass tube held in an alcohol frame becomes negatively electrified</p> <p>A glass rod is excited and connected with the electroscope by means of copper, iron, platinum wires, by dry silk, wet silk, cotton, wooden rods, thin sheets or rods of glass (varnished), vulcanized india-rubber, dry paper, &amp;c., &amp;c.</p> <p>A brass or leaden tube held in the hand and struck with flannel exhibits no excitement.</p> <p>Held in vulcanized india-rubber or otherwise insulated it does.</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p> <p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p> <p>Show the difference of tension on parts of long conductor by means of the repulsion of pith balls. Test also by proof plane and electroscopes</p> <p>Test by proof plane and electroscopes the tensions on different parts of insulated, saucepan, flat metallic disk, hat, &amp;c.</p> <p>Roll up a charged sheet of tin-foil in connexion with the electroscope.</p> <p>Roll up the same placed on a sheet of varnished glass on the table</p> <p>Examine the place of the electricity when a charge insulated ball is clasped between two insulated metallic hemispheres</p> <p>Show rotation of electric wheel.</p> <p>Chase gold leaf with excited rod.</p> <p>Gold leaf kite hovering around knob of Leyden jar. The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p> <p>Bertech's machine</p> <p>Holtz's machine.</p> <p>Cylinder machine.</p> <p>Double plate machine</p> <p>A body may be charged either by the addition or subtraction of electricity or by both combined.</p> <p>Study the method of charging a prime conductor mounted with a point by excited glass or sealing wax</p> <p>Examine the electricities in the prime conductor and rubber.</p> <p>Elementary jar made by two sheets of tin-foil separated by glass.</p> <p>Single Leyden jar charged and discharged</p> <p>Dissected jar.</p> <p>Partial discharge of Leyden jar from the glass to the inner coating</p> <p>Examine the residual charge, primary, secondary, &amp;c</p> <p>A jar cannot be charged unless its outer coating is in connexion with the earth.</p> <p>Charge a jar with both positive and negative from the same prime conductor.</p> <p>Faraday's experiment to show the gradual charging of a submarine cable.</p> <p>Show cascade arrangement.</p> <p>Measure capacity of jar by unit jar.</p> <p>Use of pith ball electroscope.</p>
Nature of surface	<p>Ground glass rubbed with flannel becomes negatively electrified</p> <p>A glass tube held in an alcohol frame becomes negatively electrified</p> <p>A glass rod is excited and connected with the electroscope by means of copper, iron, platinum wires, by dry silk, wet silk, cotton, wooden rods, thin sheets or rods of glass (varnished), vulcanized india-rubber, dry paper, &amp;c., &amp;c.</p> <p>A brass or leaden tube held in the hand and struck with flannel exhibits no excitement.</p> <p>Held in vulcanized india-rubber or otherwise insulated it does.</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p> <p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p> <p>Show the difference of tension on parts of long conductor by means of the repulsion of pith balls. Test also by proof plane and electroscopes</p> <p>Test by proof plane and electroscopes the tensions on different parts of insulated, saucepan, flat metallic disk, hat, &amp;c.</p> <p>Roll up a charged sheet of tin-foil in connexion with the electroscope.</p> <p>Roll up the same placed on a sheet of varnished glass on the table</p> <p>Examine the place of the electricity when a charge insulated ball is clasped between two insulated metallic hemispheres</p> <p>Show rotation of electric wheel.</p> <p>Chase gold leaf with excited rod.</p> <p>Gold leaf kite hovering around knob of Leyden jar. The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p> <p>Bertech's machine</p> <p>Holtz's machine.</p> <p>Cylinder machine.</p> <p>Double plate machine</p> <p>A body may be charged either by the addition or subtraction of electricity or by both combined.</p> <p>Study the method of charging a prime conductor mounted with a point by excited glass or sealing wax</p> <p>Examine the electricities in the prime conductor and rubber.</p> <p>Elementary jar made by two sheets of tin-foil separated by glass.</p> <p>Single Leyden jar charged and discharged</p> <p>Dissected jar.</p> <p>Partial discharge of Leyden jar from the glass to the inner coating</p> <p>Examine the residual charge, primary, secondary, &amp;c</p> <p>A jar cannot be charged unless its outer coating is in connexion with the earth.</p> <p>Charge a jar with both positive and negative from the same prime conductor.</p> <p>Faraday's experiment to show the gradual charging of a submarine cable.</p> <p>Show cascade arrangement.</p> <p>Measure capacity of jar by unit jar.</p> <p>Use of pith ball electroscope.</p>
Conductum.	<p>Ground glass rubbed with flannel becomes negatively electrified</p> <p>A glass tube held in an alcohol frame becomes negatively electrified</p> <p>A glass rod is excited and connected with the electroscope by means of copper, iron, platinum wires, by dry silk, wet silk, cotton, wooden rods, thin sheets or rods of glass (varnished), vulcanized india-rubber, dry paper, &amp;c., &amp;c.</p> <p>A brass or leaden tube held in the hand and struck with flannel exhibits no excitement.</p> <p>Held in vulcanized india-rubber or otherwise insulated it does.</p>	<p>Experiments with insulated human body.</p> <p>The electroscope being neutral, approach and withdraw excited glass and sealing wax.</p> <p>Entrap +<sup>m</sup> electricity induced in electroscope by separation of conductor from electroscope while under induction.</p> <p>Entrap -<sup>m</sup> electricity as above, using wax.</p> <p>Induce +<sup>m</sup> in electroscope by glass rod; connect with earth, remove rod and test.</p> <p>Induce -<sup>m</sup> in electroscopes as above by wax; connect, &amp;c.</p> <p>Test the charge at each end of an insulated cylinder under induction</p> <p>Connect either end of insulated cylinder under induction with the earth, and prove that one electricity only leaves it.</p> <p>Construct a semaphore of pith balls on conductor to prove the same.</p> <p>Light gas by induced free electricity from conductor.</p> <p>Light gas again by withdrawing inducer.</p> <p>Induce electricity in two spheres, insulated and in contact. Separate them and test their electricities.</p> <p>A lath rotates by attraction of rod; test the condition of the distant end.</p> <p>Deduce and illustrate the attraction of all neutral bodies by excited ones.</p> <p>Electrify surface of varnished glass beaker, and place it over pith balls on metal plate connected with the earth</p> <p>Suspend a proof plane and let it vibrate between two oppositely electrified spheres</p> <p>Take -<sup>m</sup> electricity by means of a proof plane from the table over which is an excited glass rod.</p> <p>Brass plate condenser; use.</p> <p>Make a condenser out of two sheets of tin-foil and a varnished sheet of glass. Connect with electroscope</p> <p>Make an electrophorus by means of a zinc or tin plate, an isolating handle of sealing wax or varnished glass. A sheet of vulcanized india-rubber or of varnished glass.</p> <p>Test the electrical state of the excited india-rubber by induction on the electroscope.</p> <p>Test the free electricity of the zinc plate (1) when in contact and (2) when touched and withdrawn.</p> <p>Employ better form of instrument; repeat tests as above.</p> <p>Experiments with electrophorus, such as lighting gas, exploding mixed gases, &amp;c.</p> <p>Show the difference of tension on parts of long conductor by means of the repulsion of pith balls. Test also by proof plane and electroscopes</p> <p>Test by proof plane and electroscopes the tensions on different parts of insulated, saucepan, flat metallic disk, hat, &amp;c.</p> <p>Roll up a charged sheet of tin-foil in connexion with the electroscope.</p> <p>Roll up the same placed on a sheet of varnished glass on the table</p> <p>Examine the place of the electricity when a charge insulated ball is clasped between two insulated metallic hemispheres</p> <p>Show rotation of electric wheel.</p> <p>Chase gold leaf with excited rod.</p> <p>Gold leaf kite hovering around knob of Leyden jar. The jar preferably uncovered</p> <p>Suspended wire with metallic and ordinary paper points to rotate in opposite directions.</p> <p>Needle on cap of electroscope and prime conductor.</p> <p>Melted sealing wax at the end of a needle on prime conductor.</p> <p>Bertech's machine</p> <p>Holtz's machine.</p> <p>Cylinder machine.</p> <p>Double plate machine</p> <p>A body may be charged either by the addition or subtraction of electricity or by both combined.</p> <p>Study the method of charging a prime conductor mounted with a point by excited glass or sealing wax</p> <p>Examine the electricities in the prime conductor and rubber.</p> <p>Elementary jar made by two sheets of tin-foil separated by glass.</p> <p>Single Leyden jar charged and discharged</p> <p>Dissected jar.</p> <p>Partial discharge of Leyden jar from the glass to the inner coating</p> <p>Examine the residual charge, primary, secondary, &amp;c</p> <p>A jar cannot be charged unless its outer coating is in connexion with the earth.</p> <p>Charge a jar with both positive and negative from the same prime conductor.</p> <p>Faraday's experiment to show the gradual charging of a submarine cable.</p> <p>Show cascade arrangement.</p> <p>Measure capacity of jar by unit jar.</p> <p>Use of pith ball electroscope.</p>

Experiments with jars.	<p>Charge a jar, insulate it, connect interior with earth, and test exterior                  Construct electric battery.                  Deflagrate platinum and silver wire                  Explode gunpowder, show use of wet string.                  Burst a tube filled with water.                  Light ether                  Discharge through eggs, sugar, ivory, lemon, &amp;c.                  Discharge through rarefied air, oxygen, hydrogen, and nitrogen                  Pierce paper.</p>	<p>Deposition of hydrogen on platinum shown by floating the platinum foil                  Polarity of hydrogenized platinum is the same as that of zinc.                  Reuter's pile, silver and flannel.                  Devices for the elimination of hydrogen —                  (1) Mechanical, Smee, use of platinumized silver                  (2) Damell's, substitution of copper for hydrogen.                  (3) Bunsen and Grove; burning of the hydrogen</p>	
Duration of spark.	Illuminate by a spark a revolving cross or coloured disk.	Electrolyse water, examine the proportion and nature of the gases, also their polarity.	Electrolysis.
Velocity	Model of Wheatstone's revolving mirror and apparatus for velocity.	Electrolyse salts of silver, copper, lead, &c, using platinum wire electrodes	
Atmospheric electricity.	Flame on end of fishing rod connected with the electro-scope and isolated.	Examine the deposition in a drop of solution under the microscope	
Miscellaneous.	<p>Examine electricity in steam jet near and some distance from nozzle by conductor and electro-scope.                  Explain Thomson's electrometer.                  Explain and illustrate "return" stroke                  Repel and discharge cotton wool by pointed conductor.                  Lichtenberg's figures on electrophorus, varnished glass, ebonite.</p>	<p>Amalgamation of the zinc with mercury                  Throw focus on screen and shadow of metals during their electrolytic deposition.                  In electrolyzing water it follows the current.                  Force water through a porous cell and show current by platinum poles in the cell and outside                  Faraday's voltameter.                  Guthrie's voltameter                  Tangent galvanometer —                  Explain laws of deflexion for tangent and zinc galvanometers.</p>	<p>Motion of water in direction of current                  Electrolytic measurement of current                  Magnetic measurement of current.</p>
Pneumatic electricity.	<p>Formation of jar by one man standing on insulating stool and grasping another man's hand, a sheet of vulcanized india-rubber intervening                  Test for ozone in brush discharge.                  Light gun-cotton by induced spark from flat coil.                  Show the effect on astatic needle of friction current from prism conductor                  As above, using —ve electricity.                  Change the connexions in both above cases with astatic needle.                  Connect secondary coil with astatic needle, and show reversal.                  Experiment with tertiary coil                  Tourmaline connected with Thomson's electrometer.                  (1) Heat. (2) Cool.</p>	<p>Battery of (n) cells and thin platinum wire                  Send a current round a galvanometer and between two platinum spatulae in water —                  (1) Increased effect by acidification                  (2) " " " " approach.                  (3) " " " " deeper immersion.                  Repeat as above, using platinum spiral of thin wire instead of galvanometer.                  Introduce into circuit from battery around galvanometer different metal wires —                  (1) Variation with substance of wire.                  (2) " " " " length                  (3) " " " " sectional area of wire</p>	<p>Magnetic measurement of current.                  General law of resistance.</p>
<b>VOLTAIC ELECTRICITY.</b>			
Connexion between high and low tension electricities.	<p>Deflect astatic needle by selected pairs of metals in salt water, e.g., pin and needle, copper and iron, zinc and lead, &amp;c., and compare with deflection by electricity from prime conductor.                  Volta's crown of cups with zinc and copper.                  Electric potential at the opposite poles, tested (1) with condenser and electro-scope, (2) with Thomson's electrometer.</p>	<p>Show heating effect of current on compound wire of platinum and silver                  A.—Use of Wheatstone's rheostat.                  Galvanometer with angle hoop of thick wire to be used.                  Vary number of cells with no external resistance                  Vary number of cells with large external resistance                  Vary external resistance by—                  (1) varying size of plates.                  (2) " " distance of plates.</p>	Ohm's law.
Condition of the conducting wire.	The copper wire connecting the poles attracts filings if heated.		
Effect of multiplying coils of conducting wire.	<p>Deflection of magnetic needle by current —                  (1) above needle in direction (1)                  (2) " " " " (2)                  (3) below " " (1)                  (4) " " " " (2)</p>	<p>1. Currents in same direction attract.                  2. Currents in opposite directions repel.                  3. Currents, crossing one, another tend to become parallel.                  4. Currents at right angles tend to slide.                  5. Ampères' trough and wire to show that one part of a straight current repels the other part</p>	Mechanical relations of currents
Commutator.	Attraction of filings by coil. Explain and use astatic needle with feeble currents. Construct simple form of, and explain commutator.	1. Setting up current in primary gives reverse in secondary.	Induced currents
Helices.	Make models of right and left handed helices and reversible conical helix.	2. Cessation of current in primary gives current in same direction in secondary.	
Magnatism in soft iron by current.	Pass a current across a piece of soft iron — (1) in direction 1 above the iron (2) " " " " 1 below " (3) " " " " 2 above " (4) " " " " 2 below "	3. Approach of primary gives reverse current in secondary.	
Polarity of coil.	Test the poles of the soft iron.	4. Withdrawal of primary gives same direction of current in secondary.	
Magnets. Electrical machines.	Magnetise a bar of soft iron in a helix by a current — (1) right-handed helix, current direction 1. (2) " " " " " 2. (3) left " " " " " 1. (4) " " " " " 2.	Examine the sliding of a current-bearing wire around a magnet. (1) Current (1) rotating round north pole (2) " (2) " " " " " " (3) " (1) " " " " south " (4) " (2) " " " " " "	Ampères' theory of magnetism
Theory of astatic cell.	Large hoop coil, introduce soft iron. Make horse-shoe electro-magnet, and show simple experiments of attraction The polarity of the coil is the same as that of the core. A suspended helix (solenoid) acts as a bar magnet. A hoop helix and a tube helix are fastened to a bung and floated on acid water, their terminals are of copper and zinc They turn N and S. The above are attracted and repelled by the poles of a magnet.	Rotation of a discharge in vacuo around a permanent or electro-magnet. Examine by galvanometer the current produced through a flat copper coil — (1) When placed on north pole of magnet. (2) " " " " south " " " (3) When taken off north " " " (4) " " " " south " " "	
Theory of astatic cell.	A tin tube sucked into a coil. A.—Foucault's machine. Increased effect (thermal) by increased number of cells. Show increase of potential by multiplying the cells Diminution of effect by lapse of time with angle liquid cell.	Turn the coil over and repeat. Magnetise a bar of soft iron while in a coil and examine the direction of current. Vary poles. Simple magneto-electric machine. Decompose iodide of potassium. Heat platinum wire. Heat between carbon points, &c. Explain Siemens' armature. Explain model of automatic contact breaker.	Magneto-electric machines. Automatic contact breaker.

Rohmkorf's coil.	<p>Model of dissected coil, showing— Discharge through vacuum tubes. Instantaneous nature of induced current by rotating cross Analyse discharge by a rotating mirror or uranium glass Formation of ozone. Induced current in primary or extra current. Use of condenser.</p>	<p>A soft iron bar parallel to the lines of magnetic force becomes a magnet. The lower end of a poker when struck with a hammer repels the end of a needle which points to the north. A current is established in a closed conductor when it is moved, so as to cut the lines of magnetic force.</p>	Induction by earth.
Further effect of induced current.	<p>Rotation of magnetic needle above a copper disc on the whirling table. Use of copper plate in compass. Resistance to motion of conductors in the magnetic field. Copper saw between poles. Copper coin spun between poles. Copper ring dropped between poles. Same broken.</p>	<p>A bar of soft iron in a coil in the magnetic meridian, and dip, is connected with a galvanometer and inverted. Crystallized sulphate of iron inclosed in a tube and swung between poles of an electro-magnet sets axially A.—Solution of sulphate of iron in a tube swung between the poles of an electro-magnet sets axially A.—Powdered dry white sulphate of iron is scattered on black glazed paper above poles of electro-magnet.</p>	Magnetism of iron compounds.
Applications.	<p>Working model to exhibit the production of oscillatory motion by an electro-magnet. Conversion of this into a Morse and relay.</p>	<p>Test. A.—Apparent magnetism due to structure, e.g., short iron wires side by side on wax floating on water. The whole sets equatorially.</p>	Magnetism of nickel and cobalt. Pseudoisotomagnetism.
Electro-lamp.	<p>Wheatstone's needle telegraph and needle relay. Show unequal consumption of poles in air also in vacuo. Explain differential motion of poles and their regulation by a magnet and spring.</p>	<p>A.—A number of iron disks separated by cardboard and forming a bar sets equatorially. A.—A bar of bismuth swung between poles of electro-magnets sets itself equatorially.</p>	Diamagnetism.
Wheatstone's bridge.	<p>Cake silver on negative pole by the projected carbon. Balance the astatic needle by equal currents. Interpose unequal resistances produced by variations in length, thickness, temperature, and kind.</p>	<p>A.—A pellet of bismuth is repelled from either pole. A.—The flame of a candle is split. A.—The flame of ether is split.</p>	
Thermo-electricity.	<p>Pairs of different metals such as zinc, iron, copper, tin, platinum, silver, bismuth, antimony connected with galvanometer and heated at point of contact. Cooling produces opposite current. Passage of current produces heat or cold. Platinum wire and foil to show that current travels with heat.</p>	<p>A.—Oxygen charged with chloride of ammonium vapour assembles round the poles. A.—Show influence of medium by examining apparent diamagnetism of weak solution of sulphate of iron in a strong one.</p>	
Further relation between heat and resistance.	<p>Heat one side of tangle in platinum wire Thin platinum wire in alcohol thermometer. Increased heating of platinum wire when a part is cooled.</p>		
<b>MAGNETISM.</b>			
Attraction.	<p>Show attraction by lodestone on iron filings. Directive polarity of lodestone to the earth and to other lodestone.</p>		
Polarity.	<p>Steel capable of permanent magnetization, iron not. Like poles of needles repel, unlike attract. Either pole attracts soft iron.</p>		
Poles.	<p>Break a hard steel spring magnet into lengths and test the polarity of each. Determine regions of greatest and least attraction by oscillation of needle. Determine law of variation of intensity with distance (1) on torsion balance (2) by oscillations.</p>		
Induction.	<p>Compare time of magnetization of steel and of soft iron when in contact with a magnet. A soft iron bar shifts the pole. Two permanent magnets placed N to S neutralize and exert little attraction on a soft iron bullet. Examine the magnetism in a soft iron bar suspended above a permanent magnet. The greatest possible number of soft iron bullets are suspended from one magnet. Its carrying power is altered by bringing the like or unlike pole of another magnet beneath.</p>		
Relation of heat to magnetism.	<p>Destroy the magnetism in a small steel spring magnet by red heat.</p>		
Magnetization.	<p>A nearly white hot iron ball is not attracted by a magnet. Various methods of magnetization, such as single stroke, double stroke, circular stroke, &amp;c.</p>		
Magnetic curves or lines of force.	<p>Parallel bar magnets beneath sheet of glass. Scatter iron filings on glass, tap and print with paper moistened with nut-gall and gum-water. As above, with like poles in conjunction. As above, with horse-shoe.</p>		
	<p>As above, with piece of soft iron to be magnetized by induction. A.—Grove's experiment to show the passage of light amongst oxide of iron suspended in water and surrounded by a coil.</p>		
Induction through media.	<p>Examples of attraction, and induction through wood, glass, brass, &amp;c. Diminution through iron.</p>		
Magnetism of earth.	<p>Pass a current through a wire wound on a sphere, and compare its magnetism and polarity with that of the earth. Possible cause of earth's magnetism is a series of currents passing from east to west. A.—Measurement of intensity of earth's magnetism by magnetometer.</p>		
Position of earth's poles.	<p>Declination and inclination. Compare with needle about bar magnet.</p>		
		<p>SKETCH OF EXPERIMENTS IN INORGANIC CHEMISTRY. By Dr. FRANKLAND.</p>	
		<ol style="list-style-type: none"> <li>1. Ignition of platinum wire and of magnesium wire in air, to show effect of chemical action in the second case.</li> <li>2. Transformation of liquids and gases into solids and vice versa by chemical action.</li> <li>3. Ignition of phosphorus by red hot bar of iron placed at a distance of several inches.</li> <li>4. Attraction of a suspended wooden rod by an electrically excited glass tube held at a distance of several inches.</li> <li>5. A glass rod moistened with concentrated sulphuric acid held close to a small heap of a mixture of sugar and potassium chlorate produces no effect, but inflames the mixture as soon as the rod is brought into actual contact with it.</li> <li>6. An example of direct chemical union.—Combustion of hydrogen and chlorine by heat.</li> <li>7. Chemical displacement:—Precipitation of copper from a solution of cupric sulphate by a bright plate of iron.</li> <li>8. Mutual chemical exchange:—Add solution of potassium iodide to solution of mercuric chloride.</li> <li>9. Re-arrangement of elements in a compound:—Coagulation of albumen by heat.</li> <li>10. Resolution of a compound into its elements, or into two or more less complex compounds.—Heat mercuric oxide and show oxygen and mercury produced.</li> <li>11. Electrolysis of water, with demonstration of properties of the separated gases.</li> <li>12. Preparation of hydrogen by the action of sodium upon water.</li> <li>13. Preparation and collection of hydrogen from zinc and dilute sulphuric acid.</li> <li>14. Preparation and collection of hydrogen from zinc, and solution of caustic soda.</li> <li>15. Burn jar of hydrogen, mouth upwards, and another with the mouth downwards.</li> <li>16. Pour hydrogen upwards from one jar into another.</li> <li>17. Extinguish a burning taper in hydrogen.</li> <li>18. Preparation and collection of chlorine from manganese oxide and hydrochloric acid.</li> <li>19. Bleach carmine paper in the gas.</li> <li>20. Electrolysis of solution of hydrochloric acid. Collect gases separately and show their properties.</li> <li>21. Burn jet of hydrogen in chlorine.</li> <li>22. Prepare hydrochloric acid gas from common salt and sulphuric acid. Collect over mercury or by displacement of air.</li> <li>23. Show by test papers alkalinity of solution of potash, acidity of solution of hydrochloric acid, and neutrality of liquid produced by the mixture of these solutions in suitable proportions.</li> <li>24. Extinguish taper in hydrochloric acid gas.</li> <li>25. Show solubility of hydrochloric acid gas in water.</li> <li>26. Prepare and collect oxygen from mercuric oxide, potassium chlorate, a mixture of potassium chlorate and manganese oxide, and by the transmission of chlorine and steam through a red-hot tube.</li> </ol>	

27. Burn a taper in oxygen, and show re-kindling from glowing wick.
28. Combustion of phosphorus in oxygen.
29. Combustion of bundle of steel wire in stream of oxygen.
30. Explosion of mixture of oxygen and hydrogen.
31. Show formation of water from jet of hydrogen burning in oxygen.
32. Show neutral reaction of water.
33. Show formation of ozone by action of moist phosphorus upon air. Show action of ozonized air upon paper impregnated with starch and potassium iodide.
34. Preparation of hydroxyl by passing a stream of carbonic anhydride through water containing baric peroxide in suspension.
35. Heat hydroxyl in test tube, and show evolution of oxygen.
36. Add argentic oxide to hydroxyl, and show production of oxygen and metallic silver.
37. Wash with solution of hydroxyl paper discoloured with plumbic sulphide.
38. Wash with solution of hydroxyl white oil paint similarly discoloured.
39. Prepare chloric peroxide ( $\text{Cl}_2\text{O}_3$ ) in test tube, and explode it with a hot wire.
40. Add sulphuric acid to a mixture of phosphorus and potassium chlorate under water.
41. Prepare hypochlorous acid by agitating chlorine with mercuric oxide and water.
42. Transmit current of chlorine through boiling milk of lime, add potassium chloride to filtered product, and then crystallize out potassium chlorate.
43. Preparation of boric acid from borax and hydrochloric acid.
44. Flame of a solution of boric acid in alcohol.
45. Preparation of charcoal from wood in test tube.
46. Show crust upon lime water after exposure to air.
47. Add hydrochloric acid to pieces of old mortar, and show that carbonic anhydride is evolved.
48. Breathe through lime water.
49. Burn candle in glass cylinder filled with air, and show formation of carbonic anhydride by lime water.
50. Prepare and collect carbonic anhydride from limestone, chalk, or marble, and hydrochloric acid.
51. Show that soap bubbles filled with air float on carbonic anhydride.
52. Pour solution of litmus into jar of carbonic anhydride.
53. Immerse lighted taper in jar of carbonic anhydride.
54. Pass carbonic anhydride through an iron tube filled with charcoal, and heated to redness. Show the inflammability of the carbonic oxide produced.
55. Prepare and collect carbonic oxide from a mixture of oxalic acid and sulphuric acid.
56. Prepare and collect carbonic oxide from a mixture of sulphuric acid and yellow prussiate of potash.
57. Inflame jar of carbonic oxide, and immerse lighted taper in the gas.
58. Agitate lime water with carbonic oxide, and show that no turbidity is produced, inflame the gas, agitate again, and demonstrate the production of carbonic anhydride.
59. Prepare nitrogen by burning phosphorus in atmospheric air.
60. Prepare and collect nitrogen from ammoniac nitrate, or from a mixture of potassium nitrate and ammoniac chloride.
61. Prepare and collect nitrogen by passing chlorine into strong solution of ammonia.
62. Immerse a burning taper in nitrogen.
63. Pass electric sparks through air in a small vessel containing litmus paper.
64. Show neutrality of nitrogen.
65. Prepare and collect nitrous oxide from ammoniac nitrate. Show production of ammoniac nitrate from nitric acid and ammoniac carbonate.
66. Show that feebly burning sulphur is extinguished in nitrous oxide, and that sulphur strongly ignited continues to burn in the gas with augmented brilliancy.
67. Immerse a burning taper in nitrous oxide.
68. Prepare and collect nitric oxide from copper and nitric acid.
69. Add nitric oxide to air in a jar over water.
70. Immerse a burning taper in nitric oxide.
71. Show that feebly burning phosphorus is extinguished in nitric oxide, and that strongly ignited phosphorus burns in it brilliantly.
72. Preparation of nitrous anhydride from nitric acid and arsenous anhydride.
73. Show the reducing action of nitrous acid by adding a solution of potassium permanganate to an acidified solution of a nitrite.
74. Show the oxidizing action of nitrous acid by adding a solution of a nitrite to acidulated water tinted with magenta.
75. Prepare nitric peroxide ( $\text{N}_2\text{O}_4$ ) by mixing nitric oxide and oxygen.
76. Prepare nitric acid from potassium nitrate and sulphuric acid.
77. Prepare nitric acid by the direct combination of nitric peroxide and hydroxyl.
78. Pour nitric acid upon copper shavings.
79. Deflagrate a mixture of nitre and charcoal.
80. Add strong nitric acid to gold leaf.
81. Add strong hydrochloric acid to gold leaf.
82. Mix the two last-named liquids together and show that the gold leaf then dissolves.
83. Prepare gaseous ammonia from a mixture of ammoniac chloride and slacked lime. Collect over mercury or by displacement.
84. Demonstrate solubility of ammonia in water.
85. Immerse a taper in gaseous ammonia.
86. Burn a stream of gaseous ammonia at the end of a hot tube.
87. Show alkalinity of ammoniac.
88. Demonstrate volatility of ammoniac chloride.
89. Show production of ammoniac chloride from gaseous ammonia and hydrochloric acid gas.
90. Prepare plastic sulphur.
91. Melt sulphur in test tube and show changes as the temperature increases.
92. Prepare and collect sulphuretted hydrogen from ferrous sulphide and dilute sulphuric acid.
93. Burn jet of sulphuretted hydrogen, and hold over the flame a glass rod moistened with ammonia.
94. Show acidity of sulphuretted hydrogen.
95. Decompose sulphuretted hydrogen by sulphurous anhydride.
96. Decompose sulphuretted hydrogen by chlorine.
97. Pass sulphuretted hydrogen gas through an aqueous solution of each of the following substances—Arsenous acid, cupric sulphate, plumbic acetate, tartar emetic, and zinc sulphate.
98. Prepare sulphurous anhydride by the action of copper upon sulphuric acid. Collect over mercury or by displacement.
99. Show action of sulphurous anhydride on litmus paper.
100. Condense sulphurous anhydride in glass tube immersed in a mixture of snow and salt.
101. Immerse tape in sulphurous anhydride.
102. Demonstrate solubility of sulphurous anhydride in water.
103. Bleach infusion of rose leaves by sulphurous acid, and then restore the colour by addition of dilute sulphuric acid.
104. Convert sulphurous acid into sulphuric acid by—
  - 1st. Exposing its aqueous solution to the air and,
  - 2nd. By heating its aqueous solution with nitric acid.
105. Demonstrate the formation of sulphuric anhydride by passing sulphurous anhydride and oxygen over ignited spongy platinum.
106. Show the formation of sulphuric acid by the direct union of sulphurous anhydride and hydroxyl.
107. Prepare sulphuric acid by mixing sulphurous anhydride, oxygen or air, nitric peroxide, and steam, in a flask.
108. Add one volume of concentrated sulphuric acid to two volumes of strong syrup of white sugar placed in a capacious vessel.
109. Demonstrate the spontaneous decomposition of free hyposulphurous acid, by adding dilute sulphuric acid to a solution of sodic hyposulphite.

EDWARD FRANKLAND.

## APPENDIX III.

REPLIES TO SECRETARY'S LETTERS, DATED JULY 22<sup>ND</sup>, 1870, AND  
SEPTEMBER 27<sup>TH</sup>, 1872.A. REPLIES TO SECRETARY'S LETTER of the 22<sup>ND</sup> of July 1870.

On the 22<sup>nd</sup> of July 1870, the letter given below was sent to the Head Masters of the following Colleges and Schools:—

Charter House School.	Gresham College.	St. Paul's School.
Cheltenham College.	Harrow School.	St. Peter's College, Westminster.
Christ's Hospital.	King's College School.	Shrewsbury School.
City of London School.	Marlborough College.	Taunton College School.
Clifton College.	Merchant Taylors' School.	University College School.
Dulwich College.	Rossall School.	Wellington College.
Eton College.	Rugby School.	Winchester College.

Aid to Science Commission,  
6, Old Palace Yard, Westminster, S.W.  
July 22, 1870.

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to express a hope that you may be disposed to assist the Royal Commissioners in prosecuting the important inquiry with which they have been charged by Her Majesty, by kindly furnishing, for their use, a statement showing to what extent

scientific instruction has been introduced at \_\_\_\_\_ and how many pupils have availed themselves of it, and with what effect, in each year, since its introduction.

I have the honour to be  
Your obedient servant,  
J. NORMAN LOCKYER,  
Secretary to the Commissioners.

The following replies were received:—

## 1. ST. PETER'S COLLEGE, WESTMINSTER.

19, Dean's Yard, Westminster, S.W.,  
July 22<sup>nd</sup>.

DEAR SIR,  
I REGRET to say that owing to the very limited space at present available at Westminster, no systematic teaching of natural science has been possible. Lectures by Dr Noad (of St George's Hospital) have, for the last six years (except last year, when his other engagements prevented it), been delivered to voluntary classes of about 40 to 50 pupils, of whom not more than six or eight in each year have really exerted themselves to profit by the instruction.

I am, dear sir,  
Faithfully yours,  
CHARLES E. SCOTT

## 2. CHRIST'S HOSPITAL.

Christ's Hospital, London, E.C.  
July 24, 1870.

SIR,  
In answer to your letter dated July 22<sup>nd</sup>, I have to say that previous to last September the only regular scientific instruction given in Christ's Hospital was that included in the course of our mathematical department, in which some 50 boys learn navigation, and the other subjects required for the naval examination, and others read a great part of the subjects required in the mathematical examinations at Oxford and Cambridge. In September last, by agreement with the authorities of St Bartholomew's Hospital, a *chemistry class* was commenced under the instruction of Dr Matthiessen. The lectures and practical work were held in the laboratory of St Bartholomew's. The attendance of the boys was perfectly voluntary, and all their work was done during play hours. (I should add that the old period of the school time was shortened simultaneously, with the express purpose of favouring this and similar expansions of the educational system.) We have every reason to be satisfied with the results so far. The senior class, containing 14 boys, was tested by practical work and by the paper given at the last London University Matriculation Examination (on the same day and hour). All were reported as having done enough to pass, while several would have been distinguished. The junior class, containing 30 boys,

also satisfied the examiner by their proficiency in practical work.

The governors have accordingly resolved to continue the class under the same arrangements.

This is, so far as I know, the only instruction given here in physical science, with the exception of a course of lectures delivered in the hall three or four years ago by Professor Odling.

I have the honour to be, Sir,  
Your obedient servant,  
G. C. BELL,  
Head Master.

## 3. SHREWSBURY SCHOOL.

The School, Shrewsbury,  
July 23<sup>th</sup>, 1870.

SIR, I HAVE much pleasure in informing you that all boys attending this school are instructed in elementary mathematics according to the degree of proficiency which they have attained in arithmetic, that is, algebra, Euclid, trigonometry, and conic sections. We have no special scientific class. You will find a list of the mathematical honours gained by Shrewsbury in the report of the Public Schools' Commission.

I am, Sir,  
Your obedient servant,  
H. W. MOSS.  
J Norman Lockyer, Esq.

## 4. CHARTER HOUSE.

Charter House,  
July 29<sup>th</sup>, 1870.

SIR, In answer to your letter (July 22<sup>nd</sup>), I have much pleasure in sending information about the scientific teaching of this school.

1. For more than 10 years past there has been a class for elementary chemistry in the school. The lessons are given twice a week. There are annual prizes (generally two) for proficiency. The average attendance has been 27, the average number of boys in the school having been 135.

This year I took advantage of a course of lectures (about 20 in number) delivered at the Finsbury Institution by

Mr. Bloxam. *Four of my boys attended this course and derived much benefit from it*

ii The subject of applied mechanics has been taken up here, but not hitherto to any great extent

It is right to add that I have found many difficulties in the way of carrying out my wish to advance scientific study in this school. Very soon after I came here, the removal of the school from its present site was mooted. This question has now been determined some time, and our new buildings are in progress on a site near the town of Godalming. It is obvious that with the prospect of removal before us, I could not well have asked the governors to make any important addition to our present school accommodation, which, in my opinion, is very far from sufficient.

Our new site promises many facilities for scientific teaching, and our new buildings will not be made without reference to it. The neighbourhood to which we are going offers admirable opportunities for the practical pursuit of botany and geology, and I shall be glad to give every encouragement to the study of these subjects, as well as to those (i. and ii) already adopted, and to any others which may seem suitable for a school course.

I am, Sir,

Yours faithfully,

WM. HAIG-BROWN.

J. Norman Lockyer, Esq.

#### 5. WINCHESTER COLLEGE.

The College, Winchester,

September 3rd, 1870.

SIR, You will, I hope, have interpreted the delay in answering your communication on the subject of physical science teaching to have been due to your letter having been sent just as our holidays began.

The course which my predecessor, the Bishop of Salisbury, adopted for teaching physical science in the school was—

1. To have a succession of leading scientific men from London and Oxford, to give short courses of lectures on their special subjects to the whole school collectively.

2. To give prizes for collections of flowers.

I believe considerable interest was stimulated by these methods.

Subsequently he engaged permanently an able teacher from Oxford to come down once a week throughout the year, to give lectures on different subjects to two classes.

When I became Head Master, about four years ago, that teacher made an engagement elsewhere, and I preferred to have a resident master. Since that time there have been always three classes, having two lectures a week, one taught geology by one of our masters who is acquainted with it, the other two having lectures in botany, mechanics, and physical geography, and occasional courses in light, heat, and electricity, from the natural science lecturer. All boys in the second main division of the school attend these lectures as part of their regular work. The division consists of about 100 boys altogether. A boy stays about two years in it. When he passes from it into the sixth it is optional whether he learns physical science. About one fourth of the sixth go on with it, forming a separate class, and going on till they leave school. Prizes are given twice a year for examinations in the lectures. I see papers of some of the best and worst, and think the results are quite satisfactory.

I have latterly had another master to teach P.S. to a class who are never likely to reach the division in which it is regularly taught, and who form a "Modern Class" (of about 25).

A "Natural History Society" has been started in the school, to encourage boys to collect things and to communicate with one another about them. They have shown interest, and made creditable collections of flowers, insects, and fossils.

Prizes have been given at different times by one of our masters and myself for such collections, but I think they collect as well for themselves without prizes.

We are beginning to form gradually a museum, library, and sets of apparatus, but these are works of time and are not yet far advanced.

I look forward to the time when a laboratory can be established. At present we have no means of teaching chemistry beyond a certain amount of lectures, but I hope that will not continue to be the case long.

I have the honour to remain, Sir,

Your obedient servant,

GEORGE RIDDING, D.D.,

Head Master of Winchester College.

#### 6. THE COLLEGE SCHOOL, TAUNTON.

The College School, Taunton,

September 12th, 1870.

SIR,

I AM requested to furnish a statement showing (I) to what extent scientific instruction has been introduced at Taunton School, (II) how many pupils have availed themselves of it, and (III) with what effect, in each year since its introduction.

I. The teaching of physical science was introduced into the school in 1865. A house adjoining the old school was bought, a rough laboratory was fitted up, a typical museum was commenced, a small piece of ground was laid out as a botanical garden, and a thermometer stand, with a complete set of meteorological instruments, was erected. I began in that year by teaching comparative physiology to the higher classes, and experimental mechanics to the junior. In 1866 a class was formed in chemistry, and in 1867 I took the senior boys through a course of botany. In 1868 the teaching was systematised, and has been continued ever since, as follows—

Classes I. II (consisting of the youngest boys) An amusing lesson in general elementary science, with objects and experiments of all kinds. One hour a week.

Class III Elementary mechanics, without a text book. Three hours a week.

Class IV. Advanced mechanics, with Newth's Natural Philosophy as a text book. Three hours a week.

Class V (b) Elementary chemistry. Three hours a week. Mechanics kept up. One hour a week.

Class V. (a.) Advanced chemistry with laboratory work Barff, text book. Four hours a week.

Class VI. Botany, Oliver, text book. Two hours a week. Chemistry as before. Two hours a week.

The few seniors who have completed this course, work at comparative physiology. Three hours a week.

Classes V and VI Register the meteorological observations twice a day, three boys taking each week, and work the monthly computations for the Registrar General's Report.

A small class practises with the theodolite once a week.

A voluntary class of nine boys is at this moment reading Lockyer's Elementary Astronomy, in view of a prize offered for the subject by a gentleman in the neighbourhood.

The regular lessons in physical geography include a sketch of geology, mineralogy, and zoology, and our museum collection in these departments is rapidly increasing.

II From the first I have refused to make the science teaching optional. It has been imposed upon all the boys, and has exercised the same influence on marks and promotion as the other work. Boys now at the top of the school have gone through the entire course, and in future all will do so.

III The technical result of our science work, as shown by examination, is as follows—In 1865 one senior passed in physics, and two juniors in mechanics, in the Oxford local examination. In 1866 three juniors in mechanics. In 1868 one senior in physics, and seven juniors in mechanics. In 1869 five juniors in mechanics. In 1870 three seniors and one junior in chemistry; and in the same year two boys matriculated at the London University. I may be allowed to remark, that we are prevented from using the Oxford local examination as an efficient test of our scientific work by the rule which limits junior candidates to five subjects. It is notorious that both classics and mathematics gain many more marks in this examination than science, and thus many of our boys each year who could pass with ease in mechanics are prevented from taking the subject in.

Passing from the technical to the general results of our five years' science teaching, I can speak with very great satisfaction. It has turned many dunces into promising hopeful happy workers, and it gives to the abler boys precision of thought, the habit of accurate reasoning, and an inexhaustible fund of resource. Nor must I let it be supposed that in teaching science we undervalue the old-fashioned subjects. By improved methods and a carefully arranged time table we find room for both; and though my senior boys forego the elegant imbecilities of Latin verse composition, they write a good Latin prose, and construe Sophocles as well as the senior boys of my own time at Winchester.

The difficulty of obtaining teaching power in scientific subjects is one which will no doubt press itself on the attention of the Commissioners. There are, as yet, very few men in England whom schools, with ordinary salaries at their command, can hope to obtain. We have got over the difficulty, so far, by persuading a first-class Oxford

mathematician, with fair scientific knowledge, to spend a twelvemonth at King's College. He now takes the mechanics and the chemistry, while the junior boys, the botany, and the physiology, fall to me. But I believe that before science can be taught properly in first-grade schools, a race of scientific teachers must be called into existence.

In the course of the present year we have removed from the confined and uncomfortable premises of the ancient Grammar School to a splendid building outside Taunton, with every facility for extension and development. The architect's plans include a laboratory, museum, and scientific class rooms, and of the ground attached to the school two acres have been given to me for a botanic garden. The latter will cost 100*l.*, the former more than 1,000*l.*, in the meantime we are making shift, not unsatisfactorily, with temporary rooms. One great want at the present moment is a transit instrument, which, with clock and case, I know how to obtain for 50*l.* But though in a stately building like that which we now inhabit, our wants

are necessarily more or less magnificent, I may be permitted to lay great stress upon the cheapness with which, under humbler circumstances, efficient systematic science teaching can be organised. 5*l.* will buy a set of mechanical models, 16*l.* will fit up a rough laboratory for 16 boys. The cost of solutions and apparatus will be under 5*s.* per annum to each pupil, and this is really all that is absolutely necessary.

I take the liberty of enclosing with this report—

1. Two short pamphlets which express my own view and experience more in detail.
2. A set of papers illustrating our botanical teaching.
3. A prospectus of the school.

I am, Sir,

Your faithful servant,

W TUCKWELL.

To the Secretary of the Commission on Scientific Instruction and the Advancement of Science.

BOTANICAL TEACHING AT TAUNTON COLLEGE SCHOOL.

NATURAL ORDERS.

DIVISION I. POLYPETALÆ		Class I. Dicotyledones.		Div II. MONOPETALÆ.		Div. III. APETALÆ.	
SUB-DIV. I. THALAMIFLORÆ	SUB-DIV. II. CALYCIFLORÆ.	ORDER 1.	ORDER 1.	ORDER 1.	ORDER 1.	ORDER 1.	ORDER 1.
ORDER 1. Ranunculaceæ.	ORDER 1. Celastrineæ.	" 2. Rubiaceæ.	" 2. Rhamneæ.	" 2. Caprifoliaceæ.	ORDER 1. Polygonaceæ.	" 2. Nyctaginaceæ.	" 2. Amaranthaceæ.
" 2. Berberideæ.	" 2. Ternstroemiaceæ.	" 3. Valerianeæ.	" 2. Ternstroemiaceæ.	" 3. Valerianeæ.	" 3. Begoniaceæ.	" 3. Begoniaceæ.	" 3. Chenopodiaceæ.
" 3. Nymphaeaceæ.	" 3. Sapindaceæ.	" 4. Dipsacaceæ.	" 3. Sapindaceæ.	" 4. Dipsacaceæ.	" 4. Urticaceæ.	" 4. Urticaceæ.	" 4. Urticaceæ.
" 4. Papaveraceæ.	" 3. Hippocastaneæ.	" 5. Compositæ.	" 3. Hippocastaneæ.	" 5. Compositæ.	" 5. Cannabineæ.	" 5. Cannabineæ.	" 5. Cannabineæ.
" 5. Fumariaceæ.	" 4. Ampelideæ.	" 6(a). Lobeliaceæ.	" 4. Ampelideæ.	" 6(a). Lobeliaceæ.	" 6. Ulmaceæ.	" 6. Ulmaceæ.	" 6. Ulmaceæ.
" 6. Crucifereæ.	" 4. Leguminosæ.	" 6(b). Campanulaceæ.	" 4. Leguminosæ.	" 6(b). Campanulaceæ.	" 7. Thymeleæ.	" 7. Thymeleæ.	" 7. Thymeleæ.
" 7. Resedaceæ.	" 5. Rosaceæ.	" 7. Ericaceæ.	" 5. Rosaceæ.	" 7. Ericaceæ.	" 8. Eubagaceæ.	" 8. Eubagaceæ.	" 8. Loranthaceæ.
" 8. Cistaceæ.	" 6. Granateæ.	" 8. Epacrideæ.	" 6. Granateæ.	" 8. Epacrideæ.	" 9. Santalaceæ.	" 9. Santalaceæ.	" 9. Santalaceæ.
" 9. Violaceæ.	" 6. Saxifrageæ.	" 9. Oloneæ.	" 6. Saxifrageæ.	" 9. Oloneæ.	" 10. Polemoniaceæ.	" 10. Polemoniaceæ.	" 10. Polemoniaceæ.
" 10. Frankeniaceæ.	" 7. Crassulaceæ.	" 10. Jasmineæ.	" 7. Crassulaceæ.	" 10. Jasmineæ.	" 11. Convolvulaceæ.	" 11. Convolvulaceæ.	" 11. Convolvulaceæ.
" 11. Caryophylleæ.	" 7. Ficoides.	" 11. Apocynaceæ.	" 7. Ficoides.	" 11. Apocynaceæ.	" 12. Boragaceæ.	" 12. Boragaceæ.	" 12. Boragaceæ.
" 12. Fortulaceæ.	" 8. Cactaceæ.	" 12. Asclepadeæ.	" 8. Cactaceæ.	" 12. Asclepadeæ.	" 13. Hydrophyllaceæ.	" 13. Hydrophyllaceæ.	" 13. Hydrophyllaceæ.
" 13. Farfugulaceæ.	" 8. Droseraceæ.	" 13. Gentianeæ.	" 8. Droseraceæ.	" 13. Gentianeæ.	" 14. Salicineæ.	" 14. Salicineæ.	" 14. Salicineæ.
" 14. Tamariscineæ.	" 9. Lythraceæ.	" 14. Egoniaceæ.	" 9. Lythraceæ.	" 14. Egoniaceæ.	" 15. Cupulifereæ.	" 15. Cupulifereæ.	" 15. Cupulifereæ.
" 15. Polygaleæ.	" 10. Myrtaceæ.	" 15. Cobulaceæ.	" 10. Myrtaceæ.	" 15. Cobulaceæ.	" 16. Platynaceæ.	" 16. Platynaceæ.	" 16. Platynaceæ.
" 16. Elatineæ.	" 10. Haloragaceæ.	" 16. Polemoniaceæ.	" 10. Haloragaceæ.	" 16. Polemoniaceæ.	" 17. Garryaceæ.	" 17. Garryaceæ.	" 17. Garryaceæ.
" 17. Hypericineæ.	" 11. Onagraceæ.	" 17. Scrophularineæ.	" 11. Onagraceæ.	" 17. Scrophularineæ.	" 18. Myrtaceæ.	" 18. Myrtaceæ.	" 18. Myrtaceæ.
" 18. Aurantiaceæ.	" 11. Philadelphiceæ.	" 18. Orobanchaceæ.	" 11. Philadelphiceæ.	" 18. Orobanchaceæ.	" 19. Conifereæ.	" 19. Conifereæ.	" 19. Conifereæ.
" 19. Camelliaceæ.	" 12. Passifloraceæ.	" 19. Verbenaceæ.	" 12. Passifloraceæ.	" 19. Verbenaceæ.	" 20. Cypodeæ.	" 20. Cypodeæ.	" 20. Cypodeæ.
" 20. Malvaceæ.	" 12. Cucurbitaceæ.	" 20. Acanthaceæ.	" 12. Cucurbitaceæ.	" 20. Acanthaceæ.			
" 21. Tubaceæ.	" 13. Passifloraceæ.	" 21. Lenticularineæ.	" 13. Passifloraceæ.	" 21. Lenticularineæ.			
" 22. Bythneriaceæ.	" 18. Umbellifereæ.	" 22. Ebenaceæ.	" 18. Umbellifereæ.	" 22. Ebenaceæ.			
" 23. Eleocarpeæ.	" 14. Araliaceæ.	" 23. Frimulaceæ.	" 14. Araliaceæ.	" 23. Frimulaceæ.			
" 24. Lineeæ.	" 12. Cornaceæ.	" 24. Strychnaceæ.	" 12. Cornaceæ.	" 24. Strychnaceæ.			
" 25. Geraniaceæ.		" 25. Flumbagineæ.		" 25. Flumbagineæ.			
" 26. Tropaeolaceæ.							
" 27. Rutaceæ.							
" 28. Illicineæ.							
" 29. Empetraceæ.							

Class II. Monocotyledones.		Class III. Acotyledones.	
Div I. PETALOIDÆ.	Div II. GLUMACEÆ.	Div I. VASCULAREÆ.	Div. II. CELLULAREÆ.
ORDER 1. Hydrocharitideæ.	ORDER 1. Cyperaceæ.	ORDER 1. Filices.	ORDER 1. Musci.
" 2. Orchideæ.	" 2. Gramineæ.	" 2. Lycopodiaceæ.	" 2. Characeæ?
" 3. Scitamineæ.		" 3. Marialaceæ.	" 3. Hepaticæ.
" 4. Musaceæ.		" 4. Equisetaceæ.	" 4. Licheneæ.
" 5. Irideæ.			" 5. Fungi.
" 6. Amaryllidideæ.			" 6. Algeæ.
" 7. Melanthaceæ.			
" 8. Bromeliaceæ.			
" 9. Comelidaceæ.			
" 10. Palmaceæ.			
" 11. Dioscoreæ.			
" 12. Alismaceæ.			
" 13. Najasceæ.			
" 14. Liliaceæ.			
" 15. Juncaceæ.			
" 16. Aroideæ.			
" 17. Lemnaceæ.			
" 18. Typhaceæ.			
" 19. Eriocauloneæ.			

The numbered Orders are British. Those printed in Italics are Exotic, but contain plants commonly cultivated in England or possessing special interest.



SCHEDULE.

ORGANS,	COHESION SUPPRESSION.	ADHESION INSERTION	LEAF.
Calyx, sepals.	<i>Asepalous</i> <i>Polysepalous</i> <i>Gamosepalous</i>	<i>Superior</i> <i>Inferior</i>	Position - { <i>Radial.</i> <i>Cauline.</i>
Corolla, petals.	<i>Apetalous</i> <i>Polypetalous</i> <i>Gamopetalous</i>	<i>Hypogynous</i> <i>Perigynous</i> <i>Epigynous</i>	Insertion - { <i>Sessile</i> <i>Stalked.</i>
Perianth, leaves.	<i>Polyphyllous</i> <i>Gamophyllous</i>	<i>Hypogynous</i> <i>Perigynous</i> <i>Epigynous</i>	Arrangement { <i>Alternate.</i> <i>Opposite</i> <i>Whorled</i> <i>Decussate.</i>
Stamens, filaments, anthers.	— <i>androus</i> — <i>adelphous</i> — <i>dynamous</i> <i>Syngenesous</i>	<i>Hypogynous</i> <i>Perigynous</i> <i>Epigynous</i> <i>Epipetalous</i> <i>Gynandrous</i>	Composition { <i>Simple</i> <i>Compound</i>
Pistil, carpels.	<i>Syncarpous</i> <i>Apocarpous</i>	<i>Superior</i> <i>Inferior</i>	Shape { <i>Roundish, Ovate</i> <i>Obovate, Oval</i> <i>Lanceolate, Linear</i> <i>Subulate, Cordate.</i> <i>Sagittate, Hastate.</i> <i>Ternate, Pinnate</i> <i>Diglate, Palmate</i> <i>Fedate, Reniform.</i>
			Margin - { <i>Entire, Serrate.</i> <i>Dentate, Crenate</i>
			Stipulation - <i>Stipulate, Ex-stipulate</i>
Class _____		Order _____	
Division _____		Genus _____	INFLORESCENCE - { <i>Spike, Raceme.</i> <i>Panicle, Corymb</i> <i>Cyme, Umbel, Head</i>
Sub-division _____		Species _____	BRACKETATION - <i>Bracteate, Ebracteate.</i>

BLANK SCHEDULE.

ORGANS.	No.	COHESION SUPPRESSION	ADHESION INSERTION	LEAF.
Calyx, sepals.				Position.
Corolla, petals.				Insertion.
Perianth, leaves.				Arrangement.
Stamens, filaments, anthers.				Composition.
Pistil, carpels.				Shape.
				Margin
				Stipulation
				INFLORESCENCE
				BRACKETATION
				Filled up by
Class _____		Order _____		
Division _____		Genus _____		
Sub-division _____		Species _____		Date

7. ROSSALL SCHOOL.

To Her Majesty's Commission on Scientific Instruction and the Advancement of Science.

MY LORDS,

I AM honoured with your Lordships' instructions to present a statement showing to what extent scientific instruction has been introduced into Rossall School, and how many pupils have availed themselves of it, and with what effect, in each year since its introduction.

Natural Science has been taught at this school with varying and uncertified results for some years past. With the commencement of this present year, and upon the appointment of a new Head Master, it has taken a prominent position in the general curriculum. A regular science master was appointed (a distinguished young Oxford man, Mr Herbert Tomlinson, Junior Student of Christ Church, Whitworth (Oxford) Exhibitioner, F.R.A.S.), and about 100l per annum allowed for chemicals, apparatus, &c.

There is a large lecture room, capable of accommodating

50 boys at a time with ease, and well furnished with laboratory, &c., and all requirements for illustrating lectures on mechanics, heat, magnetism, electricity, pneumatics, and chemistry. In last Christmas Report of the School, it was stated that "Natural Science would henceforth be taught to the whole of the Modern School and to volunteers from the Classical" (charge one guinea a year). The whole school at present numbers 302; the modern side, 68; and, with the exception of the preparatory (30), and lower school (35), the classical side have almost universally volunteered to study natural science. The classical side at present only attend one hour per week, and the modern side two hours. This last, however, the head master hopes to see re-arranged to the still further promotion of the sciences. Besides this general teaching, however, our energetic natural science master has organized a special class to meet the requirements of boys reading the higher subjects and desirous of working experiments. The boys evidently take great interest in their work, and many of them are making considerable progress. We have a small observatory with a good equatorial, and lectures on astronomy are being given to the highest form, classical and modern, and volunteers are taught how to use the instruments and make observations. Of this last class the number is about 12. In connexion with Natural Science, and in the direction pointed out by the Whitworth Exhibitions (of which one was put at the disposal of the head master), carpenters' workshops have been fitted up, and benches and tools provided for as many as seven at a time (charge, including use of tools, 5s per quarter). In extension of this branch of education, the head master is particularly anxious (when funds admit) to add lathes, one or more, and a stone polishing machine, and a forge. Arrangements have been made for setting up a complete system of meteorological observations.

Your Lordships will, perhaps, allow me here to express one or two convictions that have become imprinted on my mind in this matter. First, I feel strongly that boyhood is essentially the age of observation and love of nature. A boy's quick eye for a bird's nest has always struck me as a valuable power that ought to be educated. It is the same with mushrooms, trees likely to supply walking canes, objects of interest on the seashore, &c., &c. Stones, shells, fossils, skeletons, may be had in any number from the boys at the least sign of encouragement. Firm believer as I am, myself, in Latin and Greek for cultivating the higher powers of the human mind, memory and judgment, I am still ready to admit that to exclude Natural Science as a study, is to leave untrained the third in rank, perhaps, but the first in development, of our powers—observation. Lastly in Lancashire I find there is a strong demand for common-sense philosophy; and I so far sympathize with the sentiment as to feel that, whether capable of the profundities of metaphysics and mathematics or not, no one would be the worse for knowing the difference between a "hawk and a handsaw."

I have the honour to be, my lords,  
Your lordships' faithful servant,  
ROBERT HENRIKER, M.A.,  
Head Master.

Rossall, 15th September 1870.

### 8. THE CITY OF LONDON SCHOOL.

City of London School, E.C.

SIR,  
16th Sept. 1870.  
I was requested last July to furnish you with a report on the scientific instruction given at the City of London School, and I was asked to state the subjects and number of pupils taught, the times of study, and the results of the study each year. As the request arrived during our examinations, and just before the conclusion of the term, it was impossible to draw up the statement immediately. But I requested Mr Durham, our lecturer, to compile the requisite information with as little delay as possible. This he has done. I have inspected his report, to the general accuracy of which I can certify, and I now have the pleasure of forwarding it to you.

I am, Sir,  
Your obedient servant,  
J. Norman Lockyer, Esq.,  
Edwin A. Abbott.  
6, Old Palace Yard, S.W.

City of London School,

SIR,  
19th Sept. 1870.  
In your communication of the 23rd July you requested that I would furnish you with a statement showing (1) To what extent scientific instruction had been introduced at the City of London School. (2) How many

pupils have availed themselves of it; and (3) With what effect, in each year, since its introduction.

1. To enable you to form some idea of the extent of the scientific instruction introduced at the City of London School, I will give a list of the subjects taught in each division, of which there are six.

The 1st division being formed of the 6th and 5th forms.

" 2nd division " 4th and Latin classes.  
" 3rd division " 3rd and 2nd classes.  
" 4th division " 1st and grammar classes.  
" 5th division " 1st jun. and 2nd jun. classes.  
" 6th division " 3rd jun. and 4th jun. classes.

Each division has one lecture a week.

#### SUBJECTS TAUGHT.

##### 6th Division, A.

- A { (a) Atomic theory  
(b) Hydrogen, oxygen, nitrogen, and the compounds formed by their union.  
Physical and chemical properties of water.  
Do " " " " air  
(c) Thermometers, barometers, air pump, &c.  
(d) Ventilation.  
(e) Use of aqua fortis as a chemical test (special attention to)

##### 5th Division, B.

- B { (a) Subjects mentioned under A.  
(b) Carbon and its compounds with oxygen and hydrogen (inorganic compounds) and coal gas.  
(c) Blowpipe, nature of flame, conduction and convection of heat  
(d) Davy lamp.

##### 4th Division, C.

- C { (a) Subjects under cap A. & B.  
(b) Sulphur  
Phosphorus } and their compounds with O & H.  
Chlorine } especial attention to their uses as  
Bromine } re-agents.  
Iodine }  
Fluorine, } hydric fluoride, hydric hydrofluo-  
silicate }  
(c) Special attention is given to the manufacture of oil of vitriol, and murettic acid.

##### 3rd Division, D.

- D { (a) Subjects given under cap A. B & C  
(b) The common metals (special attention being given to the metallurgical processes for obtaining iron, copper, lead, zinc, silver, mercury, tin, and gold)  
(c) Manufacture of steel  
Tempering steel.  
(d) Manufacture of pigments (common).

##### 2nd Division, E.

- E { (a) Subjects given in A. B. C. & D.  
(b) Manufacture of pigments  
(c) Alkalies and alkaline earths.  
(d) Heat  
(e) Frictional and voltaic { especial attention to  
electricity } electric telegraphy.  
(f) Magnetism  
(g) Outline of theoretical chemical analysis  
(h) Outline of physical geography (slight).

##### 1st Division.

- (a) Organic chemistry (special attention is given to fermentation, and the manufacture of soaps, candles, dyes, &c.).  
(b) Higher branches of experimental physics and inorganic chemistry.

In addition to the lectures, a class was formed (28th October 1868) for the study of practical chemistry (principally preliminary examination by the blowpipe); the three best boys in each of the nine head classes (viz. 6th form to 1st junior class, inclusive) are allowed to join this class.

During the last term, however, 34 boys were permitted to avail themselves of this privilege.

Those who have a decided taste for the study of science are prepared in all its branches.

(2) To what extent have the pupils availed themselves, &c.?

Scientific instruction (chemistry and experimental physics) was first introduced as an optional study at Easter, 1847. Towards the close of the year 1860, the study of science was made compulsory.

The number of boys who availed themselves of it while an optional study is shown by the following table, viz—

In July 1847	-	168	In July, 1854	-	123		
"	1848	-	130	"	1855	-	137
"	1849	-	176	"	1856	-	156
"	1850	-	187	"	1857	-	182
"	1851	-	164	"	1858	-	188
"	1852	-	161	"	1859	-	167
"	1853	-	137	"	1860	-	178

And the subjoined list will give the average number of boys in the City of London School from 1861-1870 inclusive:—

In 1861	-	-	630	In 1866	-	-	649
"	1862	-	628	"	1867	-	651
"	1863	-	622	"	1868	-	654
"	1864	-	637	"	1869	-	657
"	1865	-	633	"	1870	-	654

(3.) And with what effect in each year since, &c ?

To show with what success the instruction in science (previous to 1860) has been attended, I will name a few of the pupils who have highly distinguished themselves, and who left the City of London School previous to this date, viz., 1860.

Edward Divers, M.D. - (Lecturer on Medical Jurisprudence at Middlesex Hospital.)

Prof Unwin, C.E.B. So (Examiner in Mechanical and Machine Drawing, R.S.M.)

Prof. Bloxam, F.C.S. - (Lecturer on Natural Science, Cheltenham College.)

Prof Heaton, F.C.S. - (Late Charing Cross Hospital) Lecturer on Chemistry and Natural Philosophy (Epsom College).

Wm. Hy. Perkins, F.R.S., F.C.S., Honorary Secretary to the Chemical Society

John Spiller, F.C.S. - (Late Assistant Chemist to War Department, Woolwich,) Honorary Secretary to the Photographic Society

H. Matthews, F.C.S.

Wm. Spiller, F.C.S.

J. A. Aldis, M.A., &c.

The first public examination in chemistry in connexion with South Kensington was held in 1860, and we obtained one 1st and two 2nd class prizes

I am afraid we cannot give you a complete list of honours for this year (1860), as I am obliged to trust to my memory, for no account of science successes gained previous to 1861 has been kept by us. In this difficulty, I applied to the Secretary, Science and Art Department, who deputed Mr. McLeod to state that to give the information I required would involve very considerable research, and to express his regret that the Department had not the means of instituting it. If, however, I should learn any further details I will forward them to you.

I will now, as briefly as possible, give you a list of the honours, distinctions, &c., gained by the City of London School during the last 10 years

In 1861:

The school obtained at South Kensington  
1 gold medal for experimental physics  
1 " " mechanical physics  
1 bronze " experimental physics.

In 1862:

At South Kensington we obtained—

7 1st class prizes in experimental physics  
3 1st class " chemistry  
2 2nd class " " "  
1 2nd class " experimental physics.  
1 2nd class " mechanical physics.  
1 3rd class " chemistry.

And at the Royal School of Mines we obtained the 2nd prize in 1st class in physics, and a 1st class in chemistry

In 1863:

We obtained at Magdalen College, Oxford, the open Natural Science exhibition, and at the Royal School of Mines we had

2 in 1st class in experimental physics.  
1 in 1st class in chemistry, and  
1 in the 2nd class in chemistry.

At South Kensington this school obtained—

2 royal exhibitions for physical science; also  
1 gold medal for experimental physics.  
1 " " mechanical physics

silver medals for experimental physics

1 bronze " " " and  
3 1st class Queen's prizes in inorganic chemistry.  
1 " " " organic chemistry  
1 " " " mechanical physics  
4 " " " acoustics, light and heat.  
1 " " " magnetism and electricity  
3 2nd class " " "  
2 " " " inorganic chemistry  
1 " " " acoustics, light and heat.  
6 3rd class " " inorganic chemistry  
1 " " " magnetism and electricity, and  
7 honourable mention in inorganic chemistry

In 1864:

At the University of London—

1 passed in honours, in chemistry and natural philosophy, in preliminary scientific examination for degree of M.B.  
1 was placed in honours in chemistry at the matriculation examination.  
1 obtained honours in zoology and the university prize at the matriculation examination  
1 passed in honours in chemistry at the matriculation examination.

At the Royal School of Mines—

1 obtained 2nd place in 1st class in mineralogy for 2nd year students  
1 do for geology in do  
4 were placed in 1st class in chemistry for 1st year students  
1 placed in do, in physics for do  
1 do in 2nd class in chemistry for do.  
1 do. in 3rd class in physics for do.

And at South Kensington were gained—

1 silver medal for acoustics, light, and heat.  
1 bronze " do  
1 do. theoretical mechanics, also  
4 1st class Queen's prize in inorganic chemistry.  
3 " " " organic chemistry.  
2 " " " magnetism and electricity.  
1 1st class Queen's prize in acoustics, light, and heat.  
2 " " " theoretical mechanics.  
1 " " " vegetable physiology and economic botany.  
1 " " " animal physiology  
1 " " " physical geography.  
1 " " " geology.  
4 2nd class " inorganic chemistry  
3 " " " acoustics, light and heat  
1 " " " magnetism and electricity.  
1 " " " vegetable physiology and economic botany.  
1 " " " animal physiology.  
1 " " " physical geography.  
1 " " " mathematics,  
1 " " " metallurgy  
17 3d class " inorganic chemistry.  
1 " " " acoustics, light and heat.  
1 " " " applied mechanics  
1 " " " zoology  
1 " " " physical geography  
1 " " " mathematics.  
1 " " " geology  
1 " " " marine steam.  
1 " " " practical plane and descriptive geometry.  
6 Honourable mention in inorganic chemistry.  
2 " " " magnetism and electricity.  
1 " " " geology  
1 " " " marine steam.  
1 " " " mineralogy.

In 1865:

At the University of London—

One passed in the first B.Sc. examination, and at University College, London—

We obtained the gold medal for analytical chemistry, and the silver medal for theoretical chemistry. In the examinations at the

## Royal School of Mines, London—

- 1 received the Royal exhibition of 25*l*. (for 2nd year students) for mineralogy and geology  
 Passed the examination for the 3rd year, viz: those in natural history and palæontology in the first class. Received the Edward Forbes medal and prize of books to the value of 8 guineas for natural history and palæontology, being first in a special examination in those subjects, and received the title of "Associate of the Royal School of Mines"  
 And in the examination for first year students we obtained the 1st year's prize of 15*l*. for proficiency in physics. We had likewise—
- 2 placed in the 1st class in physics.  
 2 " " " chemistry  
 1 " " " practical chemistry  
 1 " " 2nd " mineralogy  
 1 " " " geology.

## At South Kensington we gained—

- 1 bronze medal for proficiency in geology.  
 Also 1 silver " applied mechanics  
 1 bronze " inorganic chemistry.  
 1 " " organic chemistry.  
 And 2 Queen's exhibitions, 50*l*. for 3 years and free instruction at Government School of Science, Dublin. Also
- 3 placed in the 1st class in inorganic chemistry.  
 2 " " " organic chemistry  
 3 " " " magnetism & electricity.  
 1 " " " applied mechanics.  
 2 " " " animal physiology.  
 6 " " 2nd " inorganic chemistry  
 3 " " " magnetism & electricity.  
 1 " " " theoretical mechanics  
 1 " " " animal physiology.  
 2 " " " physical geography.  
 1 " " " steam.  
 1 " " " geology.  
 10 " " 3rd " inorganic chemistry.  
 2 " " " acoustics, light, and heat  
 4 " " " magnetism and electricity.  
 1 " " " theoretical mechanics  
 2 " " " vegetable physiology and economic botany.  
 1 " " " steam  
 1 " " " mineralogy  
 1 " " " geology.  
 1 " " " mechanical and machine drawing.  
 1 " " " mining  
 16 " " 4th " inorganic chemistry  
 3 " " " acoustics, light, and heat  
 1 " " " theoretical mechanics  
 1 " " " vegetable physiology.  
 2 " " " zoology  
 1 " " " steam  
 1 " " " mechanical and machine drawing  
 1 " " " building construction.

## In 1866:

- 1 of the old pupils was elected a Fellow of the Royal Society, and  
 2 were elected Fellows of the Chemical Society.

## At the University of London—

- 1 in the examination for the degree of B.Sc. obtained 3rd class honours in chemistry and 2nd class honours in geology and palæontology, and degree of Bachelor of Science, while  
 1 in the preliminary scientific examination for M.B. passed in the 1st class in honours in chemistry and natural philosophy.

## At the Oxford Senior Local Examination—

- 1 passed with 2nd class honours in chemistry and physics.

## At the Royal School of Mines, London—

- 1 was passed in the 1st class in physics.  
 2 were " " 2nd " do  
 1 was " " " chemistry  
 1 " " " geology.  
 1 " " " mechanical drawing.

## At the Government School of Science, Dublin, we obtained the

- 1st prize in practical chemistry.  
 1st " magnetism and electricity.  
 1st " geology.  
 2nd " theoretical chemistry.  
 2nd " natural philosophy.  
 3rd " geology.

## At King's College, London (evening classes), we gained a prize in experimental physics and a certificate in zoology.

## At South Kensington—

A Royal exhibition of 50*l* for three years, with free education at the Royal School of Mines and Royal College of Chemistry; also

- 3 1st class prizes in inorganic chemistry  
 3 " " " acoustics, light and heat.  
 1 " " " magnetism and electricity.  
 1 " " " theoretical mechanics  
 1 " " " applied mechanics.  
 1 " " " zoology.  
 1 " " " physical geography  
 2 2nd " " inorganic chemistry.  
 4 " " " magnetism and electricity.  
 1 " " " vegetable physiology.  
 1 " " " physical geography.  
 2 " " " elementary mathematics.  
 1 " " " geology  
 2 2 3rd " " inorganic chemistry.  
 2 " " " geometry, and  
 1 " " " in each of the following subjects—

Acoustics, light and heat.	Physical geography.
Theoretical mechanics	Elementary mathematics
Applied mechanics.	Steam.
Animal physiology.	Metallurgy.

- 15 were placed in the 4th class in inorganic chemistry  
 2 " " " organic chemistry,  
 and

1 was " " " acoustics, light and heat, magnetism and electricity, and navigation.

- 16 obtained a 5th class in inorganic chemistry, and  
 1 " " " systematic botany.  
 1 " " " mining.

## In 1867:

- 1 was appointed to be demonstrator of chemistry at King's College, London  
 1 to be senior assistant chemist to the Rivers Commission.  
 1 to be assistant chemist to the War Department, Woolwich, and  
 1 was selected to be educated at the expense of the Government for ultimate employment in the higher branches of the Department for the conservation of the forests under Government in India.

## At the University of London—

- 1 gained the 1st place in M.B. examination with 2nd class honours in physiology and 3rd class honours in chemistry, also degree of B.Sc. with 1st class honours in zoology and 2nd class honours in botany.

## At the Royal School of Mines—

- I was awarded the 1st of two scholarships of 15*l*. for 1st year students, and placed 1st in physics and mathematical drawing, and 1st in chemistry; and we gained  
 1 1st class in geology  
 1 was placed 1st in 2nd class in chemistry  
 1 was placed in the 2nd class in mineralogy.  
 1 passed in chemistry  
 1 " mineralogy  
 1 " mechanical drawing, and

## At the Government School of Science, Dublin, we obtained the

- 1st prize in physics  
 1st " zoology  
 1st " magnetism, electricity, and galvanism.  
 2nd " acoustics, light and heat.  
 2nd " mechanics.

## At the Pharmaceutical Society—

A junior Jacob Bell memorial scholarship, 30%, with free instruction in the laboratory of the society for 1 year.

## South Kensington—

Royal exhibitions of 50% per annum for 3 years, with free education at the R.S.M. and R.C.C. London; and

- 1 gold medal in theoretical mechanics
- 1 silver " " for mechanical physics
- 1 " " " magnetism and electricity.
- 1 " " " inorganic chemistry
- 1 " " " acoustics, light and heat.
- 1 bronze " " applied mechanics
- 1 " " " magnetism and electricity.
- 1 " " " animal physiology.
- 1 " " " inorganic chemistry.
- 1 " " " organic chemistry, also
- 6 1st class prizes in inorganic chemistry
- 2 " " " organic do
- 2 " " " acoustics, light, and heat.
- 5 " " " magnetism and electricity
- 2 " " " animal physiology, and
- 1 " " prize for each of the following theoretical mechanics; applied mechanics; zoology, physical geography; elementary mathematics, practical, plane, and descriptive geometry, mineralogy, geology, and building construction
- 4 2nd class prizes in inorganic chemistry.
- 3 " " " organic chemistry
- 2 " " " magnetism and electricity.
- 2 " " " mechanical and machine drawing, and
- 1 " " " in each of the following.—applied mechanics, animal physiology, zoology, physical geography, steam, metallurgy, geology, mining, building construction, and navigation.
- 4 3rd class prizes in inorganic chemistry
- 2 " " " organic chemistry.
- 4 " " " acoustics, light, and heat
- 2 " " " vegetable physiology
- 4 " " " physical geography. And
- 1 3rd class prize in each of the following.—Magnetism and electricity, theoretical mechanics, practical, plane, and descriptive geometry, metallurgy, mining, building construction, navigation, and higher mathematics.
- 1 4th class in each of the following.—Magnetism and electricity, applied mechanics, physical geography, steam, metallurgy, mineralogy, nautical astronomy.
- 2 5th class certificates in acoustics, light, and heat
- 3 " " " theoretical mechanics.
- 2 " " " applied mechanics, and
- 1 " " " nautical astronomy, geology, magnetism and electricity

## In 1868:

- 1 was appointed assistant chemist to the Royal Institution of Great Britain, and
- 1 was appointed chief private assistant to Professor Frankland, F.R.S. of the Royal School of Mines and Royal College of Chemistry.

## At the University of London—

- 1 in the 2nd B.A. examination passed with 3d class honours in animal physiology
- 1 in the 1st B.Sc. examination obtained honours in biology
- 1 in the 1st B.C. examination obtained honours in chemistry.
- 1 in the 1st B.C. examination obtained honours in natural philosophy. And
- 1 obtained the Whitworth exhibition for mechanical sciences, value 25*l.* for one year.

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## At the Royal School of Mines—

1 obtained title of Royal School of Mines, and 1st class in metallurgy; 1st class in applied mechanics for 3rd year students.

1 obtained the Directors' Medal and Prize of Books (25*l.*); 1st class in mechanical drawing, 1st geology, 2nd mineralogy for 2nd year students, and for the 1st year students—

- 1 obtained Royal scholarship of 15*l.*
- 2 were placed in 1st class in chemistry
- 2 " " " physics
- 1 " " " mechanical drawing.
- 1 was placed in 2nd class in " and
- 2 were placed in " chemistry

## At the Government School of Science, Dublin—

The 1st prize in practical chemistry  
" 1st " manufactures  
" 2nd " comparative anatomy were gained.

## King's College, London (evening classes)

To one was awarded the 1st prize in zoology, 2nd prize in geology, 2nd prize in chemistry, and admitted Associate of King's College, London

## At South Kensington was gained

A Royal exhibition 50% per annum for three years, with free education at R.S.M. and R.C.C., London, also one bronze medal for proficiency in organic chemistry.

- 1 bronze medal for proficiency in metallurgy, and
- 3 1st class Queen's prizes in inorganic chemistry.
- 1 " " " organic chemistry,
- acoustics, light and heat, magnetism and electricity, and metallurgy.
- 4 2nd class Queen's prizes in inorganic chemistry.
- 2 " " " organic chemistry.
- 3 " " " magnetism and electricity.
- 2 " " " animal physiology.
- 1 " " " in each of the following.—acoustics, light and heat, zoology, systematic botany, and metallurgy.
- 2 3rd class prizes in acoustics, light and heat.
- 2 " " " vegetable physiology
- 1 3rd class prizes in each of the following.—inorganic chemistry, applied mechanics, mechanicals, zoology, steam, metallurgy and geology.
- 2 4th class in mineralogy; while
- 1 5th class certificate was obtained in each of the following.—theoretical mechanics, applied mechanics, vegetable physiology, animal physiology, steam, and metallurgy.

## In 1869:

- was appointed honorary secretary to the Chemical Society.
- 1 was appointed honorary secretary to the Photographic Society.
- 1 was appointed professor of chemistry and natural philosophy at Epsom College.
- 1 was appointed assayer to the Walaroo Mining Company, South Australia
- 1 was appointed Fellow of the Chemical Society
- 1 " " " Geographical Society.
- 2 were appointed assistant chemists to the Royal College of Chemistry.
- 1 was appointed assistant chemist to the London Hospital.
- 1 was appointed to St Thomas's Hospital.

## St. John's College, Cambridge:

1 gained the open scholarship for natural science (50*l.* a year), and

## At the University of London—

- 1 in the 1st B.Sc. examination and preliminary M.B. examination was placed—
- 1st in the 1st class in botany, and gained an exhibition of 40*l.* for two years, and
- 1st in the 1st class in zoology, and gained an exhibition of 40*l.* for two years.

O

- 1 obtained the degree of M.B., with 1st class honours in medicine, and 2d " " midwifery, also the Degree of B.S. (Bachelor of Surgery), with 1st place in 1st class honours (and gold medal) in surgery, with an university scholarship of 50*l.* a year for two years
- 1 in the 1st B.Sc. examination gained honours in chemistry and natural philosophy.
- 1 passed in 2nd division in 1st B.S., and preliminary scientific M.B.
- 1 obtained 2nd class honours in zoology in do. do.
- At the Society of Apothecaries—
- 1 obtained the 1st place and gold medal in a competitive examination of medical students for prizes in botany, annually given by this society.
- At the Royal School of Mines—
- To 1 was awarded the title of Associate of the Royal School of Mines in mining and metallurgical divisions, he having gained a 1st class in mining and ditto in applied mechanics for third year students.
- Another took the Duke of Cornwall's scholarship's 30*l.* for two years, he having been placed 2nd in 1st class in mining
- 2nd in 1st " geology, and " " " mechanical drawing for second year students
- A third obtained the 1st of two Royal exhibitions of 15*l.* for 1st year students, and was placed 1st in 1st class in chemistry.
- 2nd " " experimental physics
- 1st in 2nd class in mechanical drawing
- A fourth was placed in the 1st class in chemistry for 1st year students.
- At King's College, London (evening classes)—
- A special certificate in practical chemistry anatomy
- " " " chemistry.
- " " " medicine.
- " " " forensic medicine and botany.
- A certificate of honour in materia medica.
- " " " clinical surgery, and the Todd medal and prize of books for chemical medicine.
- At South Kensington—
- 2 obtained 1st class in honours in magnetism and electricity.
- 1 " " " inorganic chemistry.
- 1 " " " acoustics, light and heat.
- We gained—
- 1 2nd class in honours in each of the following:—acoustics, light and heat, magnetism and electricity, and elementary mathematics. Also
- 1 1st class advanced stage in each of the following:—Magnetism and electricity, elementary mathematics, applied mechanics, and organic chemistry.
- 4 2nd class advanced stage in theoretical mechanics.
- 3 " " " elementary mathematics.
- 2 " " " organic chemistry.
- 2 " " " navigation, and each of the following:—zoology, higher mathematics, acoustics, light and heat, vegetable anatomy and physiology, and metallurgy.
- 1 1st class elementary stage in metallurgy, physical geography, and inorganic chemistry
- 3 2nd class elementary stage in inorganic chemistry, geology, building construction, physical geography, and magnetism and electricity.
- 5 3rd class elementary stage in inorganic chemistry.
- 2 " " " mineralogy
- 2 " " " practical, plane, and descriptive geometry; and systematic botany, mechanical and machine drawing, and physical geography

In 1870;

- 1 was appointed lecturer on medical jurisprudence at the Middlesex Hospital
- 1 " " professional examiner in mechanical and machine drawing for the R.S.M. and S.K.
- 1 " " assistant examiner in chemistry to South Kensington (for the current year).
- 2 were appointed gas examiners, 1 under corporation, London, 1 for Dalston district.
- 1 was appointed chemical superintendent of the Schultz Gunpowder Works, Hants.
- 1 " " assistant to Dr. Thudichum (Lecturer on Pathological Chemistry St. Thomas's Hospital).

At the University of Cambridge—

- A natural science scholarship at St. John's College

At the University of London—

- 1 degree of B.Sc. in 2nd division.
- 1 in 1st B.Sc. in honours examination, 1st class in chemistry and 1st class in natural philosophy.

At the Royal School of Mines—

- 1 has gained the title of Ass. R.S.M., in natural history and palæontology, being 1st in 1st class in natural history, and 1st (only one) in 1st class in palæontology for 3rd year students.
- In the examination for 2nd-year students, 1 has taken the 2nd place in 1st class in mechanical and machine drawing, and 1st do. in 2nd class in mineralogy, and " " " geology.

At the Medical College, St. Thomas's Hospital (Winter Session).

- We have obtained the 1st place in chemistry

At the London Institution—

- 1 has taken the 1st class in chemistry, and the 7th " elementary physics

At South Kensington—

- 1 1st class in honours in inorganic chemistry.
- 1 " " " acoustics, light, and heat
- 1 " " " stages 4 and 5 mathematics
- 1 2nd class " " practical, plane, and descriptive geometry.
- 1 " " " stages 1, 2, and 3 mathematics.
- 1 " " " inorganic chemistry
- 2 1st class advanced stage in magnetism and electricity.
- 1 " " " each of the following:—inorganic chemistry, mechanical and machine drawing, and pure mathematics
- 3 2nd class advanced stage in inorganic chemistry.
- 1 " " " organic chemistry acoustics, light and heat, and magnetism and electricity
- 6 1st class elementary stage in inorganic chemistry.
- 3 " " " magnetism and electricity.
- 3 " " " physical geography.
- 2 " " " pure mathematics.
- 1 " " " mechanical and machine drawing
- 8 2nd class elementary stage in inorganic chemistry, magnetism and electricity.
- 2 " " " animal physiology
- 2 " " " physical geography
- 1 " " " pure mathematics and in theoretical mechanics.

HENRY DURHAM,

Lecturer on Chemistry and Experimental Physics in the City of London School

To the Rev. E. Abbott Abbott, M.A.

have examined the above and can certify to its general accuracy.

EDWIN A. ABBOTT, M.A.,  
Head Master of the City of London School.  
J. Norman Lockyer, Esq.

City of London School,  
Milk Street, Cheapside, E.C.

27th September 1870.

SIR,  
I AM requested by the Head Master, as a supplement to my report to you on the scientific honours and distinctions gained by pupils of the City of London School, to state that the first of the five exhibitions for mechanical science (theoretical division) given by Sir Joseph Whitworth, has this year been awarded to Wm Garnett, who left this school in July 1869 for Cambridge.

I have the honour to be, Sir,  
Your obedient servant,  
H. DURHAM,  
Lecturer on Chemistry and Experimental  
Physics, &c

J. Norman Lockyer, Esq.

#### 9. CHELTENHAM COLLEGE.

To the Royal Commission on Scientific Instruction.

The College, Cheltenham,

October 22nd, 1870

My Lords and Gentlemen,

This college contains three departments—

The classical.

The military and civil.

The junior

In the junior department, where no boy remains after 13, there is no instruction in physical science or in natural philosophy.

In both of the senior departments there is such instruction, and to show the extent to which it has been carried out, and in some degree the effect, I beg to submit to you the following statement:—

Scientific instruction in physical science was introduced, in the year 1854, into the military and civil department only, and is now given to the nine upper classes of that department, containing about 120 boys.

The subjects now taught are—

Geology,

Heat,

Chemistry and electricity

Commencing with geology in the lowest class, and following the order above.

In the upper classes the amount of knowledge acquired is very far, and in not a few instances considerable. It may, perhaps, be best understood by reference to the examination papers in those subjects given by the examiners in the competitive tests for admission to Woolwich.

In these, the boys have obtained, from 60 to 80 per cent. of the marks assigned to the subject.

The upper classes receive instruction, by means of lectures, three times in the week, and the lower classes twice a week. Besides the lectures, the boys have to read up the subjects from text books, and those who are studying chemistry and electricity also work in the laboratory under the supervision of the science master to the military and civil department.

When physical science was first introduced in 1854, the instruction was limited to the first two classes, but was gradually extended to its present limits—the first 9 out of the 19 classes in the department.

Physical science was introduced into the classical department in 1869, and the subjects taught since that date are—

1 Botany.

2 Physical geography.

3. Heat and electricity.

Physical science is taught in the classical department at the same hours as, and, therefore, as an alternative subject with, German, and is taught twice a week in the first 7 of the 17 classes.

In the three highest classes a second physical science is also taught twice a week at the same hours as, and, therefore, as an alternative subject with, French.

Thirteen boys in the three highest classes are now receiving instruction in botany thrice a week; as well as instruction in heat and electricity twice a week, but boys in the four next classes receive instruction in one physical subject only.

For the future it is intended to teach botany to the three lowest of these seven classes, to begin heat and electricity

in the fourth class, and for the benefit of the three upper classes to have two sets of lectures, either or both of which they may attend; one comprising heat and electricity, the other recurring to botany.

The number of boys now learning physical science in the classical department is 63, and they attend five different sets of lectures.

It is believed that with the limited time and limited means at our disposal, it is a wise plan to aim at securing in a classical school thorough scientific grounding in (at most) two or three physical subjects only, and it is believed that botany is the best entrance to physical science for a boy whose education is mainly linguistic, so far as it goes, and not superficial, but dealing mainly with the diction and idioms and literature of Latin, Greek, English, and French.

Botany has certainly been found here a successful means of cultivating the faculty of observation of nature in classical boys.

Physical geography was not a success with the lower classes, though to a very few of our best boys the physical explanation of natural phenomena proved very interesting, and probably we shall not drop it wholly from our curriculum.

Heat and electricity is the most ambitious of the physical subjects hitherto taught in the classical department, and there have always been two or three boys who show aptitude and enthusiasm for the subject, who seem able to lay a real grasp on the fundamental principles of the science, and to apply them deductively to any given examples.

Should any further information be desired by H. M. Commissioners, it will be a pleasure to me to attempt to give it.

I am, my lords and gentlemen,

Your obedient servant,  
T. W. JEX-BLAKE,  
Principal of the College,  
Cheltenham.

#### 10. CLIFTON COLLEGE.

DEAR SIR, October 23rd, 1870.

AFTER a delay, which I must beg you to excuse, and which has been owing to the unexpected pressure of other engagements, I have the honour to send you my report of our scientific work here.

I hope it may be in some degree the kind of report which was required, but if not, it will give me great pleasure to answer any questions or give any further information on the subject which I can, or to request any of my scientific masters to give more specific information, if that is required.

I have put it in the shape of a plain memorandum, but if it is proper that it should be presented in the shape of a letter addressed to your chairman, I shall be glad to have it so far altered, or I will trust to your courtesy to have the necessary alterations made.

I am your obedient servant,  
J. PERCYVAL.

The Secretary of the  
Duke of Devonshire's  
Commission.

#### MEMORANDUM ON THE SCIENTIFIC TEACHING at Clifton College.

Before the year 1867, Natural Science was taught only as an extra subject, and by lectures at which attendance was voluntary. But since the spring of that year, scientific instruction has formed part of the regular routine throughout the whole College, with the exception of the two lowest forms of our Junior School, which consist of boys from 9 to 11 years of age, and the two highest forms on the classical side, in which science is an optional subject. Through all the intermediate forms science has taken its place side by side with the traditional subjects of school instruction, and has its due influence in helping a boy's progress up the school.

As, however, the time which can be thus given to scientific study by all boys without distinction is necessarily limited, and merely sufficient to give an elementary knowledge of chemistry and physics, to which our attention has hitherto been chiefly devoted, with something of scientific training and discipline, our method has been to supplement this by other teaching, the attendance at which is optional. By means of this a select number of boys obtain a more advanced scientific education in place of a special study of other subjects, or, in some cases, in addition to the usual course of classical or other work.

Thus, every boy who has, since the year 1867, risen through the school to the fifth form, has been carefully instructed

in the elements of chemistry and the chief branches of physics, each boy on the classical side having regularly extended two lectures a week, and on the modern side three.

Considering the supreme importance of the method adopted in all teaching and the disadvantage which teachers of new subjects labour under from having no traditional or approved methods to guide them, I shall perhaps, hardly be going beyond what is required in this memorandum if I freely describe the method we have hitherto adopted. Every boy is required during the lecture to take notes in his note book, and afterwards to write out, at his leisure, on the opposite pages, a more detailed and careful fair copy of these notes.

The boys are also required to provide themselves with text books; if these are to be had at a reasonable price, such as Rowley's or Ellis' Chemistry, Owen's or Owen's Heat, &c. As yet, however, one of the difficulties in the way of teaching many branches of science is the want of suitable text books.

For some time one mode of testing the boys' attention to the lectures and their understanding of them was, (1.) by examining and marking the note books, the progress being counted towards the boys' progress up the school; (2.) by first one question of the lecturer each day on the subjects of the previous lecture; and (3.) by a written examination similar to that in other subjects at the end of each term. But we have now adopted a modification of this method which we find to be considerably better, as producing more effect and attention on the part of the boys. The note books of the subjects are also tested by a fortnightly examination on paper, in addition to the usual termly examination. These papers are corrected and given back to the boys by the lecturer, who thus has an opportunity of going over again with his class any points which seem to have been misunderstood or imperfectly apprehended, so that no boy of ordinary intelligence or industry can fail to get a sound and clear knowledge of the subjects.

I have said above that our subjects have been chiefly chemistry and physics, but I ought to have added that the younger boys (i.e. boys of 13 and under) have been taught, during some term, physical geography, instead of elementary physics or chemistry, and will in future be taught elementary botany and physical geography alternately.

The voluntary study of scientific subjects to which I have alluded, an implementing that in which all boys are obliged to engage, consists of three parts:—

- (1) Work in the chemical laboratory, in which about 16 boys can practice analysis at the same time. Here boys who devote themselves more especially to science, work under the guidance and instruction of the chemical master, from four to eight or ten hours a week each. The average number of boys who thus work is 20.
- (2) Lectures on physical geography and botany, or zoology, which are so arranged that any boys who wish can attend them. There have been attended by an average of about 50 boys.
- (3) Special classes of boys, who, in place of classical or other work, pursue the more advanced study of particular subjects in addition to the work above described. At present we have two such classes, containing together about 20 boys, both working at least during the present term, one giving about eight hours a week to it, the other about four.

Such is the work which we have been conducting to do. The results of a three year's experience are more difficult to describe with perfect accuracy. If measured by lessons given at the universities, or elsewhere, they would be considered inadequate, as compared with what we should have to show in some other subject, but the grade of honours, especially in a new subject which is not the chief study of the whole school, is always imperfect and often arbitrary.

In our case it has happened that very few boys of ability have devoted themselves specially to scientific work, and even those few have generally made it subsidiary to their mathematical training. Thus, the best representative of our Science School, who has gone to Oxford, obtained the Mathematical Scholarship at Christ Church, and was also nearly equal to the successful candidates for the Natural Science Scholarship, while one boy has obtained a Natural Science Exhibition at Cambridge.

Some others, who seemed to have no ability at all for long work or literature, have done so well in their scientific work while at school, that they may expect to gain good classes at Oxford. The only candidate whom we have sent to Wadsworth from our special scientific class passed into the Academy very creditably. Of the two whom we have sent for matriculation at the London University, one passed high as honours and the other in the first class.

I mention these facts, not because I count them as of much value in themselves, but as showing that we have reason to expect good results from the system adopted. The results by which I estimate the worth of our scientific teaching are of a different kind, and much more valuable.

A few stray distinctions might easily be granted without a general system of instruction affecting the whole school; but it is by their influence on the teaching of boys that the value of scientific subjects must be measured.

Concerning it, then, and confining myself exclusively to what is clear to every one acquainted with our school life, I can point to the following good results as already evident:—

(1.) A new interest in these school work, so many boys who before had scarcely any interest at all in it.

(2.) A consequent increase of the spirit of work throughout the school.

(3.) The general admission which is given to boys of a scientific turn by the opening thing fielded them, inasmuch as the number of boys who obtain first prizes in scientific subjects has risen to a higher point in the school and so call out more scholars in these subjects in which they do not excel, besides bringing them more into contact with boys of superior ability, and consequently decreasing in many cases, the period of idle and unproductive idleness to which many boys are now condemned, and leading to awaken in many boys a new consciousness of their own mental powers, and the pleasure of successful mental exertion, which is commonly one of the most difficult parts of the schoolmaster's work.

(4.) A new interest pervading the school in regard to scientific subjects and pursuits, which thus becomes matter of talk and inquiry, seeking themselves into the common life of the boys, and creating a more intelligent tone.

This last result is already bearing very marked fruits in the growth of a progressive Scientific Society, which is managed by the boys themselves and one or two of the science masters. This society holds fortnightly meetings, at which scientific papers are read and discussed, objects illustrative of natural history are exhibited and explained, and so forth. A record of its proceedings in boys by the secretaries, the first volume of which will shortly be printed. The number of boys who can belong to it is limited to 70, and the interest excited by it in the school is so considerable that there are regularly a number of boys waiting their turn for election.

We are at present engaged in the formation of a museum, which we are making of a strictly educational character, i.e. admitting nothing but what contributes directly to its educational value; we are also erecting a notable second botanical garden with typical specimens of plants, which will tend to help the study of botany; and we are about to set up an apparatus for meteorological observations.

In all this our aim has been to make the boys themselves the chief agents, only advised, directed, and assisted by the science masters, and one or two scientific neighbours who take a warm interest in these matters.

Thus, our natural history master is president of the Scientific Society, and curator of the museum and botanical garden, but for everything connected with their management he has associated with him one or two of the boys, made up of those most prominent in these subjects.

I have dwelt upon this voluntary and extraneous part of our scientific work, as distinct from our school teaching, because it would otherwise have been impossible to give a correct idea of the influence of science in the school; and, moreover, I attach great importance to this voluntary work, and should wish to see it encouraged and fostered in all schools.

How we are to occupy the thoughts and direct the life of boys out of school, is a question which has hitherto not with suitable like adequate attention. The variety which can be introduced into school routine has limits which are now reached, and it is idle to suppose that we shall ever be able to conduce boys in school by the mere extension of their own studies. To the science masters, a considerable portion of their school business will always continue to be a business discipline. And yet our education fails if we do not succeed in developing tastes and creating intellectual activity.

If nothing is done for boys during their leisure time, the result is a great deal of idleness and idleness, if pains are expended and concerned, and nothing else done, there results what we see so much of at present, an excessive growth of idleness, deriving off and absorbing energies which might, in many cases, have been more profitably used with at least equal satisfaction devoted to literary or scientific pursuits. Hence the supreme importance of encouraging such pursuits as natural history, and the formation amongst boys of societies for the studying the love of such pursuits. I have said above that a schoolmaster finds one of his greatest difficulties in dealing with ordinary boys to convert in some way them to first class



of mental powers, and to be at all active in their use, so that some of our most valuable educational aids are those which foster intellectual tastes, and bring home to boys the sense of an intellectual pleasure.

For this end science seems to have great advantages over every other subject of school instruction. I know of nothing else which has so many attractions for ordinary boys, or which consequently can affect so wide an area of school life.

Scientific subjects rouse an interest in many minds which other subjects have not touched, and thus I attribute in a great degree to the fact that they appeal to so many faculties and touch upon common life at so many points, that they have in them a special reality for dull and unimaginative boys.

I believe there is not a master in our school, however devoted to the study of languages or literature, who would be willing that any of our scientific work should be discontinued, or who would not be obliged to confess to the evident advantages which have already resulted from it. Yet our present results can hardly be considered as more than an intimation of what may be expected when the teaching of science has got beyond its present rudimentary stage, that is, when good text books and apparatus are more accessible, when masters thoroughly trained in approved and effective methods of teaching are less rare, and when the relations between science and other subjects have been more clearly settled.

Our supply of masters for the teaching of science has hitherto been as follows—

- (1) One master who devotes his whole time to the teaching of chemistry by means of lectures and laboratory instruction.
- (2) One who lectures on physics, and also teaches some mathematics.
- (3) One who teaches botany, physical geography, and zoology, is curator of our museum and botanical garden, and president of the Scientific Society, and also does a little classical work.
- (4) And one who has for some time assisted the chemical master in the laboratory and in examinations.

J PERCIVAL,  
Head Master  
Clifton College  
October 19th, 1870.

11 RUGBY SCHOOL

School House, Rugby,  
October 28th, 1870

DEAR SIR,

I beg now to enclose with this, in reply to your inquiry of July 22nd last, two short printed statements on the subject of scientific instruction in Rugby School, by the two masters who principally teach in that department.

Boys are allowed considerable latitude of choice in reference to the particular branch of natural science, &c., which they prefer.

All the middle school, 270 in number, are always engaged with some branch of that subject, and half the upper school, or thereabouts. This upper school is 180 strong, so that there are 270 middle school  
+90 upper school

or 360 out of the total of the school (which may be put at 500) so engaged.

I should add that special buildings for experiments, and lecture theatres with apparatus, &c., have been rather elaborately and expensively provided within the last few years. I enclose a list of honours gained by late pupils.

I hope this may prove a satisfactory account, and shall be happy to supplement the information now given if required.

I am always  
Your obedient servant,

J Norman Lockyer, Esq. HENRY HATMAN

LIST OF NATURAL SCIENCE HONOURS IN Rugby School from 1851

1851	F Hart	-	1st Class Nat. Sc. Tripos	Cambridge
1853	A. A. Harrison	Do	do do	Do
1854	J. W. Woodall	-	1st Class Nat. Sc.	Oxford
1855	R. H. Seott	-	1st Honours in Expt. Sc.	Trin Coll
1864	S. S. Brown	-	1st Class Nat. Sc.	Dublin
1864	G. H. West	-	Nat. Sc. Studentsh. Ch. Ch.	Oxford
1867	F. W. Eison	-	Nat. Sc. Studentsh. Ch. Ch.	Oxford.
1868	G. H. West	-	Burdett-Coutts' Geological Scholarship	Oxford.
1868	G. B. Longstaff	-	Nat. Sc. Scholarship, New College	Oxford
1869	E. Clemenshaw	-	Nat. Sc. Postmastership, Merton College	Oxford.
1870	S. Lupton	-	Nat. Sc. Studentsh. Ch. Ch.	Oxford
1870	H. H. Johnston	-	Whitworth Exhibition	Oxford
1870	C. S. Taylor	-	1st Class Nat. Sc.	Oxford.

The following account was written as a contribution to Mr. Farrar's Paper, read before the British Association in September 1866, on Natural Science in Public Schools, and is printed at Dr. Butler's request—

NATURAL SCIENCE TEACHING AT RUGBY SCHOOL

It will be convenient to arrange my remarks under the following heads—

- (1) A sketch of the system adopted before 1864
- (2) The changes proposed by the Commissioners
- (3) The changes actually adopted, and the present working of the system
- (4) Remarks on the results,

(1) Before the summer of 1864, a boy on entering Rugby might signify his wish to learn either Modern Languages or Natural Science, the lessons were given at the same time, and, therefore, excluded one another. If he chose Natural Science he paid an entrance fee of 17 *ls.*, which went to an apparatus fund, and 57 *5s.* annually to the lecturer. Out of the whole School, numbering from 450 to 500, about one tenth generally were in the Natural Science classes.

The necessary consequences of this system, and its inherent defects, are pointed out in the Report of the Commissioners on Public Schools, vol. i p. 278, to which, for the sake of brevity, I refer.

(2) The changes proposed by the Commissioners may be seen in the same volume, p. 293. In brief, they are as follows—That it should no longer be an alternative with Modern Languages, but that all boys should learn some branch of Natural Science. That there should be two principal branches, one consisting of Chemistry and Physics, the other of Physiology and Natural History, animal and vegetable, and that the classes in Natural Science should be entirely independent of the general divisions of the School, so that boys might be arranged for this study exclusively according to their proficiency in it.

(3) It must be understood that Rugby School is divided for teaching purposes into five parts. The highest consists of the Sixth Form, with about 45 boys. The next is the Upper School, containing four forms, or about 135 boys, the next is the Upper Middle School, with about 140 boys, then the Lower Middle School, with about 130 boys, and, lastly, the Lower School, with about 60 boys. The average ages of the boys in these five divisions will not be far from 18, 17, 16, 15, 14, respectively. The object of the division of the School into these parts is to enable a small number of Mathematical and Modern Language Masters to teach the whole School, and each of these divisions, it will be understood, is doing the same kind of work at the same time\*. So, for example, on the mornings of Monday, Wednesday, and Friday, after breakfast the Upper School have their Mathematical lessons, and, therefore, no other division of the School is at Mathematics at that time, and this number of boys, about 135, is arranged in six Mathematical classes or sets according to their proficiency.

The necessity of the existence of these divisions is so obvious that it is rather surprising that the Commissioners should have overlooked it, and should have recommended that the whole School, and not only one of the divisions of it, should be rearranged for Natural Science. Hence this part of their recommendations was set aside.

Again, the subjects recommended were Physiology, animal and vegetable, and Chemistry and Physics. But there exists at present but one School which can be used as an Experimental School. For there is only one School which is used exclusively by the Masters who teach Natural Science, and it would be impossible to prepare an experimental lecture in any other School. Restrictions such as these, and others which it would be tedious to explain in detail, have caused the adoption of the system I shall proceed to describe, which must be considered as the system of the Commissioners in spirit, adapted to meet the exigencies of the case.

In the Lower School no Natural Science is taught at all. In the Lower Middle and Upper Middle Schools all do Natural Science, two hours a week in School, and as much time for preparation, being given to Science, in the Upper School, it is alternative with German, and in the Sixth Form it is optional. In the Lower Middles there are four sets in Natural Science, in the Upper Middles four sets, in the Upper School two sets, and in the Sixth Form one set. This is the existing state of things, and may be from time to time slightly modified. It would be a simple matter to arrange the work if boys entered at one time only of the year, and into only one part of the School, but the facts are most inconvenient. At the beginning of each of the three Terms, new boys come into the Upper and Lower Middle School, and others are promoted from the Lower to the Upper Middles, from the Upper Middles to the Upper School, and from the Upper School to the Sixth. It is not only difficult, but quite impossible, that all these new and

\* Vide Time table in the Appendix

promoted boys can find sets into which they can easily be placed, and every plan must be a compromise. The general arrangement is this, that new boys shall do Botany their first year, Mechanics their second, Geology their third, and Chemistry their fourth, and the year begins in January.\* The new boys of January, and the previous September, are arranged at that time into as many Botanical sets as is requisite, generally one in the Upper Middles, and two in the Lower Middles; and continue at this subject for one Term. At Easter promotions take place; some few of the Botanists, two or three, perhaps, of the Upper Middles find themselves in the Upper School, and have to give up Botany, the promoted Botanists of the Lower Middles fall naturally into the Botanical set of the Upper Middles; but what is to be done with the new boys, and those promoted from the Lower School, who find themselves at Easter in the Lower Middles? To meet this difficulty the two Botanical sets, or their remains, in the Lower Middles, are arranged in order of proficiency, and the first part goes on with the subject under one Master, and the last, with the new boys, begins over again. And without increasing the number of the Natural Science Masters, and, therefore, increasing the school terms, no plan can be hit upon which shall avoid some such inconvenience as this. The new boys who come in October are too numerous to treat in this way, and they are constituted into sets by themselves in the Upper and Lower Middles, and do some small by-subject for a single Term, such as some branch of Physical Geography, and then fall into the regular course in the following January. In January, then, the Botanical sets begin for the new comers, and the mechanical sets for those who have been one year in the School, and similarly the Geological sets. So that in the Lower Middles there is one Mechanical and one Physical Geography, and two Botanical sets; in the Upper Middles, two Mechanical, and one Geological, and one Botanical, and in the Upper School, no Botanical, one Geological, and one Chemical set. In the Sixth, one Chemical set †

I fear the above will be difficult to follow; but it cannot be made simple, as the circumstances, and, therefore, the arrangements, are more or less complicated.

Next as to the nature of the teaching.

In Botany, the instruction is given partly by lectures and partly from Oliver's Botany. Flowers are dissected and examined by every boy, and their parts recognised and compared in different plants, and then named. No technical terms are given till a familiarity with the organ to be named or described has given rise to their want. The terms which express the cohesion and adhesion of the parts are gradually acquired until the floral schedule, so highly recommended by Henslow and Oliver, can be readily worked. Fruit, seed, inflorescence, the forms of leaf, stem, root, are then treated, the principal facts of vegetable physiology illustrated, and the principle of classification into natural orders explained, for the arrangement of which Bentham's "Handbook of the British Flora" is used. Contrary to all previous expectation, when this subject was first introduced it became at once both popular and effective among the boys. The spirit of the teaching is unquestionably derived from the brilliant "Leçons Élémentaires de Botanique fondées sur l'analyse de 50 plantes vulgaires," par M. Emm. Le Moout, a model of an elementary work on Natural Science. There is no elementary work in English on any scientific subject which can be considered as equal to it. If anyone thinks Botany dry and uninteresting, and consisting of words alone, let him get Le Moout, and he will be fascinated by the lucidity of his style and the interest he throws round the subject.

The lectures are illustrated by Henslow's nine diagrams, by a large and excellent collection of paintings and diagrams made by the lecturers and their friends, and by Botanical collections made for use in lectures. The principal lecturer on this subject is Mr. Kitchener. When the year's course is over, such boys as show a special taste are invited to take Botanical walks with Mr. Kitchener, to consult with him the School Herbarium, and are stimulated by prizes for advanced knowledge and for dried collections, both local and general.

In Mechanics, the lecturer is the Rev. F. N. Hutchinson, M.A., F.C.S., the senior Natural Science Master. The lectures include experimental investigations worked by the Mechanical powers, with numerous examples worked by the boys; into the elements of Mechanism, conversion of motion, cams, the steam engine, the equilibrium of roofs, bridges, strength of materials, &c. They are illustrated by a large collection of models, and are very effective and popular lectures.

In Geology, the lecturer is Mr. Wilson. This subject is only temporarily introduced, on account of the want of another Experimental School. When this is built, the third year's course will be some part of Experimental Physics, in which there already exists at Rugby a fair amount of apparatus. It is very desirable that boys should obtain some knowledge of Geology, but it is not so well fitted for School teaching as some of the other subjects, on several grounds. Perhaps a larger proportion of boys are interested in the subject than in any other, but the subject presupposes more knowledge and experience than most boys possess, and their work has a tendency to become either superficial or undigested knowledge derived from books alone. The lectures include the easier part of Lyell's "Principles," i.e. the causes of change now in operation on the earth; next, an account of the phenomena observable in the crust of the earth; stratification and its disturbances, and the construction of maps and sections; and, lastly, the history of the stratified rocks and of life on the earth. These lectures are illustrated by a fair Geological collection, which has been much increased of late, and by an excellent collection of diagrams and views to illustrate Geological phenomena.

In Chemistry, the lecturer is Mr. Hutchinson. He has an excellent lecture room, and a small but well-fitted laboratory, and he takes his classes through the non-metallic and the metallic elements: the lectures are fully illustrated by experiments. Boys, whose parents wish them to study Chemistry more completely, can go through a complete course of practical analysis in the laboratory, by becoming private pupils of Mr. Hutchinson. At present, 16 boys are studying analysis.\*

This being the matter of the teaching, it remains to say a few words on the manner. This is nearly the same in all the classes, *mutatis mutandis*: the lecture is given, interspersed with questions, illustrations, and experiments, and the boys take rough notes, which are recast into an intelligible and presentable form in note books. These are sent up about once a fortnight, looked over, corrected, and returned; and they form at once the test of how far the matter has been understood, the test of the industry, care, and attention of the boy, and an excellent subject for their English composition.

Examination papers are given to the sets every three or four weeks, and to these and to the note books marks are assigned which have weight in the promotion from Form to Form. The marks assigned to each subject are proportional to the number of hours spent in School on that subject.

There are School prizes given annually for proficiency in each of the branches of Natural Science above mentioned.

This leads me, lastly, to speak of the results.

(4.) First, as to the value of the teaching itself; secondly, as to its effects on the other branches of study.

There can be no doubt, I think, that at Rugby the experiment has been tried under very favourable circumstances. The Head Master has been not only favourable to the movement, but has almost originated it, and sympathises heartily with the promotion of education by means of Natural Science; and the Natural Science Masters whom he has are men of some experience and enthusiasm for their work, and carefully watch the results of their teaching. I think the experience gained at Rugby points to these conclusions. That Botany, structural and classificatory, may be taught with great effect, and interest a large number of boys, and is the best subject to start with. That its exactness of terminology, the necessity of care in examining the flowers, and the impossibility of superficial knowledge, are its first recommendations; and the successive gradations in the generalizations as to the unity of type of flowers, and the principles of a natural classification, are of great value to the clever boys. The teaching must be based on personal examination of flowers, assisted by diagrams, and everything like cram strongly discouraged.

Mechanics are found rarely to be done well by those who are not also the best Mathematicians. But it is a subject which in its applications interests many boys, and would be much better done, and would be correspondingly more profitable, if the standard of Geometry and Arithmetic were higher than it is. The ignorance of Arithmetic which is exhibited by most of the new boys of 14 or 15 would be very surprising, if it had not long since ceased to surprise the only persons who are acquainted with it; and it forms the main hindrance to teaching Mechanics Skill, under the circumstances, the results are fairly satisfactory.

The Geological teaching need not be discussed at length, as it is temporary, at least in the Middle School. Its value is more literary than scientific. The boys can bring neither

\* Since this was written, it has been thought better to make the course begin in September instead of in January.

† From September 1884 to July 1887 the subject of lectures to the Sixth Form is Electricity and Magnetism. They are given by Mr. Hutchinson.

\* For the last few years there have been from 20 to 50 in the Laboratory.—L. N. H., October, 1883.

Mineralogical, nor Chemical, nor Anatomical knowledge, nor have they observed enough of rocks to make Geological teaching sound. The most that they can acquire, and thus the majority do acquire, is the general outline of the history of the earth, and of the agencies by which that history has been effected, with a conviction that the subject is an extremely interesting one. It supplies them with an object rather than with a method.

Of the value of elementary teaching in Chemistry there can be only one opinion. It is felt to be a new era in a boy's mental progress when he has realized the laws that regulate Chemical combination, and sees traces of order amid the seemingly endless variety. But the number of boys who get real hold of Chemistry from lectures alone is small, as might be expected from the nature of the subject. Not more than the non-metallic elements should enter into the School course.

Of the value of experimental teaching in Physics, especially Pneumatics, Heat, Acoustics, Optics, and Electricity, there can be no doubt. Nothing but impossibilities would prevent the immediate introduction of each of these subjects in turn into the Rugby curriculum.

The decided opinion of those who have given most attention to the subject is, that Experimental Physics ought to form the staple of scientific teaching at Schools. The Report drawn up by the Committee of the Council of the British Association will enter fully into this matter.

Lastly, what are the general results of the introduction of scientific teaching in the opinion of the body of Masters? In brief it is this, that the School as a whole is the better for it, and that the scholarship is not worse. The number of boys whose industry and attention is not caught by any School study is markedly less, there is more respect for work and for abilities in the different fields now open to a boy; and though pursued often with great vigour, and sometimes with great success, by boys distinguished in Classics, it is not found to interfere with their proficiency in Classics, nor are there any symptoms of overwork in the School. This is the testimony of Classical Masters, by no means specially favourable to Science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the results of their two or three years in our Middle School, the introduction of Science into our course has been the greatest possible gain. And others who have left from the Upper part of the School, without hope of distinguishing themselves in Classics or Mathematics, have adopted Science as their study at the Universities. I am confident that no Master in Rugby School would wish to give up Natural Science and recur to the old curriculum.

J. M. WILSON.

APPENDIX—ARRANGEMENT OF TIME, JANUARY 1867

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
SIXTH	1 2 3 4 5 O F O C	1 2 3 4 5 O T M C	1 2 3 4 5 O O G N M C	1 2 3 4 5 O G D	1 2 3 4 5 O O G N M C	1 2 3 4 5 O T D	C Classical Lesson Cm Composition C* Looking over Verses T Tutor Subject. M Mathematics. N Natural Science. G German. F French. EF Compulsory Extra French Lesson
UPPER SCHOOL	C M T C	C C only Cm D	C M C T G N	C O E F EM	C M C G N	C F E M EM	
UPPER MIDDLE	C O M C	C N Cm. EM	C T M F C	C M Cm C*	C T O F C	C N E F EM	
LOWER MIDDLE	C O F C	C M Cm C*	C T O N C	C F Cm. EM	C T M N C	C M E F EM	EM Compulsory Extra Mathematical Lesson. D Drawing Lesson.

SCIENCE WORK IN RUGBY SCHOOL.

In September 1866, Mr. Farrar, of Harrow, read a paper before the British Association on the subject of Natural Science teaching in Public Schools, to which my friend and colleague, Mr. Wilson, contributed a sketch of what we were doing at Rugby. This was printed separately, and has been found very useful to parents of Rugby boys, as well as to others interested in education.

Since that time, however, important changes have been made in our work, which has undergone extension, and modification in various ways.

I have, therefore, at the request of others, drawn up the following brief account of our arrangements for the systematic teaching of Natural Science as they are at present carried out.

In two or three places I have quoted *verbatim* from Mr. Wilson's paper, and, in the closing paragraphs, I have gladly availed myself of his remarks on the results of the more extended teaching of Science in our School.

T. N. HUTCHINSON, M.A., F.C.S.,  
Senior Natural Science Master in Rugby School.

Natural Philosophy was first introduced into Rugby as a subject of School instruction by Dr. Tat in 1849. The lecturer was a resident physician in the town, an F.R.S. His lectures, which included Chemistry and Physics, were delivered in the Town Hall, and attendance was voluntary. Dr. Goulburn afterwards appointed successively two of the Classical Masters who had strong scientific tastes to carry on the instruction in Natural Philosophy. After Dr. Temple became Head Master, the Natural Science work was undertaken by one of the Mathematical Masters, and, in 1859, the Trustees added a lecture room and Laboratory to the School buildings, thus giving considerable impulse to the new studies. Soon after this another Mathematical Master took part in the Natural Science teaching, and Botany was added to the subjects of instruction, in addition to Chemistry, Geology, and Physics. During this time, however, Natural Science was only taught as an alternative subject. A boy upon entering the School had to choose between Natural Science and Modern Languages. He could not learn both, as the lessons were given at the same hours. The number of boys who chose Natural Science was, on the average, about one tenth of those in the whole School.

In January 1865, in consequence of the recommendations of the Royal Commissioners, a Natural Science Master was appointed, whose time was to be wholly devoted to Science teaching, two of the Mathematical staff assisting him.

It must be understood that Rugby School is divided, for teaching purposes, into five parts. The highest consists of the Sixth Form, with about 45 boys. The next is the Upper School, containing four forms, or about 135 boys, the next is the Upper Middle School, with about 140 boys, then the Lower Middle School, with about 130 boys; and, lastly, the Lower School, with about 60 boys. The average ages of the boys in these five divisions will not be far from 18, 17, 16, 15, and 14, respectively.

The object of the division of the School into these parts is to enable a small number of Mathematical and Modern Language Masters to teach the whole School, and each of these divisions, it will be understood, is doing the same kind of work at the same time. So, for example, on the mornings of Monday and Thursday, after breakfast, the Upper School have their Mathematical lessons, and, therefore, no other division of the School is at Mathematics at that time; and this number of boys, about 135, is arranged in six Mathematical classes or sets, according to their proficiency.

The necessity of the existence of these divisions is so obvious that it is rather surprising that the Commissioners should have overlooked it, and should have recommended that the whole school, and not only one of the divisions of it, should be rearranged for Natural Science. Hence this part of their recommendations was set aside.

For the first half-year of 1865, Natural Science was taught to every boy in the Middle and Lower School, the Sixth Form and Upper School being allowed to choose between German and Natural Science. After six months' experience, however, it was decided to drop the subject in the Lower School, the boys appearing hardly equal to the work.

From that time to the present, Natural Science has been taught throughout the entire Middle School, while the alternative of Natural Science or German is still allowed to the Sixth and Upper School, the division being generally pretty equally made. Meanwhile, the staff of Natural Science Masters has been increased to five, two more of the Mathematical Masters joining in the work; and, within the last year, a competent Laboratory Assistant has been

engaged, part of whose duties consists in superintending the boys, at certain hours, when working at Practical Chemistry.

The new Natural Science Schools, which have only recently been completed, comprise a large working Laboratory capable of accommodating 30 boys, a private Laboratory for the Chemical lecturer, a Chemical lecture theatre with raised seats for 50, a similar but still larger theatre for Physical Science and Geology, and an apparatus room with means and appliances for instrumental work of various kinds.

The regular subjects of instruction have hitherto been Botany, Physical Geography and Astronomy, Geology, Mechanics and Mechanism, Chemistry, and Electricity, including Magnetism, Heat, Hydrostatics, and Pneumatics have also occasionally been taken in lieu of other subjects. The boys are divided into "sets," each set having two lectures a week. The lectures are strictly catechetical, and are fully illustrated by plants, diagrams, specimens, models, and experiments, as the case may be; the duration of each lecture varies from three-quarters of an hour to an hour. In addition to attendance at the two weekly lectures, the boys are expected either to show up note-books from time to time, which have been elaborated from rough notes taken in the room, or to make abstracts, or work examples, so as in every case to give evidence of having intelligently followed the lecturer. Examinations are also held from time to time, and the results are embodied in the monthly characters sent to the parents.

The subject that has been found, on the whole, to answer best for a commencement is Botany. It needs no special preparatory studies, and it serves as an excellent introduction to scientific terminology and classification; while the patience, care, and accuracy of observation required in examining and comparing the different parts of plants cannot but prove of real value in the intellectual training of boys.

The introduction of elementary astronomy has been rather a matter of convenience to suit our school arrangements. The scholastic year begins in September, when two new botany "sets" commence. A certain number of new boys, however, enter the school in January, and, as it is impossible to begin the subject over again at that time, the new boys in the middle school form a supplementary set, taking up selected portions of astronomy to last two terms. These boys then go to botany in the following September.

The new boys in the middle school at Easter form a set by themselves for commencing botany, and go on with the subject as an advanced set in September. The class-book used by the botanical lecturers is Oliver's "Lessons," but the system followed in teaching is a modification of that employed by Le Maout in his fine work, "Leçons Élémentaires de Botanique." In astronomy, Mr. Norman Lockyer's little book has been used. In no case, however, does a teacher confine himself to a single text book. In geology "the lectures include the easier parts of Lyell's "Principles," i.e., the causes of change now in operation on the earth, next, an account of the phenomena observable in the crust of the earth; stratification and its disturbances, and the construction of maps and sections; and, lastly, the history of the stratified rocks and of life on the earth." The lectures are illustrated by a very fine School Museum, many of the specimens in which have been obtained by the boys themselves, and also by a capital collection of diagrams and drawings exhibiting geological phenomena. The subject is one that has been found to interest a large number of boys, and the local Geology has been well and vigorously worked out by past and present members of the geological sets. In Mechanics there have hitherto been two sets, one elementary and the other more advanced, each lasting a year. The subjects included in the easier course are, the so-called Mechanical powers with their various practical applications, the centre of gravity and different kinds of equilibrium, and the composition and resolution of forces. Models and diagrams are extensively employed, and the boys are required to work a considerable number of numerical examples, and to take full notes of each lecture, as no special text book is used.\* In the higher set the lectures comprise—

1st. The equilibrium of structures and frame-work, theory of girders, arches, roofs, tubular bridges, buttresses, &c., and here, again, the boys are taught practically to work out the tensions and thrusts of the different parts in a given roof or piece of frame-work, to find the breaking weight of beams of various kinds, &c.

2ndly. The elements of Mechanism, conversion of one kind of motion into another, crans, wheel work,

parallel motions, &c., the different arrangements being illustrated, as far as possible, by actual working models.

3rdly. The history, theory, and mechanism of the steam engine.

The chief difficulty in teaching Mechanics satisfactorily has arisen from the ignorance of many boys in Arithmetical and Geometrical. Simple as is the amount of such knowledge required to work examples in Mechanics, it is yet beyond that of a large number of boys who enter a Public School. It is proposed in future not to allow any boy to join a Mechanical set who has not reached a certain stage in the Mathematical work of the School.

The remaining subjects of Chemistry, Electricity, and Heat are not taught in lectures, except to boys in the Sixth Form and Upper School. Chemistry and Electricity have hitherto been taken in alternate years, each occupying three terms. In future, however, this will not be the case, and each boy in the Sixth or Upper School will be able to go through the three subjects of Chemistry, Electricity, and Heat in successive yearly courses.

After some years' experience, the Chemical teaching, so far as lectures are concerned, has been confined to the non-metallic elements. As a rule, the Chemistry of the metals does not present the same variety that is found in the study of the other elementary bodies, and there is too much apparent sameness in the preparation and properties of the different metallic salts to interest any but those who have a decided taste for Chemistry. Roscoe's Text book is adopted, and a large number of experiments are performed before the boys. At every fifth or sixth lesson a paper of questions is given on the subjects that have last occupied the attention of the class, and from the results of these papers the marks and order for the term are obtained.

In Electricity and Heat Ganot's "Physics" has been selected, and here, again, abundant experimental illustration is combined with written answers to questions and the working of numerical examples.

All the new Laboratory was erected it was only possible to allow of a small number of boys studying Practical Chemistry. Such boys as showed a special aptitude for Chemistry might, with their parents' permission, become private pupils of the Chemical lecturer, and work at Analysis with him in the small School Laboratory. Since the large Laboratory has been finished, however, the number of boys who have availed themselves of it has been between 30 and 40 in each term, and instead of being only open to private pupils, there will now always be, in addition to these, a practical Laboratory "set," composed of picked boys who have shown special industry and intelligence in their previous Natural Science work. In this way the Laboratory will act as a stimulus and a reward to those who are really in earnest in their work. Each Laboratory pupil has two lessons in the week of about an hour and a half's duration. The books used are Harcourt and Madan's "Practical Chemistry" for beginners, and "Fresenius" for those more advanced. The boys commence with the preparation of the commoner gases and chemical substances, so as to become practically acquainted with their properties and the ordinary methods of manipulation. They then go on with the examination of the characteristic properties of the metals and acid radicles, and so to the application of these properties in the work of actual analysis.

The Laboratory instruction is given by the senior Natural Science Master, who is also the Chemical lecturer, and his assistant. The regular Laboratory "set" comes at stated hours, twice a week, the boys mostly working in pairs. The other pupils are allowed to choose such times as fall in best with their other work, and the result is that there are few hours in the day when there is not some one working in the Laboratory. This plan has the advantage of preventing the room being overcrowded, and the boys get more individual attention from their teachers.

In brief, then, the arrangement of the Natural Science work is thus—

In September the new boys in the Middle School begin Botany in two sets under different lecturers. A third Botanical set consists of those who entered the School the previous Easter. These three sets continue separate during the October and Lent terms; but, after Easter, the three are arranged according to proficiency and merged into two sets for the last term's work, and a commencing Botany set is formed, consisting of the new boys.

Two sets commence Geology, also under different masters, consisting chiefly of those who have done Botany. These two sets are combined into one after Christmas, so as to allow one of the lecturers to take the new boys in January as an Astronomy set, which is continued through two terms.

Those who have done Botany and Geology form an elementary Mechanical set, and those who have been

\* These Lectures have been discontinued, their place being supplied by Lessons in Elementary Physics, based on Dr. Balfour Stewart's Text Book.—T. N. H., October, 1878.

through the elementary course form an advanced set for Mechanics and Mechanism, &c

Lastly, there is a Laboratory set for Practical Chemistry, formed as already described

In the Sixth Form and Upper School, which are worked together, four sets are commenced in September, each lasting a year. One in Chemistry for new boys and such as are promoted from the Middle School, one in Electricity for those who have done Chemistry, one in Heat for those who have done both Chemistry and Electricity, and a small advanced Botany set for any who have shown a special desire to continue that study.

This is the general order of the work, but individual tastes are consulted as far as possible, and any boy having a strong wish to join a particular set has usually little difficulty in doing so. Indeed, I believe it to be a matter of real importance to make the system as elastic as possible.

The new boys, of whom we can know but little, are placed in Botanical sets. But during their first year some will probably have shown that their taste lies rather in the direction of Physics than Natural History, and in such cases they would be allowed to go on with Mechanics or Physics for the next year instead of Geology, which, under ordinary circumstances, would follow Botany.

With regard to the encouragements to Natural Science at Rugby I may state—

1. That marks are assigned to the Natural Science work in determining the place of each boy at the end of the term, the subject being marked in proportion to the time devoted to it

2. The subject is included in the examination which the Sixth undergo for exhibitions in July.

3. The order of each set is published in the School "List" at Christmas and Midsummer.

4. Various prizes are given annually, one of three guineas for General Chemistry, and another of equal value for Practical Analysis. Prizes of the value of two guineas each are given for special excellence in Mechanics, Geology, and Botany. The boys are also encouraged to make collections of wild flowers, fossils, or insects, and prizes are given to the most deserving.

One of the results of the Natural Science work at Rugby has been the establishing of a School Natural History

Society. The Society has been in existence now for three years, and is in a flourishing condition. Meetings are held once a fortnight, when papers are read and objects of interest in any branch of Natural History are exhibited and explained.

Reports are published annually containing the more important papers and observations of each year. Three reports have already appeared.

Such, then, has been the nature of our work and experience at Rugby during the last few years.

With regard to the opinion in which that work is held by others most interested in the matter, I cannot do better than quote the words with which Mr. Wilson's paper ends, especially as I have no reason to believe that the opinions therein expressed have been altered since the time when those words were written.

Lastly, what are the general results of the introduction of scientific teaching in the opinion of the body of Masters? In brief it is this, that the School, as a whole, is the better for it, and that the scholarship is not worse. The number of boys whose industry and attention is not caught by any School study is markedly less; there is more respect for work and for abilities in the different fields now open to a boy, and though pursued often with great vigour, and sometimes with great success, by boys distinguished in Classics, it is not found to interfere with their proficiency in Classics, nor are there any symptoms of over-work in the School. This is the testimony of Classical Masters by no means specially favourable to Science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the results of their two or three years in our Middle School, the introduction of Science into our course has been the greatest possible gain, and others who have left from the Upper part of the school, without hope of distinguishing themselves in Classics or Mathematics, have adopted Science as their study at the universities. It is believed that no master in Rugby School would wish to give up Natural Science and recur to the old curriculum.

APPENDIX  
ARRANGEMENT OF TIME, 1870

	Monday	Tuesday	Wednesday.	Thursday	Friday	Saturday.	
SIXTH	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3	C Classical, History, or Divinity Lessons
UPPER SCHOOL	C O C O C	C O T M	C O C G N (M)	C O C F	C O T M (M)	C G N	C* Looking over Composition
UPPER MIDDLE	C O T M*	C N C E F	C M F C (M)	C O T C*	C O C N (M)	C O E M	M Mathematical Lesson.
LOWER MIDDLE	C O T M*	C N F E F	C M C O (M)	C O T C*	C M F N (M)	C O C	(M) Unprepared Mathematical Paper
LOWER SCHOOL*	C O C O	C O C O	C F C T C	C O C O	C F C T C	C O C	M* Looking over Mathematical Papers.
							F French
							G German
							N Natural Science.
							E F Extra French
							E M Extra Mathematics.
							T Tutor

The figures 1, 2, 3, 4, 5, denote respectively First, Second, Third, Fourth, and Fifth Lesson. The time for First Lesson is from 7.15 to 8.15. Second Lesson may be taken any time between 9.15 and 11.15. Third Lesson between 11.15 and 1.15. Fourth Lesson between 2.15 and 4.30, and Fifth Lesson between 4.30 and 6.

\* In the Lower School the Lessons marked C are at the disposal of the Lower School Master, and need not be all Classical

12. WELLINGTON COLLEGE.

Wellington College, Wokingham,  
November 29, 1870.

DEAR SIR,  
I HAVE the honour to enclose, in obedience to your request, a short account of the physical science teaching which forms part of our course here.

If you desire any further explanation it will give me great pleasure to afford it.

I have the honour to remain, dear sir,  
Your very faithful servant,

E. W. BENSON.

J Norman Lockyer, Esq.,  
&c. &c.

WELLINGTON COLLEGE.

Physical Science

From the opening of the College in 1859, instruction in practical chemistry has been given, in a small laboratory, to a voluntary class in the higher part of the school. No charge is made for the instruction. The average attendance, which was limited by the size of the laboratory, has been 14 boys.

In 1865, a small class for geology was formed in the Modern Department, consisting of boys not requiring classical work

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In 1867, a further change was made geology was dropped, and it was arranged that chemistry, heat, and electricity should be taught to a larger number of boys. The system then adopted has been, with some necessary modifications, continued up to the present time. This year (1870) a new class room for chemical teaching has been built, with proper appliances, and taken into use.

Division of the School.—The modern school now contains 110 boys, about one third of the school. It is divided into an upper and middle school, the line between which is drawn, in respect of age and attainments, at about the same place as in most public schools. Most of these have, in the first instance, passed through the usual training in classics, mathematics, French, &c., of the lower forms of the classical school, at the age of 13 or 14, and are not allowed to join the modern school as a refuge from classical difficulties. Many join from the higher forms. Some, who have early reached a high position and made considerable progress in classical studies, enter it from the fifth and even the sixth forms. The latter class almost invariably enter the upper division of the modern school. A few come ready to enter the modern school at once. Hence, at leaving, about half the whole number leave from the modern side.

A main object of the modern school being to prepare boys for the higher army examinations, it is necessary to educate boys on two lines, those, viz., which are contem-

plated in the regulations of the examinations, and in the scale of marks fixed for them

*Marks and Prizes*—The study of science is encouraged (1) by marks, both for term work and for examination, and for helping to decide a boy's place in the school; (2), by the publication of the classes in the school roll; (3), by marks in the examination for the modern exhibition (equal to those given for each modern language, two-sevenths of those for mathematics), (4), by an annual governor's prize for practical and theoretical chemistry

*Programme*—The programme is as follows (ascending), omitting history, divinity, and English lessons:—

2nd class	-	Mathematics.	-	
"	-	Latin	-	3 hours.
"	-	French and German	-	
"	-	Science	-	1 hour.
1st class, lower division	{	Mathematics	-	9 hours.
"	{	Latin*	-	3 "
"	{	Science or Greek.	-	3 "
5th form	-	French and German.	-	

In the second class (fourth form from the top) the time is devoted chiefly to experimental lectures, the notes of which are brought, fairly written out, at the following lesson, and then looked over and returned.

*Chemistry, Heat, Electricity*—A different subject is treated each term. For instance, in the Easter Term, 1870, elementary heat, in the following term the elements of magnetism and fractional electricity, both of which are continued higher up in the school. Most boys spend two terms in this form, which contains 30 boys.

In the upper school the three classes are under different masters, the highest of which contains 16 boys, the others 28, leaving boys in the Greek classes. There are three science lessons a week—two of them prepared, the third unprepared and devoted chiefly to working numerical examples under supervision of the master. In the first set, the three subjects, heat, chemistry, and electricity, occupy five terms, i.e., rather less than two years; in the second set no electricity has at present been taught, but all the time has been devoted to heat and chemistry, treated in a more elementary way than in the first set. No boy is promoted to the first set until he has gone, at least once, through the elements of heat and of chemistry. A boy of fair ability, spending three years in the upper school, will thus go through heat and chemistry twice, and through electricity once. This difference in the mode of treatment of the same subject constitutes the difference between the two sets, and we find that, upon the whole, the gradations of knowledge are as clearly marked and unnecessary repetitions as much avoided as in the teaching of classics and mathematics. In one point we have a distinct advantage, namely, that all the modern school give a great deal of time to mathematics, and that the promotion in science very nearly corresponds with that in mathematics. There is, therefore, a marked difference between the capacity of the two sets for working numerical examples.

The work required to be done out of school consists of fairly written out notes of experiments, of numerical examples, and of prepared portions of text books. The time in school is spent questioning upon what has been prepared or written, and in experiments and illustrations. The lessons oscillate in fact between school-lessons, properly so called, and lectures. Neither system is rigorously adhered to.

The text-books in all are Ganot's "Physics," Ferguson's "Electricity," and Barff's "Chemistry." For the lower boys, Tate's small hand-books are used, though, as above stated, the teaching is chiefly *and voce*.

(H. W. EVE)

*Laboratory Class*—In the laboratory class the pupils learn from three to five pages of Fownes' or Roscoe's "Manuals of Chemistry" in the week. Once a week they are examined, and, if found sufficiently acquainted with the portion, are directed in preparing for themselves such experiments as will illustrate the week's work. For this purpose, a laboratory is arranged to accommodate 10 or 12, as many as one teacher can direct at a time. An hour a week is given to practical working in the laboratory, and a quarter of an hour to the examination in the week's work. The senior class, in which there are pupils of the third year, is sufficiently advanced to make most of the chemical substances used in the arts and manufactures, and to conduct a simple analysis. At the end of each term the pupils are examined by written questions, and are required to make some chemical substance, and to conduct a simple analysis.

(J. G. BARFORD)

\* With an alternative of history and modern languages.

Many of the boys who learn chemistry in the ordinary classes avail themselves of the opportunity of attending the laboratory for two or three terms.

*Science Classes*—In the experimental science classes, the lessons are chiefly by lecture, and the boys are required to take notes of all that they see and hear. A chief feature in each lesson is the numerical exercises given to the boys. They are taught, where it is practicable, to reduce all phenomena to figures, and, by this means, although some of the younger boys have a knowledge of mathematics not extending beyond the elementary rules in algebra, we believe that they are led to take a greater interest in the purely mathematical work from finding a practical purpose to which it can be applied.

(CARLTON LAMBERT.)

*Mechanics*—Statics and dynamics are taught in the first mathematical sets in the modern school. The text books are Goodwin's and Todhunter's "Elementary Treatises." These subjects have been treated theoretically, but more opportunity is now about to be given to the boys of seeing the theorems which they use put to the test of experiment. The time devoted to mathematics in the first set is nine hours a week in school, and work is given which occupies about seven hours in their own rooms, thus making a total of about 16 hours a week. Of this time nearly two thirds is devoted to mechanics and hydrostatics. The teaching is by lecture occasionally, when the subject is within the grasp of the whole class, but generally by individual attention. The number of boys in this set is about 13, and the average time during which they continue in the set is about one year.

(C. L.)

*Hydrostatics*—Those boys in the 1st set who have thoroughly mastered mechanics, so far as to be able to solve simple problems in "energy," and the oscillation of cycloidal pendulums, devote their time to hydrostatics. The text book used is Besant's "Elementary Treatise," and attention is chiefly given to problems on specific gravity, condition of equilibrium and stability of floating bodies, and the relations between the pressure, density, and temperature of a gas or vapour, with the application to natural phenomena.

(C. L.)

*Optics*—Between Christmas and Easter this year, as an experiment, a course of six voluntary lectures was given by Mr. Airy, one of the masters, treating the subjects elementarily and using only geometrical methods. There was an average attendance of 22 boys, about half of whom were in the classical school, and, by the numbers who came on the day succeeding each lecture, by invitation, to ask questions arising out of the lectures, they appeared to be much interested. Several of them prepared good diagrams. An examination was held, and parts of Airy's work on "Geometrical Optics" were marked for private study, and a prize was given at the end of the term for the examination. The result was satisfactory.

*Botany*—Two annual prizes have been always given for the best collection of specimens of wild flowers.

But, for the last four years, it has been attempted to make this collecting more instructive by limiting the number of plants to be sent in, and requiring descriptive schedules (Henslow's) to be sent in with each plant. A portion of Oliver's *Botany* is also prepared, and examined in by papers.

For the two terms after Christmas 1869, botany was introduced into the highest form of the classical middle school as an alternative for German. There were two weekly hours in school assigned to the subject. But the prospects of various competitive examinations determined boys and parents, possessing a choice, so much in favour of German, that although botany was a decidedly popular subject with the boys who learnt it, it was found better to suspend teaching it until it can be re-introduced as a necessary and not optional subject on a larger scale. Only a fourth part of the boys undertook it, and these diminished as the claims of German appeared nearer.

"I used Oliver's *Lessons* as the text-book, and after the breaking up of the frost, Dr. Lindley's *Descriptive Botany*, to enable boys to fill up schedules and describe the different parts correctly. Until technical terms were mastered, we worked with reading, *and voce* questioning, and short papers, and illustrated the lessons with drawings on the black board, and dried plants. As spring advanced, I supplied each boy with a specimen for dissection and examination, and floral schedules were filled up. After promotion at end of first term, the change in the class made it apparent that, in order to teach effectually, two sets were necessary. Boys who began when flowers were plentiful made more rapid progress. Mr. Kitchener, of

Rugby, examined them at Midsummer, and considered that they had very fairly marked the first part of the subject." (C. W. PENNY)

At present the prizes for collections and schedules continue as before.

*Natural History Society*.—A Natural History Society was founded early in 1868, and has flourished. The meetings, held once a fortnight, have been numerously attended the members, who number about 20 boys, have the power of introducing others to the lectures. The average attendance at the meetings is 30 or 40, and is often much more numerous, and various interesting papers have been read, contributed by the boys themselves. Professor Kingsley and Professor Rupert Jones have taken great interest in the society, and, as well as other friends and masters, have frequently delivered lectures and addresses to them.

The Report for 1869 is enclosed

(Signed) E. W. BENSON, D. D.,  
Master.

### 13. UNIVERSITY COLLEGE SCHOOL.

REPORT ON SCIENCE TEACHING IN UNIVERSITY COLLEGE SCHOOL, LONDON, DEC. 1870.

#### INTRODUCTION.

University College School, as at present constituted, was founded in January 1832, under the joint Headmastership of Professor Key and Professor Malden.

At the end of session 1841-2, Professor Malden resigned his share in the Headmastership, continuing, however, to act as Supervising Examiner down to August 1863, and making, in that capacity, an Annual Report on certain classes selected by him, as time and circumstances allowed, from year to year.

Extracts are given from the following sources of information.

- (1.) The MS. Reports of the Headmaster to the Council of the College.
- (2.) The MS. Reports of the Supervising Examiner, Professor Malden.
- (3.) The Reports of the Council to the Members of the College.
- (4.) The communications of the Masters engaged in science teaching.
- (5.) The Report furnished in 1866-7 to the Schools Inquiry Commission. [Vol. x p. 223.]
- (6.) The Headmaster's evidence given before the same Commission in 1865. [Vol. iv p. 313.]
- (7.) The Report of the French Commissioners, MM. Demogeot and Montucci, on Secondary and Superior Education in England and Scotland, Vol. II. Paris, 1870.

The Statistical Tables are compiled from the printed prize lists of the school.

Appended are:

- (1.) A copy (in proof) of the programmes of work in the science classes, strictly so-called, and the cognate classes.
- (2.) A copy of Mr. Orme's syllabus of lectures on chemistry, printed for the use of the school, but not published.
- (3.) Specimen copies of examination questions in the science classes, 1865-9.
- (4.) Specimen copies of the school prize lists for 1840, 1855, 1857, 1867, 1869, 1870.

#### REPORT.—PART I.

*Account of the Science Classes and arrangements for Science teaching in University College School, from its first establishment down to the end of Session 1869-70, viz., July 28, 1870.*

##### Sessions 1832-3—1834-5

Schools Inquiry Commission (Minutes of Evidence) Vol. IV. p. 313, Professor Key, M.A., F.R.S., Headmaster of University College School, examined, 3rd May 1865.

Question 3003.—Is the general system of instruction in the school nearly the same as it has been since the establishment of the school?—Chemistry has been introduced, which was not taught at first, and when it was first taught it was not taught practically.

You have always had some branches of physical science?—Yes; natural experimental philosophy, and further than

that, applied mathematics; but then that is for a small number.

When you first knew the school, what branches of physical science were taught?—But little was done in this way, simply because, at the beginning, our boys were too young. We had very few old boys for a year or two.

Were the ordinary sciences of observation, botany, and zoology, taught?—Occasionally we have had botany taught, but only occasionally.

3057 Has it been tried with specimens? Has it been demonstrative?—Yes, but not systematically. My reasons for not applying our time to botany are these: it is difficult for us to obtain specimens in sufficient quantity for all the boys in a class to handle them; and even then without a magnifying glass little can be done. If a boy is not to handle the object, his observing powers are not called into play. But the science of classification, it is said, is taught in botany. Such, however, is the case in all sciences, in that of language itself, for example. At any rate, botany is a better subject for country schools than for us.

3008 Do you attach more importance to the experimental sciences?—Yes; we found we were not doing much good in the other sciences.

Do you conceive that the teaching of all these subjects of physical philosophy is imperfect unless you can make the boys use their own hands?—I should say so.

Apart from these points the general system of the school is nearly as it was constructed originally?—Very nearly indeed.

#### Note on foregoing extract.

The printed "Prize Lists" specify the following classes, which may be given as an illustration.

- Session 1833-4 I (see beginning) Class and Upper II, class in "Objects"  
 " 1834-5. Upper II and Lower III, "Objects;"  
 " Upper III, "Natural History."  
 " 1835-6. Lower III, "Objects."  
 " 1836-7. Lower II, "Objects." Mixed Class of Non-Grecians: "Physical Geography and Astronomy."  
 " 1837-8. Lower III, "Vegetable substances used for Food."  
 " 1838-9. Upper III, "Objects." Upper III. Vegetable substances."  
 " 1839-40. Lower IV, "Natural History."

The text-book employed in the object classes was Miss Mayo's "Lessons on Objects," e. g. metals, natural products, such as camphor, gum arabic, &c. These lessons were eventually discontinued, as they tended to degenerate into mere teaching of the meaning of hard words.

For natural history one of the volumes of the "Peter Parley" series formed a text-book. The museum of the college was occasionally put under contribution for illustrative specimens. The lower fourth class in this subject, in session 1839-40, was conducted by Professor Malden.

The volumes entitled "Fruit and Timber Trees" and "Vegetable substances used for Food," forming part of the "Library of Entertaining Knowledge," were used in the upper and lower divisions respectively, of the third class.

Another volume of the same series, "Menageries," was used in the beginning classes.

##### Session 1835-6

The Upper VI. class of pure mathematics was under the charge of Professor White, of University College. The same boys received instruction in natural philosophy—the first instance of the introduction of this subject into the school. Vide remarks on table No. 1 in Appendix.

The 1st and 2nd prizemen in natural philosophy were prizemen in the same order in the VI. Latin class also. The former obtained at the same time the highest prizes in German and in Geometry.

To this session belongs likewise the formation of a class of purely experimental physics; a mixed class of "non-Grecians" reading Hydrostatics.

In the following session, the prizeman in applied mathematics, J. G. Greenwood, gained also the highest prizes in Latin and in Geometry.

Mr. Greenwood graduated at the London University in 1840, obtaining the University Scholarship in classics, and is now Principal of Owens College, Manchester.

##### Session 1838-9.

The VI. class of mechanics, under Mr. Cook, numbering in the second term 20 boys, had three lessons of one hour per week, and read as text-book Whewell's "Mechanical Euclid." The non-Grecians of classes VI and V., also under Mr. Cook, numbering in the second term 19 boys

and likewise receiving three lessons of one hour per week, read the Useful Knowledge Society's "Lives of Galileo and Kepler," with illustrations by the master. The same class had in former years been accustomed to use Webster's "Elements of Physics."

The non-Grecians of class upper IV (24 boys in the second term), under Mr Webster, had two weekly lessons of one hour, and read the Useful Knowledge Society's "Introduction to Natural Philosophy." The same boys had one lesson every week with Mr. Cook on the use of the globes.

#### Session 1839-40.

The VI class received two lessons of three-quarters of an hour weekly in applied mathematics, and four lessons of similar length in experimental physics, including (exceptionally) chemistry.

The prize in applied mathematics was awarded to E. A. Bowring (now C B and M P), who was also first prizeman in the VI Latin class.

The upper V class received four lessons of three-quarters of an hour in experimental physics, using Webster's "Elements."

The prizeman in this class, L. Field, obtained the prize in chemistry in the B A examination (London) in 1844, and is now Fellow of University College.

The upper IV class received one hour's lesson a week in objects, with special reference to arts and manufactures.

The lower IV class spent three hours a week on Natural History.

#### Session 1840-1.

The VI applied mathematics met for two periods of three-quarters of an hour, and the same boys gave four periods to experimental physics.

The lower V class gave three periods and the IV class four periods to natural philosophy.

#### Session 1843-4.

##### Examiner's Report

In the examination of the sixth class in mathematical natural philosophy I read over the papers of the second boy, Hayward, and found them remarkably well done. Mr. Cook's examination was a very judicious one, but at the same time implied a considerable knowledge of elementary mechanics in the boys submitted to it, and I was glad to find by his report that rather more acquainted themselves fairly than in the pure mathematics.

The lower V class, under Mr. Ellis, was examined in the elements of natural philosophy without mathematics, but with arithmetical calculations. The examination was certainly elementary and very easy, but I did not think the worse of it on that account. On the contrary, I thought it judicious. Nine boys were "mentioned."

##### Note

In applied mathematics, seven boys were "mentioned."

In differential and integral calculus, six boys were "mentioned."

In geometry, algebra, and trigonometry, five boys were "mentioned."

The "second boy" in applied mathematics, Robert B. Hayward, was fourth wrangler in 1850, and became Fellow of St. John's.

The "first boy" on the same occasion was Geo. V. Yool, third wrangler in 1851, and subsequently Fellow of Trinity.

#### Session 1849-50

##### Examiner's Report

Mr. Spencer's two classes in natural philosophy and chemistry may be taken together, as they consisted of nearly the same boys. His senior classes in these subjects did very well.

The junior classes consisted of older boys, but boys of inferior power generally, and it so happened that the classes had dwindled down by the boys, from time to time, leaving the school. These juniors did not do well.

#### Session 1850-1.

##### Mr. Spencer's Report to Headmaster

In natural philosophy, my classes are entirely experimental. During the past year we have read mechanics and hydrostatics, but in the previous session we had an experimental course on electricity, magnetism, and electro-magnetism, besides a short course on the history and structure of the steam engine.

In chemistry, we devote ourselves entirely to inorganic chemistry.

I may mention that a very good chemist has this year spoken very highly of the papers sent in by the first and second boys in each class.

##### Note.

The "first boy" in the senior class was Michael Foster, subsequently B.A., with University Classical Scholarship, and M.D., London, now Praeceptor in Physiology at Trinity College, Cambridge, and late Professor of Practical Physiology at University College, London.

The "second boy" in the same class was William Stanley Jevons, now M.A., London, and Gold Medallist, and Professor of Logic at Owens College, Manchester.

#### Session 1851-2.

##### Headmaster's Report.

Mr. Cook's VI., mathematical mechanics and hydrostatics, &c., was a "great improvement on former years," which he chiefly attributes to the use of an improved textbook.\*

In Mr. Cook's V., experimental natural philosophy and the higher arithmetic, some did remarkably well, but, on the whole, the class was somewhat below the average.

Mr. Spencer's mathematical classes consist, for the most part, of boys unable to go on with Mr. Cook's classes, so that any demerit of theirs is not fairly attributable to their teacher. But the upper part of all his three classes passed a very satisfactory examination.

The four classes in experimental natural philosophy and chemistry (two of each), which are conducted by Mr. Spencer, appear to have been in a very creditable condition; and I am the more disposed to rely upon his report when I find that in Professor Graham's class of chemistry in the college both the silver medals in 1851-2 have been won by students who had been boys in the school in the previous session, viz., F. H. Roberts and W. S. Jevons.

##### Note.

In the VI., applied mathematics, equal prizes were given to Joseph Chamberlain, now chairman of the Executive Committee of the National Education League; and to F. Manning Needham, B.A., Lond., in 1856, and third in mathematical honours.

The first prize in Mr. Spencer's senior class of experimental physics was awarded to Edwin Lawrence, now B.A. and LL.B., Lond., in honours, and Assoc. Inst., C.E.

The Rev. Wm. Brock, of Hampstead, was first prizeman in chemistry (senior class). He matriculated from the school in 1853.

The Rev. F. H. Roberts matriculated in 1852 as fourth in honours in classics and fourth in chemistry.

#### Session 1852-3

##### Examiner's Report

I was particularly struck and very much pleased with the answers of the boys in the sixth class, under Mr. Spencer, in experimental natural philosophy. They appeared to have been thoroughly well taught, and the examination was judicious.

In like manner, so far as I am able to judge, I would report very favourably of the senior class of chemistry.

#### Session 1853-4.

##### Examiner's Report.

I was much pleased with the examination of the lower VI class in experimental natural philosophy, and I was gratified in a very high degree by the examination of the senior class in chemistry. Both these classes had been taught by Mr. Spencer, and did him very great credit.

#### Session 1855-6.

##### Report of Council.

In the sixth or highest classes of mathematics and physics, conducted by the Rev. Wm. Cook, the Council are informed that the class for mechanics, though not large, was a very efficient one, that the pupils were engaged with Newth's larger treatise, which they requested to have instead of the smaller one formerly used, and with which they were not satisfied, that there was a great ambition amongst them to work the more difficult problems, and that they succeeded very well. Once a week experiments were given in mechanics, hydrostatics, pneumatics, heat and electricity.

Mr. Cook's class for pure mathematics learned geometry—Euclid, books VI and XI; plane trigonometry, spherical trigonometry with applications to astronomy, algebra—expansion of functions of one variable into series, binomial theorem, exponential and logarithmic series, convergence of series, algebraic geometry including conic sections, cycloid,

\* Viz., Newth's "Statics" in place of Snowball's "Mechanics."  
† Newth's "Mechanics" instead of Newth's "Statics."



&c., with a few theorems in the differential calculus. The class is reported to have averaged better than any of its predecessors, to have taken a lively interest in the work, and to have had only two boys whose progress failed to give entire satisfaction. The ages of the four prizemen in these classes were respectively  $15\frac{3}{4}$ , 17,  $15\frac{1}{2}$ , and 16.

*Examiner's Report*

In Mr Spencer's two classes of natural philosophy, though some of the boys did fairly well, the questions were not generally so well answered as I have seen them in former years.

In the sixth and fifth chemistry, the boys did not seem to me to do so well as might have been expected, not so well as like classes in former years.

*Note*

The first prizeman in the VI, pure and applied mathematics, the late Jacob Staebel, was afterwards, in 1858, Andrews Scholar of University College, and stood second in mathematical honours at matriculation in 1859, and at first B A in 1860, the first place on both occasions being obtained by Mr Dale, of Trinity College, Cambridge, third wrangler in 1862.

The first prizeman in the lower VI, experimental physics, and in the senior class of chemistry was W Lant Carpenter, subsequently B.A. and B.Sc. London, and first in chemistry at the examination for the latter degree.

Session 1856-7.

*Examiner's Report.*

I looked at the papers of only two boys in the examination of the chemistry classes under Mr Spencer. They happened to be the two boys who gained the prizes in the fifth class. I scarcely need say that I found their answers good.

*Note.*

The Rev. P Magnus, late Andrews Scholar of University College, and B A and B.Sc. London, with honours in various subjects, was one of the two equal prizemen.

Session 1857-8.

*Examiner's Report.*

Mr. Cook examined the VI class in natural philosophy upon the propagation of waves of air, and musical vibrations; and also upon the phenomena of steam and congelation, and latent heat, and upon the hygrometer.

Mr Spencer gave the lower VI class in natural philosophy a short examination (five questions) upon the history of the steam engine. I saw some of the papers, and, as far as I was able to judge, the boys seemed to understand the subject.

Mr. Spencer printed questions for the examination of his three classes of chemistry. I saw the work of some of the boys in the VI and V classes, and, so far as I was able to judge, I thought it well done. Mr Spencer found himself warranted in awarding two prizes in each class, and in mentioning with praise rather a large number of the boys in each.

*Note*

The first place in Mr. Cook's examination was gained by W Rutt, now C E; the second place by Mr Magnus.

The first place in Mr. Spencer's class fell to Lt D Bevan (now the Rev.), afterwards University (Lond.) exhibitioner in English; B A. in 1863, with first class in moral philosophy, and LL B. in 1866, with first class in principles of legislation.

The second prizeman in the fifth class of chemistry was H C. Watson, afterwards scholar of Trinity College, Cambridge, and eighth wrangler in 1865; late Vice-principal of Elizabeth College, Guernsey.

The first prizeman in the fourth class of chemistry was H G. Howse, now M B and B S., London, and exhibitioner, medalist and scholar of the University; and demonstrator in anatomy at Guy's Hospital.

Session 1858-9.

*Examiner's Report.*

In applied mathematics, the VI class, under Mr. Cook, passed a hard examination in statics, and also in the elements of dynamics and of hydrostatics.

In experimental natural philosophy, Mr Spencer gave a short and good examination on the mechanical properties of the atmosphere (barometer, air pump, &c.), and on

electricity. I did not see many of the papers, but those I saw were good.

*Note.*

The first prize in Mr Cook's VI class was obtained by Mr H. C. Watson, the third by N E Hartog, afterwards B A., London, with exhibition in Latin, scholarships in mathematics and classics, and prizes in French, German, and animal physiology; more recently scholar of Trinity College, Cambridge, and in 1869 senior wrangler.

The second prizeman in Mr. Spencer's class, J E Carpenter, became scholar of University of London in logic and moral philosophy; and M A in 1866 in the same branch, and "deserving of medal."

Session 1859-60.

*Report of Council.*

Preparatory to the second term of the current session the Council, on the application of the Headmaster, made arrangements for an improved and more extensive system of instruction in chemistry. They have caused a room to be fitted up with suitable apparatus for teaching practical chemistry, and Mr George Carey Foster, assistant to Dr. Williamson in the conduct of the Birkbeck laboratory of analytical chemistry in the college, has been engaged by Professor Key, to instruct a class during the present session. The applicants for permission to attend it have been so numerous that all could not be admitted. The nature and the mode of instruction, and especially the extent of accommodation, required that the class should be of limited size, and Professor Key has made a selection of about 30\*. He has been governed in his choice by the convenience of pupils according to their engagements in other classes, by their character for good conduct, and by the probability that from their previous acquirements in the subject they would duly profit by the teaching.

*Headmaster's Report.*

To the practical class in chemistry none were admitted who had not already received theoretic instruction in the subject from Mr Spencer. Of course, where such a class meets but twice a week, the progress must be comparatively small, yet the success which followed Mr G C Foster's exertions may be regarded as a favourable augury, and although he himself was obliged to resign the duties at the end of the year, as I had been led to expect from the very outset, in consequence of an engagement abroad, I have had the good fortune to replace him by a highly qualified successor in Dr. Russell.

*Communication from Professor G Carey Foster, B.A., F.R.S. (December 1870)*

My class of practical chemistry in University College School began, I believe, in February 1859.

The course of instruction was of this kind. At the beginning of each lesson, each pair of boys was supplied with certain materials and apparatus, and, as soon as they were all in their places, I described, as fully as I could, the experiments I wished them to make, but without telling them what result to expect. When they had done this, I made them examine, during the same or the next lesson, the products of the operations they had gone through. The operations given at first were chosen so as to give an idea of the way in which chemical action occurs in a few typical cases, and especially so as to make the boys see that the elements with which they began could be traced through a whole series of changes, and could be recovered with their original properties at the end. Gradually I led them on to easy cases of qualitative analysis.

Throughout the course I purposely avoided the use of any text-book, as I specially wished that the knowledge the boys got in the class should be, as far as possible, the result of their own observations and experiments.

I went abroad in the autumn of 1859, so that I had the class only two terms.

I remember that I was well satisfied with the progress made by several of the boys, and that Dr Russell, who succeeded me, told me he found that they knew more than he expected they would have learned in the time.

*Communication from Dr. Russell (December 1870).*

I had charge of the class of practical chemistry in University College School three years. The class consisted of

\* More correctly 30 or 34.

about 20 boys; it met for one hour twice a week. The boys were expected to have attended or be attending a course, also given in the school, of theoretical chemistry, and consequently to have some general knowledge of the science.

In my class they began with the preparation of oxygen, and simple experiments illustrating its properties, putting together for themselves the apparatus necessary. From oxygen they went on to hydrogen, and the other most important non-metallic elements, experimenting with them and their principal compounds. They were taught the reactions for the most common acids, and the analysis of solutions containing several acids.

A few of the boys remained long enough, and were sufficiently advanced to study the properties of the metals, and to analyse a solution containing acids and bases, but this was rather the exception than the rule.

The boys were interested in their work, and behaved well; and my impression is that, considering the small amount of time devoted to the subject, the class was decidedly successful.

Session, 1859-60.

*Examiner's Report.*

The examination of Mr Spencer's fifth class in natural philosophy was short and easy, but in my judgment a good and sensible one, sufficient to test the knowledge of the boys, and not so hard as to discourage them.

The questions were upon specific gravities, the pressure of fluids, and the construction of the air pump and the barometer. The upper boys did thoroughly well, and several others fairly well.

*Note.*

The prizeman of division A., H A Smith, now of St. Bartholomew's, matriculated ninth in honours.

The first prizeman of division B., A. W. Harding, gained a medical exhibition at University College in 1867, and graduated as B.A., Lond., with a first class in moral philosophy, in the same year.

Session, 1862-3.

*Headmaster's Report.*

It was thought that to place in different hands the theoretical instruction and the practical instruction on chemistry, was detrimental to good progress. I have, therefore, entrusted all our chemical classes to Mr C H. Gill, as well as those of natural philosophy, treated experimentally.

Dr. Williamson bears testimony that Mr. Gill's success in imparting knowledge of the elementary principles of physics and chemistry is such as he has seldom seen equalled and scarcely ever surpassed; also that he is a truly admirable worker at experimental operations.

Session, 1863-4.

*Headmaster's Report (Nov 7, 1863).*

Mr. Gill attends from 2.15 to 4 twice a week, Mondays and Fridays. From 2.15 to 3 on Mondays he meets a double class of some 50 boys, and gives them a lecture on theoretical chemistry. On Fridays, one half of this class meet at the same time for an examination, conducted in writing, and Mr Gill employs an hour or so out of school time in the separate correction of these exercises. The other half of his theoretical class devote or will devote an hour on both Monday and Friday (from 3 to 4) to practical chemistry. I have said *will* devote, because he finds it desirable at the outset to give these boys an extra dose, so to say, of theoretical chemistry, without which they can do but little in practical chemistry.

On Tuesdays and Thursdays the classes of natural philosophy meet, one from 2.15 to 4, the other from 3 to 3.45. These two classes, each consisting of some 25 boys, stand on the same level, and must not be considered as a senior and junior.

In both classes, whether for chemistry or natural philosophy, Mr. Gill takes for his guidance the demands of the University of London.

It must not be forgotten that over and above Mr. Gill's classes, there is the class of mathematical physics conducted by Mr. Spencer, which meets every one of our four afternoons, from 1.30 to 2.15.

Afternoon Period.	M. F.				T. Th.		
	1.	2 M.	2 F.	3.	1.	2.	3.
Mr Spencer	Applied mathematics.	- - -	- - -	- - -	Applied mathematics		
Mr. Gill	- - -	- - -	- - -	- - -	- - -	V <sup>a</sup> Experimental Physics.	V <sup>b</sup> Experimental Physics.
Ditto	- - -	V <sup>a</sup> & V <sup>b</sup> Chemistry (Lect.)	V <sup>b</sup> Chemistry (examination)	V <sup>a</sup> Practical Chemistry			

Session 1864-5.

*Headmaster's evidence before Schools Inquiry Commission, 3rd May, 1865.*

2995. With regard to the physical sciences, do you give any instruction in them?—We do.

Will you state of what description?—I will take chemistry. We have two classes in chemistry. I suppose we have as many as 60 boys learning chemistry, learning it theoretically first; but we have a class of 24 boys learning it practically, and they have a laboratory of their own, and do the things as well as talk about them. They make the experiments under the eye of their teacher. I have reason to believe that they become fairly proficient. We limit the amount. We do not let them go far into it. We rather study a thorough knowledge of the little they deal with. They do get a practically useful knowledge of chemistry.

3041. What do you consider to be the practical value of the study of physical sciences for a general commercial education?—If a subject like botany is included, I should say it does but very little good indeed.

Chemistry for instance?—Well, there, I think there is a practical advantage in the study of even a little chemistry; it is so much connected with life. All our manufactures at the present day are becoming scientific manufactures.

3053. At what age do your boys begin the study of physical science?—Our rule is this, that they shall not commence that study till they are thoroughly acquainted with

fractions, vulgar and decimal, and that brings them up to the age of 13 or 14.

Do they begin the study of chemistry so early as that?—Sometimes. The young man I spoke of, Numa Hartog, did.

Apart from the simple utility of science, what place do you assign to science as an element of knowledge for educational training?—I think that chemistry is really a very valuable thing for training the reasoning powers as well as the powers of observation, but the reasoning powers particularly. As to botany, as generally taught, I look upon it as a very large ugly spelling book.

Session, 1864-5.

*Report of Council.*

Of the mathematical and physical departments, the reports are quite favourable, especially the class of physics conducted by Mr. Gill, which appears to be alike popular and effective.

Session, 1865-6.

*Headmaster's Report.*

The charge of the highest class in natural philosophy, viz., that of applied mathematics, has been entrusted to Mr J J Walker, a very distinguished mathematical student of Trinity College, Dublin, and the author of some

original papers on applied mathematics, especially one on the interesting subject of the secondary rainbow formed by reflection upon water

Report of French Commissioners.

École (Secondaire) annexée au Collège de l'Université.  
[Visited in Lent Term, 1866]

Ce qui nous a le plus surpris et charmés, dans notre visite à l'école du Collège de l'Université, c'est l'enseignement de l'économie politique, qui s'y donnait alors. Nous nous défions de cette promesse du prospectus; nous pensions que l'accès de cette science, ouvert à des enfants de 14 ou 15 ans, était un peu prématuré. Une leçon, faite en notre présence par M Hodgson, \* a dissipé nos préventions, et nous a montré que, avec du tact uni à beaucoup de savoir et d'esprit, un professeur peut instruire très-utilement aux éléments de la science économique les enfants même de cet âge.

Trente-six élèves étaient réunis dans un amphithéâtre. Le professeur faisait non pas une leçon suivie, mais une piquante conversation, qu'il dirigeait avec habileté et soutenait avec une *humour* qu'on aurait pu appeler l'esprit du bon sens. Des exemples familiers, des observations aussi amusantes que vraies, excitaient à la fois et délassaient l'attention. Le maître s'interrompait sans cesse par des questions auxquelles les élèves s'empressaient de répondre. Il amenait de petites controverses qu'il faisait discuter contradictoirement, et dont il mettait aux voix la solution. Tous ces jeunes visages, tour-à-tour sérieux et souriants, étaient sous le charme de la parole et obéissaient à toutes ses impulsions. Au sortir de la leçon, nous avons conseillé au principal un nouveau genre de punition pour les élèves dont il serait mécontent, c'est de les priver d'une séance du cours d'économie politique.

Parmi les classes de science dans l'école, nous citerons celle de mathématiques appliquées, faite par le professeur Walker. Vingt élèves étaient présents. Il s'agissait du centre de pression en hydraulique. Le professeur avait fait sa figure au tableau, la démonstration n'était, bien entendu, que purement élémentaire. Au moment où nous sommes entrés, une discussion animée s'était engagée entre les élèves et le professeur. Pourquoi, d'abord, toutes les pressions partielles seraient-elles réunies dans le centre de pression? Ce centre, où serait-il dans le rectangle? Ou serait-il dans le triangle, avec la base en bas, ou bien renversé? Tout cela formait le sujet d'un feu ardent de suppositions de la part des élèves, et d'objections de la part du professeur. De cette façon, un sujet aride pour des enfants prenait, sous la forme d'une conversation familière, une allure des plus intéressantes. Les élèves jouaient, pour ainsi dire, aux échecs avec le professeur.

Une autre classe, celle de physique expérimentale, nous a paru excellente par le choix des expériences et par l'habileté que montrait le professeur, M Gill, à faire raisonner les élèves sur les faits. Il traitait, ce jour-là, de la lumière, et les volets fermés, il faisait l'expérience bien connue des miroirs paraboliques. Par quel moyen le feu placé dans l'un des foyers allumait-il un combustible placé dans l'autre? Les élèves se sont chargés de l'expliquer au professeur. Lui, il écoutait, il feignait l'ignorance, trouvait des objections, et petit-à-petit, une erreur après l'autre a été écartée, et finalement un des jeunes auditeurs a dit le dernier mot. C'était le système de M Hodgson et du professeur Walker, transporté sur un autre terrain. Du reste, dans cette classe nous avons vu recueillir des rédactions sur la leçon précédente.

Session 1866-7.

The following details respecting the condition of the science classes are extracted from one of the tables furnished to the Schools Inquiry Commission, and printed in their report. Vol. X., p 226.

\* W B Hodgson, LL.D, member of the council of the college, gave his services during this session in instructing provisionally the class of social science in the school

Session 1866-7.	Statistics of the whole School.		Statistics of First Class.			Average Age at close of Session.	Session 1866-7.	Statistics of Lowest Class.			Session 1866-7.
	Subject.	Number of Boys learning each Subject	Number of Classes into which the Boys are formed.	Number of Boys in the Class.	Aggregate of Time per Week given to each Subject.			Work of Third or Midsummer Term.	Number of Boys in the Class.	Aggregate of Time per Week given to each Subject	
				HOURS.	Y. M.			HOURS.	Y. M.		
Mathematics							Todhunter's Conics, chaps 1-3, 5, 6, 9, Todhunter's Trigonometry, chaps 1, 3-6, 10, 13-15, Todhunter's Euclid, xi, 1-31, and about 150 deductions Elements of Statics and Dynamics, Hydrostatics, and Optics, with the construction and theory of the common machines and instruments Instruction chiefly <i>visd voce</i> , Text-book, Galbraith and Haughton.	23	6	15 8	Euclid, books 1, 2; deductions to first book, algebra to simple equations.
Pure	177	11	10	6	15 10						
Applied	10	1	10	3	15 10						
Physics	69	3	17	1½	15 3		Light and Radiant Heat, and Elements of Acoustics; instruction <i>visd voce</i>	52	1½	15 4	Elements of hydrostatics and pneumatics, determination of the specific gravity of solids, liquids, and gases.
Chemistry, theoretical.	61	2	9	1½	16 0		Preparation and properties of some of the most common metals and their compounds; instruction <i>visd voce</i> .	52	1½	15 7	Preparation and properties of some of the non-metallic elements, the compounds formed among themselves, their relations by weight.
Chemistry, practical.	15	1	15	2	15 7		Preparation by the boys themselves of some of the non-metallic elements and their compounds, testing for common acids, single and mixed.				

Communication from Mr. C. H. Gill, F.C.S.—  
(December 1870.)

During the five years in which I had charge of the classes of experimental science, 1863-4 to 1867-8 inclusive, instruction was given in the following subjects:—

1. *Elementary Chemistry*, taught by means of lectures with full experimental demonstrations, monthly examinations, in which many numerical questions always found place, and daily written exercises on the preceding lecture.

There were two classes for this subject, each meeting twice a week. In the first, any boy wishing to commence the subject was received, provided he had a competent knowledge of arithmetic; while to the second only those who had previously acquired a firm ground-work of chemical facts, either in the school itself or elsewhere, were admitted.

Most of the boys in the second or senior class, with a few of those from the junior class, also attended a class of practical chemistry, which met once a week for two hours. In this most valuable class, the boys themselves individually performed the simpler experiments of demonstration, and acquired an insight into the method pursued in solving questions by means of experiment.

2. *Experimental Physics*, taught in the same way as chemistry, and with careful exclusion of mathematical formulæ. The subjects taken were:—

Elementary dynamics and statics, including hydrostatics and pneumatics; so treated as to lead the boys to construct the formulæ relating to the simpler cases for themselves from the results of experiments exhibited or described.

Elements of heat, including the method for determining the constants and calculations relating to specific heat, &c.

Elements of light and radiant heat, including nature of light, simple laws governing its transmission, formation of images in plane and curved mirrors, refraction of light, index of refraction, formation of images by lenses, compound nature of light, nature of colour, &c.

Elements of sound, and, when time could be found, some portions of electricity and magnetism.

These subjects were spread over two years, each boy following them in the above order, and receiving two lessons of three quarters of an hour weekly.

My choice of subjects was governed by the requirements of the University of London.

The four periods of three quarters of an hour each devoted to lectures, the like time given to experimental physics, and the two hours for practical chemistry, amount to eight hours per week employed in science teaching.

The effect of the study of science in each year or even in any number of years, admits of no exact measurement: it must be sought in the capabilities of the boys so prepared. All that I can add on this point is that many boys from my classes have since elected to make science a life calling, and that no inconsiderable number have achieved University distinction.

## APPENDIX TO PART I.

Containing Statistical Tables, accompanied by remarks and explanations.

TABLE No. 1.

### 1. Applied Mathematics.

The class of applied mathematics dates from 1835-6, and was for three years under Mr. W. Wright, B.A., former scholar of Trinity College, Cambridge, afterwards LL.D., and headmaster of the Colchester Grammar School.

Mr. Wright was followed by the Rev. Wm. Cook, M.A., of Trinity College, Cambridge, who had charge of the class for 22 years.

From April 1860 to the end of the session, the class was conducted by Dr. T. Archer Hirst (afterwards F.R.S., and professor successively of mathematical physics, and of pure mathematics in University College), who continued in the school for the four following sessions as principal master in pure mathematics.

From 1860-1 to 1864-5, inclusive, the teaching of applied mathematics was in the hands of Mr. J. A. Spencer, B.A., London, and Mathematical University Exhibitioner.

Mr. J. J. Walker, M.A., of Trinity College, Dublin, succeeded Mr. Spencer in session 1865-6.

The following text-books have been used in succession:—

- (1) Whewell's "Mechanical Euclid."
- (2) Snowball's "Mechanics"
- (3) (1850-1 to 1854-5) Newth's "Elements of Mechanics and Hydrostatics."
- (4) (1855-6 to 1864-5) Newth's "Mechanics."
- (5) (1862-3 to 1866-7) Galbraith's "Optics"
- (6) (1865-6, 1866-7) Galbraith and Haughton's "Mechanics" and "Hydrostatics."

The book now sanctioned, though the instruction is principally oral, is:

- (7) Newth's "First Book of Natural Philosophy."

### 2. Experimental Physics.

It is not clear whether, under Mr. Wright, there was any experimental teaching in the sixth class of natural philosophy, or not.

The only classes which were undoubtedly experimental, up to the close of 1838-9, consisted solely of boys who did not learn Greek.

In the following session, Mr. Cook's second year, natural philosophy ceased to be a mere alternative for Greek, and became an integral, though not a compulsory, part of the curriculum.

For two or three seasons at the least, Mr. Cook gave one third only of his sixth class's time to applied mathematics (viz., 1½ hours per week), whilst two-thirds were devoted to experimental teaching. During that time, although the mathematical and experimental divisions of the class consisted of the same or very nearly the same boys, they were examined as distinct classes and received for each branch separately prizes and "honourable mentions."

As the boys who, in subsequent years, came up to the sixth class, had already gone through an experimental course, the proportion of time given by Mr. Cook to experimental teaching in that class was very much reduced. In 1855-6 only one lesson per week was so bestowed. Accordingly, in most years, the two subjects were no longer separated in Mr. Cook's examinations, and prizes and "mentions" came to be awarded on the aggregate of marks obtained in both branches combined. Mr. Cook was followed in this practice until 1863-4 by Mr. Spencer.

By the side of the sixth class, in most years, ran a lower sixth, consisting of boys of the same standing, but of inferior attainments. This class was conducted for many years by Mr. Spencer, and was purely experimental.

The fifth and fourth classes of natural philosophy were likewise under the charge of Mr. Cook and Mr. Spencer. Between the years 1838 and 1844, Mr. J. H. Webster, B.A. (now M.D.) of Jesus College, Cambridge, and the Rev. F. W. Ellis, M.A., of Trinity College, Cambridge (afterwards chaplain in Bengal), successively assisted in the teaching.

The following is the list of text-books arranged in chronological order:—

- |   |                           |
|---|---------------------------|
| (1) The Useful Knowledge Series "Introduction to Natural Philosophy"  | } used contemporaneously. |
| (2) Webster's "Elements of Physics"   |                           |
| (3) Carpenter's "Natural Philosophy for Beginners"  | } used contemporaneously. |
| (4) Carpenter's "Mechanical Philosophy"   |                           |
| (5) (1847-8 to 1851-2) Peschel's "Physics," Vol. I.   |                           |
| (6) (1852-3 to 1855-6) Lardner's "First Course of Natural Philosophy" (Mechanics, Hydrostatics, Sound, Optics). |                           |
| (7) (1853-4) Lardner's "Second Course" (Electricity, Heat, Magnetism).  |                           |
| (8) 1856-7 Lardner's "Mechanics."   |                           |
| (9) 1857-8 Lardner's "Electricity."   |                           |
| (10) Lardner's "Steam Engine."  |                           |
| (11) (1857-8 to 1862-3) Lardner's "Natural Philosophy for Schools."   |                           |

The science classes were remodelled in 1863-4, and were then placed under the charge of Mr. C. Haughton Gill, F.C.S., who has since published a text-book entitled "Chemistry for Schools."

On Mr. Gill's resignation, at the close of 1867-8, the senior class of natural philosophy was assigned to Mr. Walker, who already gave instruction in applied mathematics, and the junior class (chemical physics) to Mr. T.

A. Orme, F.C.S., whose recently published "Introduction to the Science of Heat" is in use as text-book.

3. Astronomy.

The class of astronomy was formed in 1866-7, on Mr. Walker's suggestion, and since the beginning of the following session has been conducted by him. During the first year it was taken provisionally by other masters.

4. Chemistry.

The first matriculation examination of the London University, in which chemistry has been from the first one of the compulsory subjects, was held in October 1838, and, probably with a view to direct preparation for future examinations, a class of chemistry was formed in University College School in 1839-40. The class was under Mr Cook's care. Dr. Reid's "Chemistry" was used as text-book, and experiments were performed with apparatus furnished by the college.

The subject was, however, discontinued until 1847-8, when a class was formed under Mr. Spencer's charge. In the following year Fownes' "Chemistry" (2nd edition) was introduced as text-book, and continued in use until the end of 1862-3.

The earliest date at which boys began to matriculate

from the school itself, without passing into the college, was July 1847.

The theoretical instruction in chemistry remained in Mr. Spencer's hands until the general re-construction of the science classes in 1863-4. From that date the theoretical classes and the practical class have been under the same master, for the first five years under Mr. Gill, and for the last two years under Mr. Orme, and the teaching has been mainly oral. In individual cases, the text-books of Professor Williamson or Professor Roscoe were sometimes recommended, and, since the date of their respective publication, Barff's "Introduction to Scientific Chemistry" and Gill's "Chemistry for Schools" have been in more general use, the former for the junior, and the latter for the senior class.

5. Practical Chemistry.

A class of practical chemistry was formed for the first time in Lent Term, 1859, under Mr. G. Carey Foster, B.A. Lond., now F.R.S., and Professor of Physics in University College.

He was succeeded in the following session by Dr. Russell, now Lecturer on Chemistry and Practical Chemistry at St. Bartholomew's, who taught the class for three years.

Mr. Gill had the care of the class during the six following sessions, and for the last two sessions it has been in the hands of Mr. Orme.

TABLE No. I.

Natural Philosophy Classes.	No. of Classes or Divisions of Classes.	Applied Mathematics.		Experimental Physics.		Astronomy.		Experimental Physics.		Experimental Physics.	
		Class VI.		Class VI.		Class V.		Class V.		Class IV.	
Session.		A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
1882	-	-	-	-	-	-	-	-	-	-	-
1882-3	-	-	-	-	-	-	-	-	-	-	-
1883-4	-	-	-	-	-	-	-	-	-	-	-
1884-5	-	-	-	-	-	-	-	-	-	-	-
1885-6	-	2	-	3	-	-	-	-	3	-	-
1886-7	-	2	-	4	-	-	-	-	4	-	-
1887-8	-	3	-	7	-	-	-	-	5	-	8
1888-9	-	3	-	4	-	-	-	-	3	-	4
1889-90	-	4	-	11	-	5	-	-	9	-	8
1890-1	-	4	-	4	-	3	-	-	4	-	5
1891-2	-	3	-	8	-	5	-	-	4	-	-
1892-3	-	5	-	5	-	5	-	-	5+2	-	8
1893-4	-	5	-	7	-	7	-	-	4+12+3	-	-
1894-5	-	4	-	3	-	3	-	-	7+8	-	-
1895-6	-	4	-	8	-	4	-	-	13+4	-	-
1896-7	-	3	-	4	-	4	-	-	2	-	-
1897-8	-	4	-	5	-	5	-	-	3+11	-	-
1898-9	-	5	-	3	-	3	-	-	9+3+5	-	-
1899-00	-	5	-	4	-	4	-	-	5+3	-	3
1890-1	-	5	-	4	-	4+8	-	-	3+6	-	-
1891-2	-	5	-	2	-	3+10	-	-	7+3	-	-
1892-3	-	5	-	6	-	9+10	-	-	7+5	-	-
1893-4	-	5	-	6	-	6+9	-	-	3+3	-	-
1894-5	-	5	-	2	-	2+12	-	-	3+7	-	-
1895-6	-	5	-	5	-	5+11	-	-	2+11	-	-
1896-7	-	5	-	9	-	9+10	-	-	2	-	2
1897-8	-	5	-	7	-	7+11	-	-	9	-	10
1898-9	-	5	-	9	-	9+12	-	-	12	-	5
1899-00	-	5	-	9	-	9+9	-	-	11	-	6
1890-1	-	4	-	7	-	7	-	-	6	-	5
1891-2	-	4	-	4	-	4	-	-	5+9	-	-
1892-3	-	4	-	6	-	6	-	-	9+5	-	-
1893-4	-	3	-	4	-	-	-	-	12	-	-
1894-5	-	3	-	5	-	7	-	-	10	-	-
1895-6	-	3	-	5	-	10	-	-	10	-	-
1896-7	-	4	-	10	-	17	-	16	4	51	11
1897-8	-	5	-	9+10	-	6+4	-	24	7	15	3
1898-9	-	4	-	12	-	4	-	18	6	9	2
1899-00	-	4	-	10	-	4	-	22	8	2	2
1890-70	-	4	-	10	-	4	-	22	10	16	2

TABLE No. I—continued.

Chemistry Classes.	No. of Classes or Divisions of Classes.	Practical.		Theoretical.		Theoretical.		Theoretical.	
		Class VI.		Class VI.		Class V.		Class IV.	
Session.		A.	B.	A.	B.	A.	B.	A.	B.
1832									
1832-3									
1833-4									
1834-5									
1835-6									
1836-7									
1837-8									
1838-9									
1839-40	1				5				
1840-1									
1841-2									
1842-3									
1843-4									
1844-5									
1845-6									
1846-7									
1847-8	1						18		
1848-9	2				10		8		
1849-50	2				9		6		
1850-1	2				11		7		
1851-2	2				8		7		
1852-3	2				10		6		
1853-4	2				8		6		
1854-5	2				13		10		
1855-6	2				14		9		
1856-7	2				11		15		
1857-8	3				13		10		8
1858-9	3	15	7		20		6		
1859-60	4		8+5		10		5		
1860-1	5		1+7		7		6		5
1861-2	5		1+5		4		5+5		
1862-3	3		4		9+4				
1863-4	3		6			7	13		
1864-5	3		8		5		9		
1865-6	3		5		6		10		
1866-7	3	15	8	8	3	55	11		
1867-8	3	17	7	14	8	49	15		
1868-9	3	9	4	16	11	37	9		
1869-70	3	16	8	15	7	41	17		

The A. column gives the number of boys in each class at the end of the session, at which time the principal examination takes place.

The B. column gives the number of boys in each class who in each year obtained prizes or honourable mentions on the aggregate results of the three terminal examinations.

Generally speaking, it is necessary to obtain at least half the maximum of marks, in order to be entitled to a "mention."

The spaces are left blank where there is no exact information as to numbers.

TABLE No. II.

Showing the NUMBER of FORMER PUPILS of UNIVERSITY COLLEGE SCHOOL, to whom prizes have been awarded in the Natural Philosophy classes, and gold or silver medals in the Chemistry classes, of University College, in each year since 1836

Session	Applied Mathematics.			Experimental Physics.	Chemistry.	
	Extra Senior Class.	Senior Class.	Junior Class.		Gold Medals.	Silver Medals.
1836-7				1		
1837-8		1				
1838-9	1		1			
1839-40			1			
1840-1			3			
1841-2		2	1	1		
1842-3			1	1		
1843-4		1	1	2		
1844-5		2	2			
1845-6	2	1				
1846-7			1			
1847-8		1	1			
1848-9		1				
1849-50						
1850-1						2
1851-2				1	1	
1852-3						
1853-4		1				
1854-5			2			
1855-6		1			2	
1856-7		1	2			
1857-8		1		1		1

TABLE No. II.—*continued*

Session.	Applied Mathematics.			Experimental Physics	Chemistry	
	Extra Senior Class	Senior Class.	Junior Class.		Gold Medals	Silver Medals.
1858-9	—	—	2	—	—	—
1859-60	—	—	2	3	5	—
1860-1	—	2	2	1	—	—
1861-2	—	1	1	1	—	—
1862-3	—	1	1	1	1	1
1863-4	—	—	1	1	—	1
1864-5	—	1	2	—	1	—
1865-6	—	1	2	1	—	—
1866-7	—	—	3	—	1	—
1867-8	—	1	—	—	—	—
1868-9	—	—	—	1	—	—
1869-70	—	—	—	1	1	—

The results of the teaching in University College School are naturally best seen in the success of its pupils in the college to which it is attached, and for which, in accordance with the intention of its founders, it acts as a nursery.

The above table has, therefore, been drawn up for the purpose of showing (with approximate accuracy) the number of

prizes obtained by former pupils of the school in the science classes of University College.

Of certificates, as distinguished from prizes, corresponding in principle to the "honourable mentions" or "commendations" of the school prize lists, no account has been taken.

TABLE No. III.

The following table contains, in its first column, the name of every boy who, within the seven years, 1863-4, 1869-70, obtained a prize in any one of the four senior science classes, viz., applied mathematics (A M), senior experimental natural philosophy (E P), senior theoretical chemistry (C), or practical chemistry (P.C.).

The second column gives the session, and the third column the class or classes in which the said prize or prizes were obtained.

The fourth column specifies the various additional subjects in which prizes ("commendations" or "honourable mentions" not being taken into account) were won by the same boy in the same session.

The fifth column gives the sum total of the prizes obtained.

The sixth column shows the College and University distinctions subsequently gained, including the London matriculation "honours," which, in some instances, preceded by a few weeks the winning of the school prize.

To explain the significance of the table, it must be stated that, in University College School, (1) the number of subjects taught is unusually great; (2) the boys are classed separately and individually for each subject, and (3) prizes are given yearly in each class.

The proportion during the past seven years has been three classes and four prizes to seven boys.

The curriculum of the upper school (as distinguished from the junior school or classes for beginners) extends over six (or seven) sessions or years, and is adapted to prepare boys by the end of the session in which they complete their sixteenth year, for passing the matriculation examination of the University of London and entering as students of University College.

The present number of pupils in the school is (Dec 1870) 442, [increased to 500, Feb 1871.]

The object of this table is to show that science teaching forms an integral and not an incidental part of the school curriculum; that the boys who distinguish themselves in the science classes do not form a "caste," or devote themselves to a speciality; that the foremost place in the science classes is sought for with the same interest and eagerness which attend the struggle for corresponding distinction in the traditional and more generally established subjects of school education, and that success in the latter is promoted rather than repressed by simultaneous attention to the former.

1	2	3	4	5	6
Name.	Date of Science Prize.	Subject of Science Prize.	Other Prizes obtained in the same Session.	Total No. of Prizes.	College and University honours [Matriculation—Matriculation in the University of London.]
Atkinson, R. W.	1865-6	P. C.	— — — — —	1	Matriculated 1867 from school, prizes in University College, Royal Entrance exhibition (1868), and Royal Scholarship (1870) in Royal School of Mines.
Ball, W. W. R.	1866-7	A. M.	Grecian history, mathematics, chemical physics	4	Matriculated 1867 from school, Mathematical Entrance exhibition in University College (1867), and Mathematical Scholarship (1869), B.A. (1869) with first class in logic, Entrance Scholarship (1869) at Trinity College, Cambridge.
Bishop, W. B.	1869-70	P. C.	Roman history	3	(Still in school)
Bridgewater, B. J.	1864-5	P. C.	Book-keeping, perspective	3	(In business.)
Bryden, J.	1867-8	A. M.	Grecian history, mathematics	3	Matriculated 1869 from University College.
Camberbatch, C. W.	1863-4	A. M.	Greek, English poem	3	Matriculated 1868 (private study).
Dale, H. F.	1865-6	A. M. & E. P.	English essay, social science, chemistry, chess.	6	(In Canada.)
Emanuel, E. J.	1866-7	A. M., E P and C.	French, German, English, English essay, mathematics, natural philosophy (notes).	9	Prizes in University College, matriculated 1868, 22nd in honours.

TABLE No. III—continued.

1	2	3	4	5	6
Name.	Date of Science Prize.	Subject of Science Prize.	Other Prizes obtained in the same Session.	Total No. of Prizes.	College and University Honours, [Matriculation = Matriculation in the University of London.]
Frankland, F. W.	1867-8	E. P.	Latin, Grecian, history, mathematics.	4	Mathematical Entrance exhibition in University College 1869, matriculated 1870, second in honours with University exhibition (matriculated at earliest possible age).
Ditto	1868-9	A. M. and C.	Greek, Latin, Grecian history, Roman history, mathematics.	7	
Clarke, G.	1867-8	P. C.	Chemistry	2	Matriculated 1869 (January) from school
Goodall, F. T.	1868-4	A. M.	French, French essay, English, mathematics, natural philosophy, natural philosophy (notes), arithmetic.	8	Gold and silver medals, and scholarship in Royal Academy, 1869.
Goslett, M. W.	1868-4	C.	Roman history, geography, mathematics.	4	(In business.)
Ditto	1864-5	E.	Natural philosophy (notes)	2	
Greenfield, J. H.	1869-70	E. P.	- - - - -	1	Matriculated 1870 from school, 65th in honours.
Higgs, A. H.	1864-5	A. M.	But for absence from chief examination, through illness, would most probably have been first in several classes.	-	Matriculated 1867 from University College (at earliest possible age), first in honours with University exhibition, classical and mathematical scholarships in University College, 1867, first entrance scholarship at Balliol College, Oxford, 1862, first B.A. London 1869, with University scholarship in Latin.
Jonas, J. J.	1867-8	E. P.	English - - - - -	2	Matriculated 1869 from University College.
Jones, D.	1867-8	C.	English, Roman history, astronomy	4	Matriculated 1869 from school, 16th in honours and "worthy of a prize."
Keed, E. A.	1869-70	A. M., C. and P. C.	Latin, English history - - -	5	Matriculated 1870 from school, 11th in honours and "worthy of a prize."
Kennek, G. H.	1865-6	P. C.	Chemistry - - - - -	2	Matriculated 1867.
Levenson, B. J.	1869-70	A. M.	Greek, French, reading, mathematics, matriculation mathematics, arithmetic.	7	Entrance mathematical exhibition in University College 1870. [Matriculated Jan. 1871 from school, first in honours with University Exhibition.]
Levenson, J. J.	1868-9	A. M.	German, English history - - -	3	Matriculated 1869 from school, third in honours with University exhibition.
Loddiges, C.	1868-4	C. and P. C.	Mathematics, natural philosophy	4	(In business.)
Lynch, E. M.	1867-8	A. M.	Greek, Latin, mathematics - - -	4	Matriculated 1868 from school, 10th in honours, entrance classical exhibition in University College 1868, and scholarship 1870.
Maunder, E. W.	1865-6	E. P.	Latin, French, English history, mathematics, arithmetic.	6	Matriculated 1867 from school.
Muirhead, A.	1864-5	A. M. and C.	Mathematics, chemistry (notes), arithmetic.	5	Prizes in University College 1867, B.Sc. London 1869, with first class in chemistry.
Oster, S. F.	1865-6	E. P.	Chemistry - - - - -	2	First B.Sc. London 1869.
Pyke, L. E.	1868-9	P. C.	Chemistry - - - - -	2	Matriculated 1869 from school, 10th in honours, and "worthy of a prize."
Pyke, M. J.	1869-70	E. P.	Mathematics - - - - -	2	Matriculated 1869 from school.
Rickards, F.	1863-4	A. M.	Greek, Latin, mathematics, book-keeping.	5	Prize in University College 1866, matriculated 1866
Robson, W. H.	1865-6	A. M. and C.	Latin, English history, mathematics, chess.	6	Matriculated 1866 from school, first in honours with University exhibition.
Rutt, A.	1863-4	C.	German - - - - -	2	-
Scholl, B. F.	1867-8	A. M.	Geography, mathematics, drawing, perspective.	5	-
Scwell, E. J.	1865-6	A. M.	Latin, mathematics - - - - -	3	Matriculated January 1867 from school, 11th in honours, entrance exhibition for combined classes, mathematics, and physics in University College 1866 (October), first B.A. London 1868 with first class in English, appointment in India Civil Service, open competition, 1870
Symes, E. S.	1866-7	E. P. and P. C.	Chemistry - - - - -	3	Matriculated 1869 from school, 39th in honours.
Taylor, A.	1863-4	P. C.	- - - - -	1	-
Thompson, J. W.	1868-9	E. P.	French, impromptu speaking, chemistry.	4	Matriculated 1870 from school, 45th in honours.
Voelcker, G. R.	1869-70	C.	- - - - -	1	Matriculated 1870 from school.
Wyatt, F. B.	1869-70	A. M.	Social science, mathematics, arithmetic, drawing, perspective.	6	-



## REPORT.—PART II.

Account of the present arrangements for Science teaching in University College School.

Michaelmas Term, 1870.

## Conditions of Admission, &amp;c

Boys who have reached the fifth class of arithmetic (below which standard they are disqualified) are required to enter on the first year's course of science, unless their parents object.

The printed programme of the work of the arithmetic classes will show what degree of arithmetical proficiency is implied.

A few boys, though qualified according to the arithmetical standard, are kept back for a year or so, in consequence of being considered too young.

A few parents object, either on the ground of general indifference to science teaching, or because they think it unprofitable for their own sons, but the number of objections is very small.

Boys who are proved, by their want of success at the monthly examinations or otherwise, to be taking no interest in the science classes, and to be making no progress, are removed from them as soon as there appears no reasonable hope of their continuing to attend with profit.

In the present session, 1870-1, the backward boys of the classes of chemistry and chemical physics will be formed, at the commencement of the second term, into a separate class for "object" lessons (meeting twice a week only, 1½ hours), so as to leave the more advanced boys without impediment to their more rapid progress.

The complete science course comprises normally three years.

## First Year.

Three hours per week.)

Junior class of chemistry, two lessons.

Class of chemical physics, two lessons.

Boys who are preparing for matriculation in the University of London at the end of the current session, but who are not sufficiently advanced for the senior class of chemistry, are allowed exceptionally to attend the class of practical chemistry in their first year. These boys are necessarily not under 15 years of age.

## Second Year.

(Six hours per week.)

Class of experimental natural philosophy, two lectures and two exercise lessons. Time, three hours.

Senior class of chemistry, two lessons per week in theoretical chemistry, and one lesson of an hour and a half in practical chemistry. Time, three hours.

## Third Year.

(Six hours per week.)

Class of applied mathematics, four lessons. Time, three hours.

Senior class of theoretical and practical chemistry. Time, three hours.

The second and third years' courses, though kept distinct where age permits, are in practice sometimes compressed into one year. In this case the time devoted to science lessons is nine hours per week.

The class of astronomy is an "objet de luxe" attached to the second year's course, but not forming an essential part of it.

The class of applied mathematics numbers at the present time (December 1870) 11 boys: the senior theoretical chemical class, 14 boys; the practical chemistry class, the same number, plus 3 boys out of the junior theoretical class, the astronomy class, 11 boys; and the class of chemical physics and chemistry, 78 boys, to be reduced after Christmas to about 40.

## \* Work of the IV class of Arithmetic.

1st term.—Decimals and complex vulgar fractions. Metric system.  
2nd term.—Square root. Questions on the circle and on rectangular areas and solids generally.  
3rd term.—Chain rule. Lessons on the "British Standards" of value, weight, length and capacity. Reduction of weights avoirdupois to Troy weights, and vice versa.  
Throughout the session, problems.

## Communication from J. J. Walker, M.A. (Dec. 1870).

On Mr. Gull's resignation of his connexion with University College School at the end of the session, 1867-8, the instruction of the experimental class in the elements of mechanical science, in the outlines of the theories of sound and light, and in the elements of plane optics was entrusted to me, specially with the view of making this class, which would normally be the second year's in the complete science course of University College School, a preparation for the matriculation examination of London University in natural philosophy, and for the class of applied mathematics forming the third year's work in our science course.

In the current session, 1870-1, two lectures in each week are given of an exclusively experimental character, for the purpose of establishing fundamental physical laws, and the properties of the simple machines and instruments; while two other "exercise lessons" are given in an ordinary schoolroom, away from apparatus and models, in which the boys are practised in easy deductions from the fundamental principles established in the experimental lectures, and in the solution of such questions as usually form a part of an examination in the elements of natural philosophy.

The extent to which the subjects taught are carried, and the order in which they are taken up, will be best gathered from the printed programme of the course.\*

For the work of the class of applied mathematics, I refer also to the printed programme †.

At the commencement of session 1866-7, a class of elementary astronomy was formed, of which I have had charge. It has been composed each session of those boys who had previously made some progress in the elements of geometry, and who could find time for the subject during their school course in consequence of not being, as a general rule, (subject to exceptions), intended for a university career.

Two lectures weekly are given, a part of each being devoted to descriptive astronomy and star lessons, the constellations most easily observed in the early night at the particular season of the year being sketched, and directions given by which the boys may be enabled to recognize them in a clear sky from the gardens or upper windows of their residences. The remainder of the lecture is devoted to the elements of spherical astronomy with examples drawn from observations supposed to be made on the meridian (so as to obviate any need for the employment of trigonometry), to the explanation of sidereal, apparent, and mean solar time, and the seasons; to the outlines of the elliptic movements of the moon and planets, and to the theory and approximate calculation of eclipses and tides. "Parallax," and "apparent diameter" are explained particularly in connexion with the sun and moon, and the class are led to deduce the approximate dimensions of the solar system from the values of these angles supplied by observers. I term the instruction given "lectures," because no text-book is used, sketches and diagrams are made on the black-board and the teaching is oral, but the boys take their notes, and their attention and comprehension are tested by frequent questions and paper exercises. Generally, in science teaching, I make it a practice not to state anything which can be drawn from the boys themselves by questions more or less "leading" according to the nature of the deduction sought, or by appeal to their own observation and experience; and to interweave

## \* NATURAL PHILOSOPHY (EXPERIMENTAL).

1st term.—Properties of rigid matter. Inertia. Force or pressure. Restiction. Equilibrium of three forces. Centre of weight. Stable and unstable equilibrium. Mechanical powers. Newton's first law. Uniform movement. Uniformly accelerated movement. Motion or momentum. Newton's second law. Atwood's machine. Laws of falling bodies. The pendulum and applications. Principles of clock and watch work.

2nd term.—Newton's third law of motion. Collision and impact. Elasticity. Circular movement and applications. Properties of fluids. Hydrostatic pressure. Archimedes' principle. Specific weight. Simple machines. Atmospheric pressure, engines and instruments depending on it. Principles of the steam engine. Laws of statical friction. Work and energy, with principles of conservation thereof. Molecular forces and capillarity.

3rd term.—Outline of theories of sound and light. Plane mirrors. Images formed by reflection on the surface of water. The prism and dispersion of light. Lenses. Simple optical instruments. Double refraction. Polarisation of light.

The lessons to be devoted alternately to experimental demonstrations or explanations of general principles, and to illustrative exercises and applications of the same.

## † APPLIED MATHEMATICS.

1st term.—Elementary statics and uniformly accelerated rectilinear movement. Examples and problems.

2nd term.—Hydrostatics and Pneumatics, as treated by elementary mathematics, with examples and problems. Continuation of work of 1st term.

3rd term.—Geometrical optics. Statical Friction. Couples and equilibrium of coplanar forces generally. Galileo's theorem. Impact and collision. Centrifugal force. Projection. Rectilinear vibrations. Simple Pendulum. D'Alembert's principle, with easy applications. Problems.

with the lessons an outline of the history of the progress of science, fixing the epochs by reference to the leading political or social events with which they have been contemporaneous, as far as likely to be known to the class. At the examination of the natural philosophy class towards the end of the session, selected boys from the class are required to repeat certain experiments and demonstrations with the apparatus with their own hands.

*Communication from T. A. Orme, F.C.S.—(Dec. 1870.)*

Since the beginning of session 1868-9, chemistry and chemical physics have been taught by me. There have been three classes of chemistry, a lower, an upper, and a practical class; and one class of chemical physics. The subjects to which most attention has been paid are the chemistry of the non-metallic elements and of their compounds; heat, and the leading facts of electricity (chiefly voltaic electricity) and of magnetism.

The object sought, whilst giving instruction in these subjects, has been rather to teach boys to study scientifically than to impart to them any purely technical information, which would only in a few rare cases be of service to them in after life. The following method has been adopted in order to attain this end—

The only facts which the boys have been taught are the connected facts of the science to which they relate. No reference has been made to any startling but as yet insufficiently explained phenomenon, unless it tends to throw doubt upon a generally received hypothesis. Very little time has been expended on the study of the merely physical properties of bodies; and the boys have been strongly discouraged from committing such facts to memory. In the junior classes, the boys have been taught to reason from stated phenomena rather than to be perfectly accurate in their memory of them; in the senior classes, they themselves bring about these phenomena in a practical class, and describe them fully in the theoretical one.

Very special attention has been paid to popular fallacies, incorrect expressions, faulty definitions, and baseless theories, such as the following—that marble is always colder than wood, that there is a difference between a combustible and a supporter of combustion, that mercury is repelled by glass, that certain compounds can be classified chemically under the heads of acid, base, and salt, that there are two electric fluids, and such like.

Text-books have been employed, except in the class of practical chemistry; but merely as books of reference, and the order adopted in them has not been adhered to in the lectures. The boys have learnt chiefly from notes taken during the lecture and from a syllabus of the lectures printed specially for their use.

All the classes have been examined about every five weeks; and in such a way that, while pure and simple "cramping" is rendered almost impossible, a steadily studious boy, who strives to understand every point when it is discussed, and who looks back to past work when present work renders that advisable, has every opportunity afforded him of attaining to the highest place in the class. The class receives no notice whatever of these periodical examinations, and they are held at various intervals, the average being as above stated, about five weeks. The questions are dictated to the boys one by one, every four or five minutes, and the answer to one question is required to be written down before the next is given out. No marks are given for any answer which is not strictly to the point, perfectly accurate, and sufficiently short; marks are deducted for any superfluous words; any apparatus that is mentioned, however simple, has to be sketched by the junior boys, sketched and described by those in the senior classes. After the examination, and on the same day, the proper answers are given to the class, and, at the next meeting, such vague, illogical, or otherwise faulty answers as may have been received are pointed out, and the mistakes corrected. Though but a small per-centage of boys can be induced to work hard at any particular subject, a very large per-centage of them can be taught their own ignorance, so that silly shambling answers diminish in number as the session proceeds. At the final Summer Term Examination, of which notice must be given beforehand, the classes are examined by printed papers, but the questions are required to be answered in the same order as that in which they are given, every boy having by this time learnt pretty well the exact extent of his own knowledge. No marks whatever are given for any answer to a question which is not answered in its proper place.

#### 14. MERCHANT TAYLORS' SCHOOL.

10, Leinster Gardens, Hyde Park, W.

DEAR SIR.

Feb 1, 1871.

I AM very sorry that your circular of inquiry on the part of the "Commission of Scientific Instruction" has

received no answer from me. It arrived just as Merchant Taylors' School was breaking up for the summer holidays and was mislaid, and so escaped my memory.

I have since resigned the Head Mastership, but I am able to reply to your questions.

There is no provision, at present, for what is termed scientific instruction at Merchant Taylors', though the mathematical reading is very high, and the university distinctions in mathematics have been proportionally great. It is impossible, from want of room, and from other circumstances, to introduce new subjects so long as the school remains in its present confined locality. But I may tell you, for the information of the Commission, that in a scheme which is before the Merchant Taylors' Company, drawn up by me with a view to the re-arrangement of the school and its studies, when it shall be removed to the Charterhouse, the importance of scientific instruction is not overlooked. I cannot, of course, pledge the Company or the new Head Master to the adoption of that scheme, but I have little doubt that the educational basis of the school will be enlarged, not merely in the way of scientific instruction, but in other ways.

I am, dear sir,

Yours faithfully,  
J. A. HANBY, D.C.L.,  
Late Head Master of Merchant  
Taylors' School

To the Secretary of the Commission  
on Scientific Instruction.

#### 15. ETON COLLEGE.

Eton College, Windsor,

Feb 3, 1871.

SIR,

I ENCLOSE some printed forms which show the arrangement of classes receiving scientific instruction at Eton, and I beg to add the following explanation.

The upper boys at Eton (i.e., the sixth and fifth forms, containing together about 450 boys), are divided into three groups, A, B, and C. Group A contains the first 100 boys in the school, divided into various classes for classics, mathematics, &c. Groups B and C comprise the rest of the fifth form, consisting of (about) 350 boys in all.

All boys in groups B and C have two lessons a week in some scientific subject, and have questions to answer or notes or short essays to write out of school.

An average boy gets into the fifth form (i.e., the lower part of the C division), at from 14 to 15. It takes him two years and a half or three years to pass through the C and B divisions into the first 100. During this time he is obliged to learn some branch of science. When he reaches the first 100 (i.e., the A division), he has a choice of subjects, some branch of science being amongst them. Boys begin generally with physical geography, and afterwards have mechanics, hydrostatics, and astronomy, but we have to alter the order of subjects, occasionally, to adjust the classes. This system has been going on for nearly three years, and is, I think, working fairly well.

In October last we got our new laboratory opened, and Mr. Madan, the Lecturer in Chemistry, besides teaching a voluntary class of the A boys, has a class of about 35 (not volunteers) in chemistry from the B division, and the same number in physics (heat) from the C division. He is also about to start a voluntary class in chemistry for younger boys. Some of the upper boys come voluntarily for extra work to the laboratory in playhours. The chemistry classes have, I think, been very successful indeed.

Boys in the ordinary course are compelled to begin chemistry before they get through the B division. The best of these generally volunteer to go on with it afterwards. The success of the chemistry teaching makes me wish very much to have another science teacher, e.g., for botany and geology. I believe we should get very good results from it.

I am, sir, your obedient servant,  
J. J. HANBY.

The large table headed A division, Lent School Time, 1871, shows the arrangement of the voluntary classes in the first 100. Every boy must take up two subjects, e.g., French and German, or French and Chemistry, or one of the extra classical books there mentioned, or Italian, or Modern History, but he selects for himself which two subjects he shall take.

The other classes given in tables B. and C. are in no sense voluntary. The subjects and hours are prescribed.

I send a few specimen papers of questions, such as are given weekly, or set in the examination at the end of the school time.

A. DIVISION.—LENT SCHOOL-TIME, 1871.

PLATO. Mr. Johnson.	FRENCH		GERMAN	ITALIAN	ESCHYL. AGAM. Head Master	CHEMISTRY.	MON. HISTORY. Mr. Browning	
Thursday and Saturday, 9.45.	Tuesday, 9.45; Friday, 8.	Thursday and Saturday, 9.45.	Tuesday, 9.45; Friday, 8.	Monday and Wednesday, 9.45	A Thursday and Saturday, 9.45	A Monday and Wednesday, 10.30.	Tuesday, 9.45; Friday, 8	
Radcliffe ma. K. S. Macaulay ma. K. S. Wintle Balfour Lacata Hobhouse Paul, K. S. Joyne, K. S. Radcliffe ma. K. S. Donkin ma. K. S. Heathcote Dawson Armitstead ma. K. S. Corrie, K. S. Thurston ma. K. S. Selwyn, K. S. Welldon, K. S. Tarver, K. S. Milman, K. S. Bryans, K. S. Ritchie, K. S. Cooke, K. S. Mundy, K. S. Collin, K. S. Browning, K. S. Granger, K. S.	Mr. F Tarver. Carter, K.S. Neal Courthope ma. Longman Hayes Edmonstone Day Bonsor ma. Radley ma. Middleton ma.	Mr. H Tarver. Tilley, K. S. Benson Farquhar Harcourt Mr. Sidney Hollway, K. S.	Foruby Farquhar Smith Bovill MacCall Hanbury ma. Birkbeck Ruggles-Brise ma Granger, K. S.	Pulman, K. S. Carter, K. S. Douton, K. S. Donkin ma. K. S. Fryor ma Hall Murray ma Courthope ma Collin, K. S. Lees Browning, K. S. Harter Bonsor ma. Bode, K. S.	Stapylton Preston Prideaux-Brune B.-Reynardson ma. Leahy Reade, K. S. Macnaghten Cartwright	Radcliffe ma. K. S. Tilley, K. S. Salt, K. S. Fulman, K. S. Douton, K. S. Macaulay ma. K. S. Taber Balfour Benson Lacata Joyne, K. S. Radcliffe ma. K. S. Blakesley, K. S. Keating, K. S. Heathcote Mulholland ma Armitstead ma. K. S. Corrie, K. S. Selwyn, K. S. Welldon, K. S. Tarver, K. S. Sayer, K. S. Acland-Hood Bryans, K. S. Macnaghten Murray ma Downes, K. S. Cartwright Lawford ma. Heygate Mr. Bruce Hollway, K. S. Swan, K. S.	Blakesley, K. S. Mulholland ma. Sayer, K. S. Reade, K. S. Hall Ritchie, K. S. Neal Cooke, K. S. Spring-Rice, K. S. Hayes Greenwood ma.	Gould, K. S. Chute ma. K. S. Stapylton Paul, K. S. Dawson B.-Reynardson ma. Thurston ma. K. S. Milman, K. S. Durnford ma Ryder Grubbe ma. Cammell ma. Cole Donaldson ma.
	Mr. Boublot.	Mr. F Tarver.	Thursday and Saturday, 9.45	Monday and Wednesday, 10.30.	B Thursday and Saturday, 10.30	B Thursday and Saturday, 10.30		
	Prideaux-Brune Leahy Brown Greenwood ma. Harter Buxton Johnson Myers ma.	Foruby Fryor ma. Ricardo Acland-Hood Arkwright Bovill MacCall Durnford ma Anson Grubbe ma. Hanbury ma. Birkbeck Ruggles-Brise ma.	Dopaldson ma. Swan, K. S. Middleton ma.	Arkwright Harcourt Mundy, K. S. Mr. Sidney Wilkinson Anson Buxton Johnson	Salt, K. S. Gould, K. S. Chute ma. K. S. Taber Ricardo Brown Longman Spring-Rice, K. S. Lees Downes, K. S. Mr. Bruce	Hobhouse Keating, K. S. Smith Ryder Edmonstone Day Lawford ma. Cammell ma Bode, K. S. Radley ma Heygate Myers ma. Cole		

APPENDIX TO SIXTH REPORT

Lent School-time, 1871.

PHYSICAL SCIENCE.

B.

Monday, 7.30 a.m. Friday, 5.15 p.m.

*Chemistry* = Mr. Madan.

(In the Laboratory)

*Physical Geography.*

DIV. IV.—Farrer to Kirkinton-Saul - Mr. Hale.  
(In Mr. Wolley-Dod's Schoolroom.)

DIV. V. & VI.—Caldecott to Daniel - Mr. Mozley.  
(In Mr. Mozley's Schoolroom.)

DIV. VIII. - - - - - Mr. Cockahott.  
(In Mr. C. C. James' Schoolroom.)

*Astronomy.*

DIV. VI.—Olphand to Sturgis - Mr. Carter.  
(In Mr. Carter's Schoolroom)

DIVS. VI. & VII.—Heywood-Jones to Thring - Mr. Dalton.  
(In Mr. Jynes' Schoolroom)

*Mechanics.*

DIV. VII.—Tennyson to Miles *ma.* - Mr. Rouse,  
(In Mr. Rouse's Schoolroom)

C.

Wednesday, 3 p.m. Saturday, 9 45 a.m.

*Heat.*

DIV. IX. - - - - - Mr. Madan.  
(In the Laboratory.)

*Physical Geography.*

DIV. X.—Tatham, K. S. to Fort - Mr. Mozley.  
(In Mr. Mozley's Schoolroom.)

DIV. XI. - - - - - Mr. Hale.  
(In Mr. Snow's Schoolroom.)

DIV. X.—Fraser to Bowman } - Mr. Cockahott.  
DIV. XII.—Jerus to Thomas }  
(In Mr. Thackeray's Schoolroom.)

*Mechanics.*

DIVS. XII. & XIII.—Morris to Mr. Lawley - Mr. Rouse,  
(In Mr. Rouse's Schoolroom.)

*Astronomy*

DIV. XIII.—Majoribanks *ma* to La Terrière - Mr. Dalton.  
(In Mr. Browning's Schoolroom.)

DIV. XIV. (In Mr. C. C. James' Schoolroom.) Mr. Carter.

Div. I., II., III.—A.  
*Chemistry.*  
Midsummer 1870.

1. Describe the properties of the different allotropic forms of phosphorus, stating how the one may be converted into the other.
2. What compounds does phosphorus form with oxygen? Give the mode of preparation, and the properties of the highest oxide.
3. What is that property of acids which we call their "basicity"? Illustrate your answer from the acids of phosphorus.
4. Describe experiments which illustrate the affinity of chlorine for hydrogen, and give the chief properties of the substance formed by their union.
5. How is "bleaching powder" prepared, and for what purposes is it used? Give experiments.
6. Give the sources, the mode of preparation, and the tests for the presence of iodine.
7. Enumerate the chief properties of chlorine, bromine, and iodine, in such a way as to show that they form a group in which bromine occupies the middle place.
8. How should we decide whether a body should be called a metal or a non-metal? Take, as instances, antimony, graphite, lead, pyrites.
9. What is meant by the atomicity of a substance? How are metals classified according to their atomicity?
10. To what group of metals does silver belong? Mention its chief uses, and the method of obtaining the metal from them.
11. Give examples of the different methods by which silver may be reduced from its compounds.

Div. I., II., III.—B

*Chemistry.*

Midsummer 1870.

1. Describe an experiment which shows how nitrogen may be made to combine directly with oxygen; state which oxide is formed, and by what test we may recognise its presence.
2. Give the method of preparation and properties of nitrogen dioxide.
3. Which of the nitrogen oxides combine chemically with water, and what substances are thus produced?
4. State the four laws of chemical combination, illustrating them, as far as possible, from the series of nitrogen oxides.
5. Define an "atom" and a "molecule," and show on what principles the atomic weight of a substance may be determined although we cannot isolate and weigh a single atom.
6. How may it be shown that carbon exists in (a) chalk or marble, (b) sugar?
7. How is the presence of carbon dioxide in air accounted for, and why does it not accumulate there?
8. Contrast the properties of the two carbon oxides, and show how the one may be obtained from the other.
9. What different actions has chlorine upon ethylene? Express the changes in the form of equations.
10. Describe briefly the process for manufacturing coal gas.
11. What is combustion? Describe experiments which illustrate its nature.
12. From what sources are boron and silicon respectively obtained.
13. How is boron trioxide obtained, and what are its properties?

Div. IV.

*Chemistry.*

December 1870.

1. Define "an element," "a compound." By what experiments may we prove that three of the four ancient elements are compound bodies?
2. Describe the construction of an air pump; and give any two experiments which prove that air has weight.
3. The readings of a barometer on two successive days were 30.258 in and 29.432 in. Show clearly what is meant by this statement, and reduce the readings to millimetres.  
(The metre = 39.37 in.)
4. What is the law which expresses the change in volume of a gas when the pressure upon it is varied? Describe an apparatus which illustrates this law.
5. Give examples of chemical combination at ordinary temperatures between (a) two solids, (b) two gases.
6. From what sources may oxygen be obtained? Describe the ordinary method of preparing the gas, giving a sketch of the apparatus used.
7. When is a substance said to have a "neutral," "acid," and "alkaline" reaction respectively? Give examples.
8. Enumerate the chief properties of hydrogen, describing experiments by which they may be demonstrated.
9. A rectangular india-rubber bag 1 metre long, 50 cm. broad, and 30 cm. deep, is to be filled with hydrogen. How much zinc is required for the purpose.  
(One gramme of hydrogen is obtained for every 32.5 grammes of zinc dissolved. One litre of hydrogen weighs 0.0896 grm.)
10. What other substances besides oxygen and nitrogen occur in air, and how may their presence be detected and accounted for?
11. Describe fully an apparatus for the analysis of air by leading it over heated copper.  
By means of such an apparatus Dumas found that 100 grms. of pure dry air consisted of 23 grms. of oxygen and 77 grms. of nitrogen.  
The weight of 1 litre of oxygen is 1.430 grm.; of nitrogen 1.256 grm.; of air 1.293 grm. Calculate from these data the composition of 100 litres of air by volume.
12. How may ammonia be prepared and collected? Give the chief properties of the gas.

*Astronomy.—B.*

November 21st, 1870.

1. Explain (with a figure) how a solar eclipse is caused, and mention some of the phenomena which accompany it.
2. What is meant by "spring tides" and "neap tides"? Show what causes combine to produce them.

3. Write a short general account of the solar system.
4. State what you know of the planets Venus, Mars, and Jupiter, as to magnitude, distance from the sun, and attendant satellites.
5. When and by whom was the velocity of light discovered? What observations led to its discovery? Write a short account of a terrestrial experiment bearing on this subject.
6. What are the "signs of the Zodiac?" From what do they take their names? Into how many constellations are the heavens divided? By whom was the arrangement made? Why does the discovery of new stars not involve new constellations?
7. What is the present rule for the determination of a leap-year? Give a full account of the changes made in the calendar during the Christian era.
8. How many kinds of years are recognised in astronomy? Explain why none of them can be used as our civil year, and state from which of them the civil year is derived.

*Physical Geography*

1. Give, in round numbers, the distance of the earth from the sun, and the diameter of the earth.
2. What is the shape of the earth, and how is it caused?
3. What is the density of the earth as compared with water?
4. What is known of the heat of the interior of the earth?
5. Describe the atmosphere,—its composition, pressure, and extent.
6. Why is it incorrect to speak of parallels of longitude?
7. How are the rocks composing the earth's crust arranged by geologists?
8. Explain the following terms —Metamorphic, colitic, carboniferous, cretaceous, fossil.
9. What are the principal causes of the diversities of the earth's surface?
10. What districts of Europe have extensive continuous granitic formations?
11. What parts of Europe disclose strata of the secondary period?

*Physical Geography*

B—December 1869.

1. What are the chemical constituents of water?
2. What seas are exceptions to the rule that inland seas are less salt than the ocean, and why?
3. What is the mean depth of the ocean, and the mean temperature at great depths?
4. What is shown by the colour of a sea being green?
5. What are the principal causes which account for the existence of currents?
6. How do you account for currents, moving towards the equator, having a westerly course?
7. Give some account of the Gulf Stream.
8. What is the Sargasso Sea? and by what name do the French geographers call it?
9. What is the difference between wind-waves and earthquake waves?
10. What are Artesian wells? What proof have they afforded of the temperature of the interior of the earth?
11. Explain the terms—  
Water-sched,  
Ryer-baan
12. Enumerate the rivers forming the river system of the Arctic ocean. Give some account of three of them.

*Physical Geography*

C.—May 1870.

1. What proportion of the earth's surface is covered by the ocean, and what are the chief basins into which it is divided?
2. What do you know of the Atlantic Ocean—its size, depth, bed, &c.?
3. Give some particulars concerning the Pacific Ocean.
4. What is known respecting the depth of the sea?
5. To what causes are the different colours of the sea to be ascribed?
6. What is known of the temperature of the sea?
7. What is the mean proportion of saline matter in the sea? How does the saltness of a sea affect its gravity? and what results from this? In what way does the water of the Mediterranean and Red Sea differ from sea water in general, and how do you account for this difference?
8. What has been observed respecting the magnitude and velocity of waves?  
Give some illustrations of the form of waves. What is the difference between wind waves and earthquake waves?  
Show how the wind waves are formed.

34734.

*Physical Geography.*

C—Michaelmas School-time, 1870.

1. State what you know of the earth as a member of the solar system.
2. Describe fully the motions of the earth, and of any of the other planets.
3. What is a satellite? State fully what is meant by the word "month."
4. What result has the earth's rotation had upon its form? Do you know anything similar of other planets?
5. What is the cause of the seasons? How do we know the earth is round?
6. Explain the following terms: Ecliptic, tropic, equator, meridian. Why is there perpetual day or perpetual night at the poles?
7. Why is it incorrect to speak of parallels of longitude?
8. What is the composition of the atmosphere? How and why does pressure vary?
9. What is known of the interior of the heat of the earth?

*Physical Geography.*

C.—November 1870.

1. What are the two main classes into which the materials of the earth's crust are divided? What class is there intermediate between these, and what are its characteristics?
2. Give the principal kinds of stratified rock in each of the three geological periods.
3. What are fossils, and how do they serve to establish the age of different strata?
4. Give the chief fossils belonging to the different periods. What kinds are most abundant through all of them?
5. What is the nature of basalt? and where in the British Islands is it found?
6. State the geological character of the country near Eton.
7. Describe geologically any three counties in different parts of England.
8. Give the meaning of the terms Eocene, Miocene, Pliocene. In what part of England do we find the rocks of oldest formation?

*Physical Geography*

C—December 7th.

1. Show how rain exercises a destructive effect on the surface of the earth. Give instances.
2. Give as many instances as you can of the destructive effects of rivers.
3. Explain why waterfalls often occur in rivers.
4. What is meant by denudation? How is this exemplified by deltas? Draw a map of the deltas of either the Nile or the Mississippi.
5. What is an avalanche, and how is it caused?
6. Explain the effect of frost on a chalk cliff.
7. How are glaciers formed? What effects are caused by glaciers?
8. How do you account for the parallel roads of Glen Roy?
9. What are erratics?
10. Give some account of the different effects caused by the action of the sea.

Class Examination Paper set in the course of the School Time.

*Hydrostatics. B. Division.*

1. Distinguish between the three different states of matter.
2. Describe the Florentine experiment, which was supposed to prove that liquids are incompressible. What did it really prove?
3. Define the words "horizontal" and "vertical."
4. What is meant by saying that "water rises to its own level?" How much allowance has to be made in levelling for the curvature of the earth's surface?
5. What makes water rise to the surface in Artesian wells?
6. How did Pascal prove the immense pressure of a long thin vertical column of water?
7. How is it proved that the pressure on the base of any vessel containing liquid depends not upon the weight, but upon the height of the liquid?
8. Describe a safety valve.
9. When a body is placed in water, by how much is its apparent weight less than its real weight? How was this fact discovered?

E

Class Examination Paper set in the course of the School Time.

*Machinery. C*

1. Show how a moveable pulley doubles the force of a workman.
2. Give figures of moveable pulleys, hanging by the same, and by different, strings. Show what forces balance each other on each of them.
3. Mention different kinds of levers, and state where the force is applied, and where the resistance is overcome in each.
4. At what distances from the fixed point will weights of 10 lbs. and 2 lbs. balance each other on a straight lever?
5. Draw figures of a wheel and axle, showing clearly how the ropes work, and the advantage of using the machine.
6. What substitutes are used in a windlass and a capstan for a wheel and rope?
7. What substitutes are used in a rack and pinion for an axle and rope?
8. Show how a crane works, and how it multiplies forces.
9. When force is multiplied by any machine, show that longer time is spent.

COLLECTIONS—July 1869.

*C. Davison.*

1. The arms of a balance are of unequal lengths. What weights in the scale-pans will keep the beam horizontal?
2. Describe any common machine for weighing light articles, e.g., letters.
3. Give examples of different kinds of levers, showing in each case where the fulcrum is, and where the power is applied. To which kind does a wheelbarrow belong, an oar, a man's arm, a pair of shears.
4. Describe a machine for weighing heavy carriages. Explain carefully how the different levers composing it are supported, and at what point each is pressed down by the carriage.
5. The shafts of a cart are inclined upwards. What portion of the force exerted by the horse is effective in pulling the cart? What becomes of the rest of the force?
6. Two toothed wheels work together: the first is turned by a handle, the second turns an axle on which a rope is coiled. Compare the weight lifted with the force used.
7. What objections against the common screw are overcome by Hunter's screw? Explain how it is that, in this machine, the plate does not descend as rapidly as the upper screw. Compare the pressure with the force used.

COLLECTIONS—Easter 1870

*Hydrostatics. B*

1. Mention some illustrations of the principle that the free surface of a liquid is a horizontal plane.
2. Describe Bramah's press and the contrivance for making it water-tight. Account for the pressure produced by it.
3. Give figures of a common pump, and of an air-pump.
4. Show how to find the specific gravity—  
1. Of a solid, 2. Of a liquid.
5. Explain how it is that water can be lifted in a thin straight open tube.
6. Describe Boyle's experiments with compressed air. What conclusions did he draw from them?  
How far has a diving bell descended when the air is compressed into half its original volume?
7. Account for the action of a siphon, and of an intermittent spring.
8. Describe the hydraulic ram.
9. What keeps the mercury in a barometer from sinking down into the cistern? If a small hole were bored in the middle of the tube, what would happen?  
How can a barometer give an indication of the probable state of the weather?
10. Describe a single-action steam engine. Explain what forces cause the alternate motion of the beam.  
What is the object—  
1. Of the fly-wheel, 2. Of the governor?
11. What is the use of the small hole in the lid of a tea-pot?

COLLECTIONS—July 1870.

*Astronomy. B.*

1. Distinguish between nebulae and star-clusters; stating what is the present state of our knowledge as to each?

2. Show how the Milky Way helps us to determine approximately the shape of the universe. Referred to the Milky Way, what is the position of the sun?

3. How are the stars in each constellation known and arranged? Name 10 of the brightest stars in the heavens.
4. State what is known of the physical constitution of the stars. What is the photosphere of a star, and what the atmosphere? What are the materials of photospheres, and in what state do they exist?
5. How, in a general way, would you describe the surface of the sun?
6. Explain fully the cause to which we owe the succession of day and night.
7. What are the latitude and longitude of a place? How much does the polar diameter of the earth differ from an equatorial diameter? Are all equatorial diameters the same?
8. Explain the cause of a solar eclipse. In the late lunar eclipse, why did the moon appear copper-coloured during the totality?
9. To what is the phenomenon of a shower of meteors due? Why do meteors occasionally reach the surface of the earth, and what are they then called?
10. State the facts of any well-authenticated cases of aerolitic falls which you remember.
11. Explain the action of a convex lens upon a beam of parallel rays of light, and show with a figure how lenses are made use of in an astronomical telescope.

COLLECTIONS—Election, 1870.

*Physical Geography. C.*

July 20th.

1. What is meant by (i) watershed, (ii) river basin?
2. Which is the right and which the left bank of a river?
3. On what does the velocity of a river depend, and what geological effect does a rapid current produce?
4. Name the Oceanic river systems?
5. Name the principal Siberian rivers. What are their characteristics?
6. Which are the chief European rivers flowing directly into the Atlantic? Describe one of them.
7. What renders the European rivers so important, both geographically and politically?
8. What are the chief rivers flowing into the Mediterranean?
9. Give some account of the Nile, and of its annual inundations.  
What historical evidence do the inundations afford?
10. What has been ascertained of late years respecting the source of the Nile?
11. What is known of Central Africa?
12. What are deltas, and how are they formed?

COLLECTIONS—December 1870.

*Astronomy. B.*

1. Enumerate the various classes of the heavenly bodies, stating briefly the characteristics of each.
2. Give reasons for believing that the earth turns round an axis.
3. What are the trade winds? Explain how each of the two parts of their direction is caused.
4. Explain the action of the tides, showing why, when there is high tide at any place, there is so also at the antipodes of the place.
5. What are the causes which produce twilight?
6. How many kinds of days are recognised in astronomy? Why does the time by a sun-dial generally differ from that by a clock? What is the maximum difference?
7. Write out Kepler's laws, and explain the second of them with a figure. Taking the earth's distance from the sun as 91,000,000 miles, and the distance of Mars from the sun as 140,000,000, find approximately the length of the year in Mars.
8. Give a short account of the constitution of a comet, and state what you know of the comet of 1843.
9. On what occasion can the distance of the sun be best determined? When will the next opportunities occur? Show briefly, with a figure, how the observations are conducted.

FIFTH FORM TRIALS—November 17, 1870.

Thursday, 10.30—12.

PHYSICAL SCIENCE.

*Astronomy.*

1. Enumerate the various classes of heavenly bodies, stating briefly the characteristics of each.

2 Explain (with a figure) how a lunar eclipse is caused, and account for the moon during a total eclipse sometimes being copper-coloured, and at others being dark.

3 When, and by whom, was the finite velocity of light discovered? What observations led to the discovery? Write a short account of an experiment which corroborates it.

4 Explain fully the two principal causes of the change of seasons.

5 Explain and account for the phases of the moon, with a figure. What other bodies exhibit the same phase.

6 What do you know concerning the dimensions and nature of the sun?

7 Explain "ecliptic," "signs of the zodiac," "zenith," "declination."

8 To what constellations do the following stars belong?—Sirius—Aldebaran—Capella—Vega—Rigel—Alcor?

#### Machinery.

1 Give a figure of a system of pulleys, each hanging by a separate string, and show what forces will balance each other on it.

2 In the various modifications of the wheel and axle—what substitutes are used for the wheel, and what for the axle? Give figures of one of each, with forces that balance each other.

3 What is meant by the statement that water rises to its own level.

Explain the Artesian well, and describe a system upon which the supply of water to a town is usually conducted.

4 To what height will water rise when the air upon it is exhausted, and why? How is the air exhausted, and the water lifted out of a common pump?

#### 16. MARLBOROUGH COLLEGE.

Marlborough College,

July 27, 1870

SIR,

In acknowledging your letter to the Master, I have to inform you that he is at present travelling on the Continent, and that I have no directions to forward any letters, but on his return in September your letter will receive his attention.

I am, sir,

Your most obedient servant,

J Norman Lockyer, Esq. JAMES LEADER

Cranbrook, Kent,

Jan. 21, 1871.

DEAR SIR,

Your note reached me this morning. As I have not yet entered on my duties at Marlborough College, I am unable to furnish, at present, any accurate reply to your inquiry.

If you will apply to the Master of University College, Oxford, he will be better able than myself to tell you about the scientific work of the College during the past years, and at some later period I shall be able to tell you more myself.

I may add that it is my own earnest desire, as soon as I am settled in the Mastership, to do all I can to develop and promote the scientific instruction now given.

I am your obedient servant,

D. Wooster, Esq., FRÉDÉRIC W. FARRAR,  
Assistant Secretary.

University College, Oxford,

Feb. 2, 1871.

SIR,

I AM sorry that I omitted to collect the materials for the Commission.

I must confess to having done so. The pressure of work on a Head Master is very great, and the frequent applications for an account of one's work interfere very seriously with doing the work.

As it is I must, I fear, refer you to my successor, who will return to Marlborough about the 9th inst., when the school reassembles. As it has not been my habit to keep careful statistics of every item of work done in the College, and as some of the questions, as to the results of work, were not, if I remember, of a nature to be very easily answered, the answers which you will receive will be somewhat vague, but a general idea of the work done can easily be given.

Your obedient servant,

G. G. BRADLEY,

Late Master of Marlborough College.

D. Wooster, Esq.

#### 17. KING'S COLLEGE SCHOOL.

King's College School, London,

Feb. 7, 1871

MY LORDS AND GENTLEMEN,

I REGRET extremely that your questions have remained so long unanswered. They reached me just when our Midsummer Term was concluded, and during our Winter Session our arrangements for scientific instruction were disarranged, owing to the resignation of our lecturer, and the necessity for the appointment of his successor. I can now, however, give you some statistics as to our present position.

1. King's College School is divided into three departments—

- a The classical school, numbering about 108 boys
- b The modern school, numbering about 195 boys
- c The lower or preparatory school, numbering 143 boys.

2. The instruction in science is given partly in the school, and partly in the lecture rooms of the College.

3. These lectures embrace—

- 1 Theoretical chemistry.
  - 2 Practical chemistry.
  - 3 Natural philosophy, including the subjects required at the London University Matriculation Examination.
- |   |     |
|---|-----|
| 4. (1) The number of boys attending the higher lectures on theoretical chemistry      | 63  |
| (2) The number attending the higher natural philosophy lectures                       | 43  |
| (3) The number attending the practical chemistry class, and working in the laboratory | 17  |
| (4) Number attending a stall higher chemistry class                                   | 1   |
| (5) Number attending the junior class in natural philosophy is                        |     |
| A. (or classical school)  | 56  |
| B. (or modern school)   | 101 |
| C. (or lower school)  | 33  |

All the boys in the modern school receive scientific instruction, and plans are in formation for developing the system still further.

There is also a class for practical instruction in the workshops, in iron work, metal work, &c., numbering from 25 to 30, though sometimes a smaller proportion.

I am

Yours very faithfully,

G. F. MACLEAR, B.D.,  
Head Master.

#### 18. DULWICH COLLEGE.

SIR,

Dulwich College, Feb. 8, 1871.

IN reply to the inquiry made by you on behalf of His Grace the Duke of Devonshire and the Royal Commissioners on Scientific Instruction, I beg to make the following statement—

In endeavouring to give an accurate account of the position assigned to scientific teaching in Dulwich College, I am met at the outset by a difficulty which will be at once recognised by the Commissioners, namely, that while our scheme of instruction on science is unusually comprehensive, it is only during the last six months that the completion of the new buildings has rendered it possible to bring it into efficient operation, and that I am at the present time actively engaged (with the sanction of the Governors of the College) in organising science classes and lectures.

With regard to the systematic teaching of science, there has been constructed, in connexion with the new buildings, a large and commodious laboratory with all the most recent and approved appliances for chemical manipulation. There are, at present, tables or compartments for 20 pupils, each with separate drainage and services of gas and water; and provision has been made for the addition of 18 more such tables. A lecture theatre, fitted with desks for taking notes, and capable of accommodating 220 or 230 students, and with rooms adjoining for the necessary apparatus and stores, has also been erected.

Instruction in science is now given as follows:

**Chemistry.**—A class for instruction in chemistry was definitely formed in September 1870, and placed under the charge of Dr. Debus, F.R.S. (Lecturer in Chemistry at Guy's Hospital), to whom I am greatly indebted for his valuable aid in organising this department. The class numbered during the last term 36 boys.

In the present term, the students have been divided

into two classes of 20 boys each, which receive instruction separately.

The time devoted to the subject has been about 3½ hours per week, exclusively of "preparation." This time has been thus apportioned—

On Wednesday morning a lecture with illustrative experiments in the theatre -	1 hour
On Wednesday afternoon, laboratory work under the direction of the chemical instructor or his assistant -	1½ hours
(Extended in some cases to 2 hours)	
On Saturday morning a class lesson, including the correction of the student's notes on the previous lectures -	1 hour

An examination is held at the end of each term, and prizes are assigned for each class at the annual examination of the school.

Instruction in chemistry is not compulsory, and is limited to the "senior school," that is, to boys in all cases above 13, and, with few exceptions, above 14 years of age.

No additional charge is made for instruction in this department. The only expense incurred by the students is the cost of class-books and of such pieces of apparatus (glass tubing, funnels, &c.) as are most conveniently treated as articles of personal property.

Similar arrangements will be made for giving instruction in other branches of physical science as soon as it is found practicable and expedient to introduce them.

In no case will any additional fee for instruction be charged.

No other subject strictly belonging to the class of physical sciences has at present been included in the course of direct and systematic instruction, except—

*Physical Geography*—For this subject also a class was formed in September last. There are now 60 boys under instruction, who are divided into two classes, the higher of which receives each week two lessons, and the lower one lesson, alternated with a lesson on political and historical geography.

One or two other branches of science have, however, been incidentally taught in connexion with other departments of instruction, especially—

*Comparative Anatomy*, in which instruction has been given during the last three years to a few of the more advanced pupils in the drawing department, including some who were preparing to enter the medical schools of the London hospitals; and—

*Colour*, which has also been treated scientifically in all cases in which it has formed a part of the art instruction.

In these subjects, however, not more than five or six boys, whose intended pursuits in life required special training, have received instruction in any one year.

It is scarcely necessary for me to add that in the mathematical department, instruction has been given in geometry and mechanics, though with reference chiefly to the mathematical course at the universities.

Another and (as I believe) a very important provision in the scheme of science teaching, consists in the courses of evening lectures on various scientific subjects, in the lecture theatre.

All boys in the "senior school" are encouraged to attend these lectures, which are open also (upon the recommendation of their form masters) to any boys of the junior school who may be desirous of availing themselves of them. The lectures are designed, not so much to impart exact knowledge (for this we look rather to our science classes), as to stimulate an interest in scientific subjects, and to convey such general information as may be fairly considered essential to a liberal education.

Arrangements have already been made for a course of evening lectures (one in each week), during the present term, on Light and Heat. A similar course will be delivered after Easter on Geology.

It is intended to provide, as speedily as possible, complete sets of apparatus, of the best quality and construction, for experiment and illustration in the several departments of scientific instruction. Some progress has already been made in this direction.

It would obviously be premature to speak of the results of arrangements of so recent date, and as yet to so great an extent of a tentative character. On one point, however, I feel justified in speaking with confidence. I am convinced that the introduction into our great schools of a wider range of optional studies is productive of incalculable advantage, not to the few alone (as is sometimes supposed), but to the many also. It gives the opportunity of searching out and developing tastes and talents, where the very existence of any taste or any talent at all was before scarcely suspected.

And this is, I am sure, especially the case with the teach-

ing of physical science, which, whatever be its value (and I believe it to be great), as an instrument of general mental training, is unquestionably the means, in many cases, of stimulating apparently dormant intellects into a healthy and vigorous activity, which reaches far beyond the subjects which originally called it into exercise.

And though it is probable that the highest places in our science classes will generally be won by boys who are at least amongst the more intelligent and earnest students in the ordinary work of the school, still much will be gained by the whole community, morally as well as intellectually, if only a few more of its members are withdrawn from the class—never, I fear, to be wholly eradicated—of the aimless and apathetic, and supplied with an object and an occupation.

In making these few remarks I have thought it right to restrict myself to the question of the practical utility of the subjects as a means of school training, without expressing any opinion as to their relative importance, as compared with other branches of instruction.

I am, &c.,

ALFRED J. CARVER, D.D.,  
Master of Dulwich College.

#### 19. ST. PAUL'S SCHOOL, LONDON.

St. Paul's, E.C.,

Jan. 30, 1871.

SIR,

I AM sorry to have acted with such seeming discourtesy, but as I had no return to make, as regards what is generally understood by the term "scientific education," for St. Paul's School, and your communication of last July seemed only a circular, I did not at the time, which was in the holidays, see the necessity, of which I am now reprieved, of making a reply.

We encourage such studies in all sorts of ways, short of introducing them formally into our school curriculum; but many of our scholars attend physical science lectures at the London Institution, and some have highly so distinguished themselves in the Universities of Oxford and Cambridge.

We have, in fact, no time, nor indeed space, to extend our system at present, the boys not residing here, and the school accommodation being too much straitened to allow additional class rooms for practical instruction.

I am, Sir,

Yours faithfully,

H. KYNASTON, D.D.,  
High Master.

#### 20. GRESHAM COLLEGE.

Gresham College, E.C.,

Jan. 31, 1871.

SIR,

YOUR letter addressed to the Principal of Gresham College has been handed to me.

You are, perhaps, unaware that Gresham College is a place for lecturing to the public, and not for teaching boys or classes.

I beg to refer you to the Charity Commissioners, who made long inquiries into our work, and into the trusts under which we hold our offices.

Scientific instruction it cannot properly be called, but scientific lectures of a popular kind are delivered to the public at large, under the will of the founder, and as the lectures are addressed to the public, there is no means of answering your inquiry.

Generally, I may say that the attendance at the scientific lectures is fair, and that many persons seem to enjoy the advantage of hearing popular expositions of scientific subjects.

The more popular the lecture the better it is attended, but the departure from the intentions of the founder is more glaring.

No evidence from the attendance at our lectures is of much use for the purposes of your Commission in my opinion.

Your obedient servant,

B. M. COWIE,  
Gresham Lecturer on Geometry.

I deprecate some of our lecturers would be glad to be called before you for your examination.

#### 21. HARROW SCHOOL.

Harrow, July 25, 1870.

DEAR SIR,

I HAVE handed your note to my colleague, Mr Griffith, our Master in Natural Science, and I have requested



him to have the kindness to answer the various questions addressed to me by your Commission  
I am, dear sir, faithfully yours,  
H. MONTAGU BUTLER.

SIR, Harrow, March 7, 1871  
I HAVE been requested by Dr Butler to give you information with reference to the instruction in natural science given in Harrow School I enclose a statement Should the Commissioners require further details, I will gladly furnish them

Your obedient servant,  
GEORGE GRIFFITH.

A system was established several years ago at Harrow for the encouragement of the study of natural science by means of voluntary examinations An account of this is given in Appendix C. of a Report "On the best means for promoting scientific education in Schools," published in the Report of the British Association for the Advancement of Science for 1867, p. liii. This system is, with some modifications, still maintained.

Four years ago a master was appointed for the purpose

of giving systematic instruction in natural science, and the subject was made part of the ordinary school work in a certain number of forms, which at that time included nearly 200 out of the 500 boys in Harrow School At present all boys in the 5th form on the classical side, and the whole of the modern side, receive instruction in experimental physics.

Those who are on the classical side attend one lecture a week. In number they are about 140, and they are arranged in four divisions, the order of which depends on proficiency in classics, mathematics, natural science, and modern languages.

The modern side, consisting at present of about 40 boys was established in 1869 They are taught in two divisions the places in which are determined by proficiency in mathematics Each division attends three lessons a week

Boys in the 6th form, and in forms below the 5th on the classical side, are not taught natural science in school. Those, however, who desire to receive instruction in those subjects which the natural science master undertakes to teach, are allowed to have private lessons during the hours which are not allotted to school work A few only receive instruction under these conditions

### B. REPLIES TO SECRETARY'S LETTER, dated Sept. 27, 1872.

On the 27th of September 1872, the letter and schedule given below were sent to the Head-Masters of the following Colleges and Schools.—

Charterhouse School.  
Cheltenham College.  
Christ's Hospital  
City of London School.  
Clifton College.  
Derby Grammar School.  
Dulwich College.

Eton College.  
Harrow School.  
King's College School.  
Manchester Grammar School.  
Marlborough College.  
Merchant Taylors' School.  
Rossall School.

Rugby School.  
Saint Peter's College, Westminster.  
Stonyhurst College.  
Taunton College School.  
University College School.  
Wellington College.  
Winchester College.

Aid to Science Commission,  
6, Old Palace Yard, London, S.W.,  
Sept. 27, 1872.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to state that the Commissioners are extremely anxious to obtain the fullest information respecting science teaching in the public and first-grade schools, and the Commissioners will, therefore, feel greatly obliged if, in addition to the information which you have already been good enough to furnish, you will kindly favour them by answering, as far as you may be able, the several questions in the accompanying schedule.

I am to add, that as the Commissioners are desirous of obtaining information from schools differing in organization, the questions in the accompanying schedule are designed to cover the work of a good many schools. It is not, therefore, expected that answers will be given to any questions but those which may happen to apply to your school.

I am further to say that I have been requested by His Grace to confer with you personally, to explain the precise objects the Commissioners have in view, and the kind of information which will be most valuable to them, if you consider such a course desirable, in which case I shall be obliged if you will inform me on what day it will be most convenient to you that I should visit your school.

I have the honour to be, Sir,  
Your obedient servant,  
J. NORMAN LOCKYER,  
Secretary.

SCHEDULE OF PARTICULARS on which Information is desired by the Royal Commission on Scientific Instruction and the Advancement of Science.

Name of School or College. \_\_\_\_\_

#### General Arrangements.

- I. How is the School classified?
- II. Is Science a necessary part of the School course, or is it taught only in special forms or departments?

#### III. Copy of Time Table.

IV. Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately)

V. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes

VI. Amount of knowledge required before the study of Science is commenced

VII. Is any alternative or choice of subjects offered?

What departments of Science are preferred?

(a) By parents?

(b) By the boys?

VIII. What branch of Science receives most attention in the School, or is found by experience to have the greatest educational value?

IX. What weight is assigned to scientific attainments in determining a boy's position in the School?

#### Methods of Teaching.

X. What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?

(b) Book work?

(c) Practical work?

XI. Which form of lesson is found to be most effective?

XII. How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?

XIII. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?

XIV. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?

XV. Describe any method of teaching some special branch of Science which has been found successful in your School.

#### Instruments of Teaching.

XVI. What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for Scientific Instruction, and how is it used?

(Plans and descriptions of these with statements of their cost and annual expense, should if possible, accompany this return.)

XVII. Number of assistants and curators, and annual cost.

XVIII. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed



Question 12. How are text books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—Both

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—The boys prepare notes partly at, and still more after the lesson, which are examined by the teacher from time to time

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?

Question 15. Describe any method of teaching some special branch of science which has been found successful in your school.

*Instruments of Teaching*

Question 16. What special provision (*e.g.*, laboratory lecture room, observatory, museum, botanic garden, &c) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible accompany this return.)

One class room, with presses for apparatus, is used for science lectures, and other rooms are used for physical geography, mechanics, astronomy, &c.

Question 17. Number of assistants and curators, and annual cost

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c?—Willis' models of the mechanical powers. About 60l worth of apparatus for illustrating lectures on heat and electricity. The master has brought and lent any diagrams which he needed.

Question 19. Is there a workshop? and if so, how, and for what particular purpose, is it used?—No

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes?

- Gleig's series, Tate's Electricity
- " " Magnetism, &c.
- And for a few more advanced pupils—
- Balfour Stewart on Heat
- Ferguson — Electricity.
- Ansted's and Hughes' Physical Geography

Question 21. To what books of reference, other than ordinary school books, have the scholars access?

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—No

*Tests of Progress.*

Question 23. How often is the work tested?—By weekly questions and half-yearly examinations

Question 24. In what way? *e.g.* by examination of note books, or by oral or written questions?—By written questions.

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?—Chiefly by the teachers of the subjects.

*Teachers.*

Question 26. Is there any difficulty in procuring competent science masters?

Question 27. Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?

Question 28. What evidence of scientific qualification tendered by candidates is found to be of most value?

Question 29. Can you state any results of science teaching in the school? such as—

- (a.) Success, professional or otherwise, of individual scholars.
- (b.) Influence upon the general studies and intellectual life of the school.

Science teaching has not been given long enough, in any efficient form, at Westminster, to enable me to answer this question

Question 30. Are any special rewards or encouragement (*e.g.* exhibitions, bursarships, or prizes) open to successful students of science in the school?—Prizes are given in books if deserved.

Question 31. What improvements, do you think, could be effected in the teaching of science in your own school?

Question 32. What are the principal obstacles to the teaching of science in your own school?—Want of space and of time for the study. The school only possesses one large schoolroom and four class-rooms; and no further space can be obtained until certain life interests have expired. As to the question of time, reference to regulations ch. vi. sect. 1. (p. 23) will show what quantity of subjects is required to be taught to *all* boys.

Question 33. How could the Universities best assist science-teaching in schools?

Question 34. Can you suggest any way in which Government could assist science teaching in schools, as, for example, by inspection?

Question 35. Have you any other information to give, or suggestions to make, likely to be helpful to the Commissioners?—I can only repeat my conviction that if science teaching is to be really efficient as an instrument of education, it must be made the principal subject of study, and that schools should be divided into classes, some taking science, and others language, as the basis of their system, adding in each case such further studies as time will allow to be pursued with advantage. The notion of pressing all subjects on all schools is in my judgment fatal to any efficient training.

CHAS B SCOTT,  
Head Master.

Oct 4th, 1872.

3. MARLBOROUGH COLLEGE.

*General Arrangements*

Question 1. How is the school classified?—There are three divisions of the school, the upper, the lower, and the modern school. The lower school contains all those junior boys whose attainments do not enable them to win a place in the upper school. The modern school is mainly composed of boys intended for the army and navy, for Woolwich, for the Engineering College, for the Indian Civil Service, and for business.

Question 2. Is science a necessary part of the school course, or is it taught only in special forms or departments?—Two hours a week of science work forms a necessary part of the school work of the upper and two middle divisions of the modern school (about 80 boys), and one hour a week is necessary in the case of the upper shell, upper fourth A, and upper fourth B, (about 75 boys in all). Otherwise certain forms are grouped together for science purposes thus about 10 boys from each of the three fifths (lower fifth A and B, and middle fifth), with five from the upper fifth, and four from the sixth form for the upper voluntary science form of 43 boys. Again, about 10 boys from each of the upper shell, upper fourth A form and upper fourth B form, form the lower voluntary science form of 31 boys. Each of those forms are voluntary; there are three alternative subjects.

Question 3. Copy of time table?—The time table differs with each form, and is in some respects flexible, but an approximate analysis of the number of hours devoted in each form to each subject has been written out on the enclosed sheet

		<i>Upper V.</i>		
Classics	-	-	-	13½
Mathematics	-	-	-	4½
Divinity	-	-	-	2
History and English*	-	-	-	2
French	-	-	-	2
Science	-	-	-	2
				26

		<i>Middle and Lower Fifths</i>		
Classics	-	-	-	13½
Mathematics	-	-	-	4
Divinity	-	-	-	2
History	-	-	-	2
French	-	-	-	2
Verses or science	-	-	-	2
				25½

		<i>Upper Shell</i>		
Classics	-	-	-	13½
Mathematics	-	-	-	4
Divinity	-	-	-	2
History	-	-	-	2
French	-	-	-	2
Science	-	-	-	2
				25½

		<i>Upper Fourth</i>		
Classics	-	-	-	13½
Mathematics	-	-	-	4
Divinity	-	-	-	2
History	-	-	-	2
French	-	-	-	2
Science (compulsory)	-	-	-	1
Science or French or verses	-	-	-	1
				25½

\* Sometimes three, one instead of a chemical lesson. A classical and a French examination done out of school hours.

Middle and Lower Fourth.	
Classics*	15½
Mathematics	4
Divinity	2
History	2
French	2
	<hr/> 25½

## MODERN SCHOOL.

Upper Division.	
Latin and English	4
French	4
German	4
Mathematics	6 or 8
Divinity	2
History	2
Science	2 or 4
Drawing	1

## Middle Division (A).

English	1
French	6
German	5½
Mathematics	6
Divinity	2
History	2
Science	2
Drawing	2
	<hr/> 26½

## Middle Division (B).

English	2
French	7½
Latin	3
Mathematics	6½
Divinity	2
History	2
Science	2
Drawing	1
	<hr/> 25½

## Lower Division

English	2
French	6
Latin	6½
Mathematics	6
Divinity	2
History	2
Drawing	1
	<hr/> 25½

## LOWER SCHOOL.

## Upper Third.

Classics	12½
Mathematics	4
History	2
Divinity	2
French	3
English	2
	<hr/> 25½

## Lower Shell

Classics	11½
Mathematics	4
History	2
Divinity	2
French	3
English	2
Singing	1
	<hr/> 25½

## Lower Third.

Classics	12½
Mathematics	4
History and English	3
Divinity	2
French	3
Drawing	1
	<hr/> 25½

\* Sometimes an English lesson.

Upper Second.	
Classics	10½
Mathematics	4
History	2
Divinity	2
French	3
English	3
Singing	1
	<hr/> 26½

Question 4. Summary of hours per week given in each class to different subjects. (If playtime is utilised for preparation or practical work, this should be shown separately.)

Monday, 10-11 a.m., middle division A, modern school	-	Chemistry.
" 11-12 a.m., middle division B, modern school	-	Chemistry.
" 4.15-5.15 p.m., upper shell form	-	Chemistry.
" 5.30-6.30 p.m., lower voluntary form, consisting of about 10 boys from the upper shell, and from each of the two upper fourths (A and B)	-	Electricity.
Tuesday, 12-1 p.m., upper div mod school	-	Chemistry.
Wednesday, 4.15-5.15 p.m., upper fourth A	-	Chemistry.
" 5.30-6.30 p.m., upper voluntary form, chiefly from the middle and two lower fifths	-	Electricity.
Thursday, 10-11 a.m., upper div., mod. school	-	Electricity.
" 12-1 p.m., mid. div. A, mod. school	-	Electricity.
Friday, 10-11 a.m., Woolwich class	-	Heat.
" 4.15-5.15 p.m., upper voluntary form	-	Chemistry.
" 5.30-6.30 p.m., upper fourth B	-	Chemistry.
Saturday, 10-11 a.m., mid. div. B, mod. school	-	Chemistry.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes?—The age of those boys who study science varies between 13 and 19, an average age would perhaps be 16. The actual number of boys who do science is at this time 202, of these 47 do only one subject a week (1 hour chemistry); 155 do two subjects a week (1 hour chemistry and 1 hour electricity), while the Woolwich class, numbering 17, do three subjects a week.

Question 6. Amount of knowledge required before the study of science is commenced?—Science is commenced here:—

(A.) In the upper school when a boy enters one of the upper fourth forms

(B.) In the modern school when a boy enters the middle division B.

Hence no special knowledge is required before a boy can enter the science zone, because he enters it and a new form simultaneously, the commencement of science being determined by his removal into another form.

If a boy shows any very special aptitude for science, and is in a form below the science zone, he is permitted *some* times, by the grace of his form master, to attend science lectures with the upper fourth A or B form, *once or twice* a week.

Question 7. Is any alternative or choice of subjects offered?—In the fifth forms a boy may choose between verses, history, and science. In the upper shell and upper fourth (A and B) forms, a boy may choose between verses, history, French, and a second *non-compulsory* hour of science work

What departments of science are preferred?

a. By parents?—Parents very rarely indeed express any choice in the matter.

b. By the boys?—Physics proper seems the preference by the boys. The note books and general interest would seem to prove that electricity, magnetism, &c., are more popular than chemistry, and easier to comprehend

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—Chemistry receives most attention here, and I believe elsewhere. I cannot say what branch of science has the greatest educational value. I should think, as matter of individual opinion (not of experience), the following subjects would be most valuable—

a. For young boys:

Elementary botany.

" chemistry.

" mechanics, pneumatics, hydrostatics, and hydraulics.

*b.* For boys between the middle fourth and the fifths :

Elementary heat  
 " electricity.  
 " magnetism  
 " sound  
 " light  
 " chemistry

*c.* For boys in and above the fifths :

Mechanics, electricity, magnetism, heat, chemistry.  
 Elementary astronomy  
 Elementary physiology.

*Question 9.* What weight is assigned to scientific attainments in determining a boy's position in the school?—There are marks assigned to each boy who does science, both in his weekly work and in quarterly examinations. These marks are added into the total to assign his final place. The exact proportion observed in adding the science marks to those attained in other subjects probably varies to a certain extent in different forms, but in every form a boy would gain very considerably by having really distinguished himself in the science work.

*Methods of Teaching*

*Question 10.* What proportions of the lessons take the form respectively of—

- (*a*) Oral teaching and demonstration?—The science work here consists of experimental lectures. Questions are asked at the commencement of the lecture, and the boys are invited and desired to ask questions as often as possible out of school.
- (*b*) Book work?—In the middle divisions A and B of the Modern School, Roscoe's Science Primer, and Balfour Stewart's Primer respectively are prepared as form work, and portions of them are discussed before lecture.
- (*c*) Practical work?—As science has not yet been long introduced into the school curriculum, and we have not as yet been able to provide a regular laboratory, practical work is only possible to any great extent in the various branches of natural history.

*Question 11.* Which form of lesson is found to be most effective?—Lectures, so long as they be of such interest that the attention of the form is well maintained upon the subject.

*Question 12.* How are text-books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—Except in the instances mentioned (*v* par. 10 *b*), the possession and use of text-books is not compulsory.

*Question 13.* Is the use of note books encouraged (*a*) during or (*b*) after the lesson, and to what extent?—The use of note books is required both during and after lecture. Rough pencil notes are expected to be taken during lecture, and these are written out afterwards, and ought to be enlarged from memory, in a fair copy note-book.

*Question 14.* How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Prizes are yearly given for various Natural History Collections *e.g.*, wild flowers; anatomised plants, land and freshwater shells, butterflies, moths, &c.

*Question 15.* Describe any method of teaching some special branch of science which has been found successful in your school?—Series of lectures have from time to time been given by different masters on geology, animal physiology, botany, &c., with satisfactory results in increasing the stock of knowledge possessed by a good many boys, and giving a marked stimulus to a few.

*Instruments of Teaching*

*Question 16.* What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

There is a good lecture room with apparatus, a museum, and a botanic garden. Owing to special circumstances it is not easy to say how much they cost, the expense of maintaining them does not in general exceed 30*l.* or 40*l.* a year.

*Question 17.* Number of assistants and curators, and annual cost?—There is only one regular science master; but several of the other masters assist the boys, especially in natural history, physical geography, &c.

The salary of the science master is about 300*l.* a year.

*Question 18.* What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—See *Question 16.*

*Question 19.* Is there a workshop? and if so, how, and for what particular purpose, is it used?—There is a workshop close to the College, fitted up by a tradesman in the

town. Boys are encouraged to learn turning, &c., under his guidance, and it is our intention to build a good and commodious workshop within the College grounds at the earliest possible opportunity.

*Question 20.* What text-books are in use? distinguishing between those for the junior and senior classes?—

For junior classes—

" Roscoe's Elementary Chemistry Primer "

" B. Stewart's Elementary Physics Primer. "

For senior classes—

" W. A. Miller's Elementary Chemistry "

" Privat-Deschanel's Natural Philosophy "

For special pupils—

" Ganot's Smaller Physics "

" Huxley's Elementary Physiology "

" Tyndall on Heat as a Mode of Motion. "

*Question 21.* To what books of reference, other than ordinary school books, have the scholars access?—There are house libraries, and there is an excellent general library to which boys have free access, and which contains some good scientific books.

*Question 22.* Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—A natural history society, the earliest, I believe, that was founded at any public school, has been in active operation for a considerable number of years. One of the masters is president, other masters frequently attend and read papers. A large number of boys belong to it. There are fortnightly meetings, at which papers are read, very often by the boys themselves. There are various sections (geological, botanical, entomological, archæological, &c.), each of which is presided over by one of the members, and which furnish quarterly or more frequent reports. There are one or two field-days every term, on these days the boys go to explore new districts beyond the reach of an ordinary walk. The influence of this society on the boys is in all respects most valuable, and the extent of practical work which it has effected may be judged by the long series of published reports, as well as by the flora of the district, and full accounts of its entomology, geology, ornithology, &c., it has produced.

*Tests of Progress.*

*Question 23.* How often is the work tested?—There is a quarterly examination. Note books are then examined, and a paper of questions given. But progress is more or less tested every week by the questions before lecture. When a boy answers badly, his note book is examined, and if insufficient is filled up out of school or re-written.

*Question 24.* In what way? *e.g.* by examination of note books, or by oral or written questions?—By each and every of these means; *vide* preceding paragraphs.

*Question 25.* By whom? by the teachers of the subjects, or by an independent examiner?—Thus far, except on one occasion, by the teacher of the subjects, but we shall in future take every opportunity that occurs to secure an inspection or examination of our science teaching by competent examiners, unconnected with the school.

*Teachers.*

*Question 26.* Is there any difficulty in procuring competent science masters?—Men, with sufficient knowledge to teach are easily procured, but we cannot be always certain of finding gentlemen who also have the important gift of being able to impart their knowledge, and to maintain the necessary discipline.

*Question 27.* Where are the best obtained? Have they been specially trained for the work, and, if so, in what does such training consist?—Masters, competent to teach one or other branch of science, can now be found at both Universities. The possession of sufficient knowledge is, however, the smallest part of the matter. Out of a hundred men who know enough of science to qualify them as instructors, there might not be a dozen who would make really good masters, and unless they knew how to teach and to rule, their knowledge would be valueless for all practical purposes.

*Question 28.* What evidence of scientific qualification tendered by candidates is found to be of most value?—Beyond the evidence of testimonials, published works, &c., I should always try to obtain some private trustworthy opinion of a candidate's qualification before appointing him to a science mastership. Further, I should always think it almost essential that he should have had some experience in teaching, and should give some promise of being likely to possess the qualities that a teacher required.

*Question 29.* Can you state any results of science teaching in the school? such as—

- (*a*) Success, professional or otherwise, of individual scholars.

## (b) Influence upon the general studies and intellectual life of the school.

The only results I can give are the averages of marks obtained at the last examination. Max. = 100.

Upper voluntary (from the fifths)	- Electricity	- 59 14
	- Chemistry	- 35 55
Upper shell	- "	- 31 48
" fourths (A)	- "	- 29 31
" (B)	- "	- 26 16
Lower voluntary (from three preceding forms)	- Electricity	- 42 03
Upper division modern school	- "	- 49 50
	- Chemistry	- 26 07
Middle division	- Electricity	- 36 58
	- Chemistry	- 17 90
Lower division	- Electricity	- 24 41
"	- Properties of Matter	- 35 05
Woolwich class	- Heat	- 36 07

Science has been introduced too recently to have produced any marked results at present. I cannot trace any influence which it has exercised on the general studies or on the intellectual life. There are, however, two good results which it is producing now, and will produce more and more. 1. It enlarges the range of knowledge and intelligent interests for a large number of boys. 2. It has succeeded in stimulating and evoking the powers of a few boys who had failed completely in other studies. These results alone are amply sufficient to justify its introduction, and encourage us to persevere.

**Question 30** Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of science in the school?—There are as yet no natural science scholarships, but prizes are freely given to reward success or effort in the acquisition of scientific knowledge.

**Question 31** What improvements, do you think, could be effected in the teaching of science in your own school?—We are anxious to build a laboratory as soon as our means allow us to do so, and we wish to have our own workshops. Further than this nothing can be at present effected consistently with the character and avowed aims of the school. My experience here has been that the demand for scientific teaching is entirely, or almost entirely, limited by the actual practical requirements of the boys. It seems to be impossible at an ordinary public school to furnish any but a very small number of boys with anything that could be fairly called a thorough education in science. In all the various competitive examinations for which the majority of them are being trained, the part occupied by science is very subordinate to that claimed by literature. Now and then we find a boy with marked scientific aptitude, and it would be our object to stimulate and help him to the utmost of our power, but the practical need of most boys, as well as the express wishes of their parents, render it impossible for us at present to extend the science teaching without injuring the school.

**Question 32** What are the principal obstacles to the teaching of science in your own school?

1 The fact that the boys' time is already absorbed by studies which have of late years been largely multiplied, and which in most cases they know to be essential to their future prospects in life.

2 The fact that the demand for scientific teaching among parents is very small. The general opinion seems to be that an ordinary knowledge of science does not open the way for any career in the future, and that a boy is more likely to win for himself a future position by following the studies which form the main curriculum of teaching.

**Question 33** How could the Universities best assist science teaching in schools?—I do not think that they could do so more than they do at present. The scholarships already founded often fail to produce even a small number of properly qualified candidates. The conclusion to which I have been most strongly led by experience is this,—that the cause of scientific education would be best served by the founding of a school in which science would occupy the chief, and literature a subordinate place. If such a school were properly endowed, and if Government undertook to provide some career for a certain number yearly of the most successful students, if, too, the school were made a thoroughly good one in all other respects, if it were directed by vigorous and able masters, and furnished with all the best appliances, I believe that much more would be done for the furtherance of real science than the comparatively trivial and not very successful efforts which some schools have made to introduce science into their ordinary course.

**Question 34.** Can you suggest any way in which Government could assist science teaching in schools, as for example, by inspection?

(a.) By setting aside a building at South Kensington, or elsewhere, in which the finest modern physical apparatus could be seen, such as the collection of the Conservatoire des Arts et Métiers in Paris, or the Physical Cabinet in Leyden.

(b.) By the grant of moneys for the purchase of apparatus and diagrams, or the loan of such apparatus, or the authorisation of the sale of such apparatus at cost price, and by accredited agents.

(c.) By making some branch of science compulsory in all Government examinations.

**Question 35.** Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?—I believe from the comparative newness of the study that we are not in a position to speak with any definiteness concerning the general results to be expected from the introduction of science teaching into schools. There can be no doubt the study ought to be generally introduced into all primary and artisans' schools for the better informing of our iron smelters, glass workers, dyers, and handicraftsmen.

Up to the present time it cannot honestly be said either that science has flourished at the public schools, or that we have solved the immense difficulties of organising the teaching of science in such a way as to produce results at all commensurate with the hopes which led to its introduction. The real causes of this are—1. That the ground is already pre-occupied by a multitude of studies which imperatively demand a place, and which are more generally required by parents. 2. That the introduction of science is still looked on by many teachers as a disturbing element in the progress of the ordinary studies. The real solution of our difficulties belongs, I believe, to the future, and it may possibly be found in the separate rather than the combined existence of scientific and literary schools. I of course assume that in scientific schools some literature would be taught, and in literary schools some science, but I think that there should be in England some schools in which the scientific element distinctly predominates, just as the literary element distinctly predominates in most schools at present.

F. W. FARRAR, B.D., F.R.S.

Head Master.

Oct. 8, 1872.

## 4. ROSSALL SCHOOL.

## General Arrangements.

**Question 1.** How is the school classified?—The school is divided into two distinct departments—the Classical and the Modern School. The difference in the courses of education provided in the two departments may be understood from a comparison of the accompanying lists of subjects of study:—

## Classical.

Greek and Latin Books.  
Exercises.  
History and Geography.  
Arithmetic.  
Mathematics.  
French.  
German.  
Drawing.  
Music and Singing.  
Writing.

## Modern.

Arithmetic and Algebra.  
Geometry  
Higher Mathematics.  
English Language.  
French.  
German.  
Latin.  
History and Geography.  
Chemistry.  
Writing and Book-keeping.  
Music.  
Drawing.

The Modern Department is divided into—

Upper A.  
Lower A.  
Upper B.  
Lower B.

**Question 2** Is Science a necessary part of the school course, or is it taught only in special forms or departments?—Science is a necessary part of the school course in the Modern Department, but is open to volunteers from the Classical.

**Question 3.** Copy of time table:—

Chapel at 7 a.m.  
Breakfast at 7.20 a.m.  
First School at 8.30 a.m. to 10.30 a.m.  
Second School at 11.0 a.m. to 12.30 p.m.  
Dinner at 1.30 p.m.  
Third School at 4.0 p.m. to 6.0 p.m.  
Tea at 6.0 p.m.  
Preparation at 7.0 p.m. to 8.15 p.m.  
Chapel at 8.30 p.m.  
Bed for Middle and Lower Schools at 9.0 p.m.  
Bed for Upper School at 10.30 p.m.

ROSSALL SCHOOL TIME TABLE, 1872.

1st School 8.30 to 10.30 a.m.  
2nd School 11.0 to 12.30 a.m.

3rd School 4.0 to 6.0 p.m.  
Sunday 9.45 to 10.0 a.m. and 4.0 to 5.0 p.m.

	SUNDAY.		MONDAY.			TUESDAY.		
	A. M. School.	P. M. School.	1st School.	2nd School.	3rd School.	1st School.	2nd School.	3rd School.
Monitors { Upper Lower	Greek Testament	Greek Testament	Classics	Mathematics	Classics	Classics	Classics	Mathematics
Probationers { Upper Lower	Articles	{ Paley and Greek Testa- ment.	Classics	Mathematics	{ Classics, History (I) (II)	Classics	Classics, French	Mathematics
A. Upper	Articles	Paley and Scripture	{ English Language, Algebra.	Science	German, French	French, Statics*	Geology,* Drawing	Geometry, Trigonometry
V Form { Upper Lower	Scripture	Greek Testament	{ Mathematics, Classics Classics, Mathematics	Classics	Classics	Classics	{ Mathematics Classics	Mathematics Mathematics
IV. Form { Upper Lower	Divinity	Greek Testament	{ Mathematics Classics	Classics Mathematics	Classics	{ Classics, German French, Classics	Mathematics Classics	Mathematics
A. Lower	Articles	Paley and Scripture	{ English Language, Algebra.	Science	German, French	Euclid, Statics*	Book-keeping, Drawing	Geography, Arithmetic
III. Form { Upper Lower	Divinity	Greek Testament	Classics	{ German, Classics Classics, German	Mathematics, Classics Classics, Mathematics	Mathematics, Classics Classics, Mathematics	Classics	{ French, Classics Classics, French
Modern B, Upper	Catechism	Scripture	French, Mathematics	Classics, N. L. French	Classics	Drawing School, Euclid	French or Mathematics	{ English Language and Drawing School.
II. Form { Upper Lower	Divinity	Scripture	{ French, Classics Classics	Classics	{ Mathematics, Classics Classics, Mathematics	Mathematics, Classics Classics, Mathematics	Classics	{ French, Classics Classics, French
Modern B, Lower	Catechism	Scripture	Mathematics, French	Classics	{ English Language, Ger- man.	Euclid, Drawing School	French or Mathematics	Classics
I Form { Upper Lower	Catechism, &c.	Scripture History	{ Classics* Classics*	English, French English, French	Mathematics, Classics Classics, Mathematics	Mathematics, Classics Classics, French	French	History, Classics History, Classics
Lower School { Upper Remove Lower Remove	Catechism	Scripture History	{ Classics French	Classics	{ Arithmetic Drawing	Geometry Classics	Classics Arithmetic	Writing Geography
Preparatory { Form III. Upper II. Lower II.		{ Scripture History New Testament, Cate- chism. New Testament, Cate- chism.	Mathematics	{ Classics Classics	English English	Classics Classics, Writing	Mathematics English	English, Geometry English, Geometry English, Mathematics

\* Drawing

APPENDIX TO SIXTH REPORT.

ROSSALL SCHOOL TIME TABLE, 1872—continued.

	WEDNESDAY.			THURSDAY.			FRIDAY.			SATURDAY.	
	1st School.	2nd School.	3rd School.	1st School.	2nd School.	3rd School.	1st School.	2nd School.	3rd School.	1st School.	2nd School.
Monitors { Upper Lower	Mathematics	Classics	Classics	Classics	Classics	{ Mathematics Classics	Classics	Mathematics	Classics	Classics	—
Probationers { Upper Lower	{ Repetition, Ma- thematics.	{ 2.) Classics	{ 3.) Composition	Classics	Classics, German	Classics, German (1)	Classics	Mathematics	History	Classics	Classics
A. Upper	{ Classics, German (1)	Euclid, Videns	Science	{ French, Trigo- nometry	Land Surveying, Drawing	{ Arithmetic } Eng Statics } Lat. (alternately)	Algebra } Conic Statics } (alternately)	Cicero, French, Geology.	{ Revision { English exami- } nation. } { English } Lit. (alternately)	French, Arithme- tic.	Cicero, French
V Form { Upper Lower	Classics	{ Classics German, Classics	Classics	{ Mathematics, Classics Classics, Matho- matics	Classics	{ German, French } Preparation, French.	French, Classics Classics, Matho- matics.	Classics	{ Natural Science, Classics.	{ Mathematics, Classics, Classics, Matho- matics.	Classics.
IV. Form { Upper Lower	Classics	{ Classics Classics, German	Classics	{ Mathematics, Classics Classics, Matho- matics.	Classics, German German, Classics	Classics	{ Classics Mathematics, and Classics.	Classics	{ Natural Science and Classics.	{ Mathematics, Classics, Classics, Matho- matics	French, Classics.
A Lower	{ Classics, German (1)	Euclid, Videns	Science	Algebra, French	Bookkeeping, Drawing.	{ Arithmetic } Eng Statics } Lit.	Algebra } French Statics } (alternately)	Cicero, French Geology	{ Revision { English exami- } nation } { English } Histy (alternately)	Arithmetic, French.	Cicero, French.
III Form { Upper Lower	Classics, Natural Science.	{ Mathematics Classics	Classics	Classics	{ Classics Mathematics	Mathematics	{ Classics Mathematics, Classics.	French, Classics Classics, French	Classics	Classics	{ Mathematics, Classics.
Modern B. Upper	{ German, English Language.	{ Classics	Science	German, Euclid	French	Mathematics	Classics, Euclid	Mathematics	{ Drawing School, Special French	{ Science, English Language.	Mechanics.
Form { Upper Lower	Classics	{ Classics Mathematics	Classics	Classics	{ Mathematics Classics	Mathematics	{ Writing } Classics	Classics	{ Classics Classics, French	Classics Classics, Writing	Mathematics, Classics.
Modern B. Lower	{ Geography, Draw- ing School	{ Mathematics	{ Dictation, Eng- lish Grammar	Euclid, German	Mathematics	French, Geography.	Classics	Science	{ Drawing School, Special French	{ English, Science	Mathcal. Paper.
I Form { Upper Lower	Classics, English Classics, English	Mathematics Classics	English English	Writing, Classics Classics	{ Mathematics, Classics, Matho- matics.	Mathematics Mathematics	Classics, English English, Mathma.	English, Classics English, Classics	French, Classics Classics	Classics Classics	Classics, Writing
Lower School { Upper Lower	Classics	History	Classics, Dictation	Classics	Classics, Arithmetic	{ Writing, Arith- metic, Draw- ing.	French, Classics	French, Classics	Arithmetic	{ Classics, Writing, Classics.	Classics.
Preparatory { Form III Upper II. Lower II.	French French English	Drawing Drawing Drawing	— — —	Classics Classics Classics Classics	Mathematics Mathematics Mathematics Writing	English, Classics English, Classics English English, Mathe- matics.	Classics Classics Classics Classics	Writing Mathematics Mathematics Writing	Classics, English Classics, English Classics English, Mathe- matics.	Classics Classics Classics Classics	Drawing — — —

Preparation in subject of ensuing morning for one hour and a quarter every evening except Sundays. Special Chemistry Class (Practical), Tuesday and Thursday afternoons, 2½ to 4.



**Question 4** Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)

**Question 5.** Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes

**Question 6.** Amount of knowledge required before the study of Science is commenced—No definite rule at present

**Question 7** Is any alternative or choice of subjects offered?

What departments of Science are preferred?

(a) By parents?—Parents exhibit complete indifference to the whole subject, with the exception that they occasionally object to their sons devoting any time at all to it

(b.) By the boys?—Practical Chemistry. Also, in an unscientific manner, Natural History

**Question 8** What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—At present Chemistry has been always held to be the chief subject in Natural Science. But as, according to my experience, Natural Science in schools, as an instrument of education, can only be useful in developing the observation, and not the memory, much less the judgment, I am inclined to think that the branches that can be best illustrated by specimens and experiments must really have the greatest educational value. If Science is to be taught as an accomplishment, like conversational French, for practical use, then probably Chemistry and Geology are the most important.

**Question 9.** What weight is assigned to scientific attainments in determining a boy's position in the school?—In the modern side, about 10 per cent. of weekly marks, determining the boys' weekly places, are allowed to the Natural Science lessons.

#### Methods of Teaching

**Question 10** What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?—The teaching is conducted by lectures accompanied by oral and written examinations.

(b) Book work?—No time is devoted to preparation out of school. Book work is subsidiary to the lectures

(c) Practical work?—Five or six boys work at practical chemistry in the laboratory for 2½ hours per week

**Question 11** Which form of lesson is found to be most effective?—The practical work, undoubtedly. Next to that the oral teaching, when accompanied by, and based upon, constant repetition and examination

**Question 12.** How are text-books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—The text-books are used chiefly as a means of repetition, not at all as a means of preparing for the lesson.

**Question 13** Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Notes are taken by the boys during the lesson.

No time is devoted by the boys to preparation for the Science classes.

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Some boys take great interest in the collection of specimens, but there is no systematic work done, and, with the exception of about six boys, no practical scientific work of any kind in chemistry or physics.

**Question 15.** Describe any method of teaching some special branch of Science which has been found successful in your school?—Geology, to a select class of volunteers, has been very fairly taught during the last quarter by lectures once a week illustrated by diagrams.

#### Instruments of Teaching.

**Question 16** What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?—

(Plans and descriptions of these, with statements of their cost and annual expense, should if possible accompany this return.)

There is an observatory containing 4½-inch object glass equatorial, a lecture room, and small laboratory. No regular observations have as yet been made at the observatory.

**Question 17** Number of assistants and curators, and annual cost?—The science teaching is conducted by one master appointed for the purpose, but no assistant

The science master has 140*l.* per annum, rising 20*l.* per

annum to 200*l.*, with board and lodging, and, with expenses of laboratory, the cost may be reckoned at about 300*l.* per annum.

**Question 18** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—There is the usual apparatus of a laboratory, with plenty of gas and water, and no lack of funds to supply whatever is necessary, whether in the way of new inventions or repair of old instruments

**Question 19** Is there a workshop? and if so, how, and for what particular purpose, is it used?—There is a workshop under the teaching of the clerk of the works. This is popular, and well attended. There is only bench accommodation for six at a time, but boys, some of high intellectual power and great refinement, will spend two hours a day, play-time, in carpentry. The study of practical engineering, under our chief engineer, is also a matter of considerable interest to boys

**Question 20** What text-books are in use, distinguishing between those for the junior and senior classes?—Roscoe's *Chemistry*, Gill's *Chemistry for Schools*; Page's *Geology*

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—There is the school library, to which all books of reference are added as required

**Question 22** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—None at present.

#### Tests of Progress.

**Question 23** How often is the work tested—Once a quarter.

**Question 24.** In what way? *e.g.*, by examination of note books, or by oral or written questions?—By a written examination, generally conducted by an outsider, and generally with unsatisfactory results.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—By an independent examiner generally. But the difficulty of getting a good science examiner is only equalled by the difficulty of getting a good science teacher

#### Teachers.

**Question 26.** Is there any difficulty in procuring competent science masters?—Immanse. The science masters seem to have learnt their subjects under lectures addressed to men, and probably men all anxious to learn. They have no prescriptive or traditional forms of teaching boys, and no appreciation of the indifference which the average boy has to all knowledge.

**Question 27** Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?—That is just the question that I am now anxiously considering. I have tried Oxford, and I have tried London. In both cases I was happy enough to obtain the services of a gentleman highly taught, and completely master of the subjects. I have once or twice attended the lectures of the London University M.A. myself, and have found them to be consummate works of art, extremely interesting and entertaining, yet this gentleman has resigned in disgust at the smallness of the results of his teaching.

**Question 28** What evidence of scientific qualification tendered by candidates is found to be of most value?—A London or Oxford degree. I have hitherto considered the best, but I should not mind trying Bonn or Leipzig

**Question 29** Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars.

(b) Influence upon the general studies and intellectual life of the school.

(a) A scholar of Rossall is now a Natural Science of St. John's, Cambridge.

(b) Nil.

**Question 30.** Are any special rewards or encouragements (*e.g.* exhibitions, scholarships, or prizes) open to successful students of science in the school?—Prizes only.

**Question 31.** What improvements do you think could be effected in the teaching of Science in your own school?—I think we must direct the study more in the direction of observation. Boys must be taught to know by sight and weight the difference between the "Arley" and the "Wigan Four-foot," between "Memel" and "Danting," "Old" and "New Red," "Arsenic and Salt." All the theories of combination, number of elementary subjects, doctrines of

molecules and atoms of gases, may be reserved till the *vacants* themselves are agreed about them.

**Question 32.** What are the principal obstacles to the teaching of Science in your own school?—(i.) The great inducements held out by the Universities for the study of classics and mathematics (ii.) The unsettled state of opinion as to what is the aim of the study. (iii.) The instinctive feeling of boys that, as at present taught, Science is not equal to Latin and Greek, or Mathematics, for educational purposes.

**Question 33.** How could the Universities best assist science-teaching in schools?—By diminishing the disparity between natural science scholarships and the others, or, which I should prefer as an educationist, by abolishing all competitive scholarships.

**Question 34.** Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?—One way in which Government might help would be to offer us commissions or civil service or colonial appointments for excellence in science studies, anything, in short, to balance the overwhelming attractions of classical and mathematical proficiency as a means of getting a livelihood.

**Question 35.** Have you any other information to give or suggestion to make likely to be helpful to the Commissioners?—Dix.

ROBERT HENNIKER,  
Head Master.

11th Oct. 1872.

### 5. CITY OF LONDON SCHOOL.

#### General Arrangements.

**Question 1** How is the school classified?—The school is divided into six divisions for scientific instruction, viz. :—

6th form	-	1st division.
5th ditto	-	
4th class	-	2nd division
Latin class	-	
3rd class	-	3rd division.
2nd class	-	
1st class	-	4th division.
Grammar class	-	
1st junior class	-	5th division.
2nd junior class	-	
3rd junior class	-	6th division.
4th junior class	-	

**Question 2.** Is Science a necessary part of the school course, or is it taught only in special forms or departments?—Science is a necessary part of the school course.

**Question 3** Copy of Time Table —

1st division	Tuesday	2 to 3 p. m.	(Lecture.)
2nd "	Monday	"	"
3rd "	Thursday	"	"
4th "	Friday	"	"
5th "	Monday	10.45 to 12 noon	"
6th "	Thursday	"	"

Practical chemistry class, Wednesday 12 to 2.

(N.B.—An occasional lesson of one hour's duration is given in the lower school.)

#### Subjects Taught.

A. 6th division —

- Atomic theory
- Hydrogen, oxygen, nitrogen, and the inorganic compounds formed by their union
- Physical and chemical properties of air and water
- Thermometers, barometers, air pump, &c.
- Ventilation.
- Especial attention is paid to the use of aqua-forts as a test for gold, &c.
- Manufacture of gun cotton and gun powder.

B. 5th division :—

- Subjects mentioned under A.
- Carbon and its inorganic compounds with oxygen and hydrogen
- Blow pipe, nature of flame, conduction and convection of heat.
- Davy lamp.

C. 4th division :—

- Subjects under A and B.
- Sulphur. } And their compounds with O  
Phosphorus, } and H.  
Chlorine }  
Bromine } Especial attention is paid to  
Iodine } their uses as re-agents  
Fluorine, hydric fluoride, hydric hydrofluo-  
sulfate. }  
(c.) Especial attention is given to the manufac-  
ture of oil of vitriol and hydrochloric acid.

D. 3rd division :—

- Subjects mentioned in A., B., and C.
- The common metals
- Especial attention being given to the metal-  
lurgical processes for obtaining iron, copper,  
lead, zinc, silver, mercury, tin, and gold.
- Manufacture of wrought-iron and steel, tem-  
pering steel.
- Manufacture of the common pigments.

E. 2nd division —

- Subjects mentioned in A., B., C., and D.
- Alkalies and alkaline earths.
- Heat.
- Frictional and voltaic } Especial attention is  
electricity. } given to electro  
telegraphy.
- Magnetism.
- Outline of theoretical chemistry, qualitative  
analysis.

F. 1st division :—

- Organic chemistry
- Higher branches of inorganic chemistry and  
experimental physics

Boys are prepared for special examinations in physical geography, zoology, and botany, &c., &c.

In addition to the before-mentioned class-lessons, the practical chemistry class work should not be forgotten.

The three best boys in each of the nine higher classes have the privilege to join this class.

The class generally has about 30 instead of 27 boys.

**Question 4** Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)

For a summary of hours per week see "Time Table" and "Subjects Taught."

A few boys in each division avail themselves of the half hours (12 to 12.30 and 3 to 3.30) for trying some of the experiments shown at the lectures. The half holiday is utilized for the practical work. Boys are also helped (during playtime) to prepare for the various Science examinations at Kensington, &c., &c.

The Science exercises have to be prepared sometime during the week.

The junior divisions have a lesson of one hour and a quarter once a week.

The upper divisions have a lesson of one hour once a week.

An occasional lesson is given in the lower school.

**Question 5.** Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes

		No of boys this term.	Average age this term.
1st division	6th form -	27	17
	5th " -	24	15½
2nd division	4th class -	36	15
	Latin class -	50	14½
3rd division	3rd class -	61	14
	2nd class -	64	13½
4th division	1st class -	85	13
	Grammar class -	97	12½
5th division	1st junior class -	70	11.8 nearly
	2nd junior class -	57	12
	3rd junior class -	49	10½
6th division	4th junior class -	47	10½

**Question 6.** Amount of knowledge required before the study of Science is commenced.

Writing,  
Reading,  
And multiplication table.

**Question 7** Is any alternative or choice of subjects offered?—No

What departments of Science are preferred?

a. By parents?—As a rule, chemistry.

b. By the boys?—Practical chemistry and electricity.

**Question 8** What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—Chemistry (for the lower school), and chemistry and physics (for the higher school).

**Question 9.** What weight is assigned to scientific attainments in determining a boy's position in the school?—  
1. Class promotion is not at present influenced by scientific attainments, but a change in this respect is on the point of being made.  
2. Prizes are given.  
3. Science counts in the general scholarships of the school.

*Methods of Teaching.*

Question 10. What proportions of the lessons take the form respectively of—

- (a.) Oral teaching and demonstration?—All the school work (1 hour to 1½ hours)
- (b.) Book work?—Home work (about ½ of an hour)
- (c.) Practical work?—Answered in Nos III and IV.

Question 11. Which form of lesson is found to be most effective?—I am of the opinion that a combination of—

- (1) Oral teaching with demonstration;
- (2) Book work, and
- (3) Practical work, will be found the most effective form of lesson, but I am unable to form a comparison, as in no division of this school is the teaching exclusively confined to any one form. The class for practical chemistry at the City School of course shows to the greatest advantage, as it is composed of the most advanced boys from each of the upper divisions.

Question 12. How are text-books used? e.g. is book work supplementary or preparatory to the oral lesson?—Supplementary

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Boys are obliged to use note books during the lesson, and encouraged to use them in preparing their home lessons, &c.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—The boys belonging to the practical chemistry class entirely prepare their own apparatus, but are not obliged to either prepare the experiments or to collect specimens during the intervals between lessons. They are, however, encouraged to try experiments both at school and at home, and also to collect "specimens."

Question 15. Describe any method of teaching some special branch of Science which has been found successful in your school?—In each branch of Science taught here the course pursued is as follows, viz—

A lecture is given, and the boys have to take notes. At the end of the lecture a short *visa voce* examination takes place.

For "home work" the boys have to write answers to certain questions on the subjects treated of in the lecture. These answers are brought on the next lesson day.

In the lower school the boys have to bring drawings of the apparatus and experiments shown at the lecture. Boys who take an interest in the subject are encouraged to remain after the lesson to receive extra instruction, and to try the experiments for themselves.

*Instruments of Teaching*

Question 16. What special provision (e.g. laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expenses, should, if possible, accompany this return.)

A lecture room (which is also used as a laboratory by the boys of the practical chemistry class), also a private laboratory. I cannot furnish you with the cost, but the accompanying plans may give you some idea.

Question 17. Number of assistants and curators, and annual cost?—One principal teacher, 180*l.* (at present rising 10*l.* per annum to 200*l.*)

One assistant, 60*l.*

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—30*l.* is allowed yearly for new instruments and to replace materials used. The apparatus is such as is generally employed to illustrate the various points (in chemistry and physics, &c.) which are brought before the pupils. A better idea than could be given by a report (necessarily so limited), would be obtained by personal inspection.

Question 19. Is there a workshop? and if so, how, and for what particular purpose is it used?—No.

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes?—

- |        |                                       |
|--------|---------------------------------------|
| Junior | Hall's Chemistry.                     |
|        | Buckmaster's Chemistry (Inorganic).   |
|        | Ferguson's Electricity.               |
|        | Tate's Heat, &c.                      |
|        | Balfour Stewart's Elementary Physics. |
| Senior | Jarman's Qualitative Analysis.        |
|        | Fownes' Chemistry.                    |
|        | Miller's Chemistry.                   |
|        | Ganot's Physics.                      |

- |        |   |   |
|--------|---|---|
| Senior | { | Brook's Natural Philosophy.                       |
|        |   | Oliver's Botany                                   |
|        |   | Carpenter's Animal Physiology.                    |
|        |   | Vegetable "                                       |
|        |   | Lyell's Geology                                   |
|        | { | Lardner's Handbook of Natural Philosophy (4 vols) |

Question 21. To what books of reference, other than ordinary school books, have the scholars access?—Boys in the 6th form can obtain admission to the Guildhall Library.

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—There is none.

*Tests of Progress.*

Question 23. How often is the work tested?—Twice a year by a written examination; also by the *visa voce* examination at the end of each lesson. (Also by occasional inspection of note books.)

Question 24. In what way? e.g. by examination of note books, or by oral or written questions?

- (1) By examination of note books.
- (2) By oral
- (3) By written } questions.
- (4) By practical work.

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?—Once a year by the public examiner, John Spiller, Esq, F.C.S., late assistant chemist to the War Department. At other times by the teacher.

*Teachers*

Question 26. Is there any difficulty in procuring competent Science Masters?—I have not experienced any.

Question 27. Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?—From the Government Science School, Royal School of Mines, and Royal College of Chemistry, &c., &c.

Question 28. What evidence of scientific qualification tendered by candidates is found to be of most value?—The most valuable evidence of "scientific qualification," as distinct from teaching qualification, would be evidence forthcoming from the professors in the foregoing institutions.

Question 29. Can you state any results of Science teaching in the school? such as—

- (a) Success, professional or otherwise, of individual scholars
- (b) Influence upon the general studies and intellectual life of the school.

Yes. A list has already been forwarded to the Royal Commission on Scientific Instruction and the Advancement of Science, to which you will perhaps kindly permit me to refer you. I would also mention that the list which was sent to the Royal Commissioners on 19th September 1870, employed me during my spare time for upwards of a fortnight.

Question 30. Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of Science in the school?—Yes. One exhibition, value about 14*l.* 10*s.*, tenable for one year; one silver medal; and 24 prizes (total value 10*l.*) Science also counts in the regular scholarships of the school.

Question 31. What improvements do you think could be effected in the teaching of Science in your own school?—I would suggest the following alterations—

- (1) Chemical proficiency to count in class promotion
- (2) An hour's oral teaching with demonstration, followed by an hour's book work, and supplemented by practical work. This would of course necessitate—
- (3) More time to be devoted to the study of Natural Science, and
- (4) More assistants
- (5) More valuable exhibitions and prizes to be given for proficiency in Natural Science.

Question 32. What are the principal obstacles to the teaching of Science in your own school?—The necessarily limited time given to the study of Natural Science.

Question 33. How could the Universities best assist Science-teaching in schools?—By offering valuable exhibitions, and by recognising the Natural Sciences as a regular subject in pass and entrance examinations.

Question 34. Can you suggest any way in which Government could assist Science-teaching in Schools, as, for example, by inspection?—Yes,—

- (1.) By inspection (if not carried to excess) by one experienced in teaching.
- (And 2.) By awarding prizes

Question 35. Have you any other information to give, or suggestion to make, likely to be helpful to the Commis-

sioners?—That the pupils of the City of London School (and the like) should be allowed to take the prizes and medals awarded by the Science and Art Department (South Kensington), but at present limited to the students of Government Science classes. Also that the list of successful candidates be published.

I understand that there has been a great falling off in the number of the pupils that have presented themselves from this school for examination at South Kensington, since the medals and prizes were limited to the students from Government Science classes.

14th October 1872

EDWIN A. ABBOTT,  
Head Master.

#### 6. WINCHESTER COLLEGE.

##### General Arrangements

Question 1. How is the school classified?—The main division is into four blocks, called—

- (A) Sixth Book of 60 (in round numbers)  
(B) Senior Part V. of 110 " "  
(C) Middle Part V. of 150 " "  
(D) Junior Part V. of 60 " "

These blocks are subdivided for the several subjects of study, as follows, into the following numbers of classes.—

	A	B	C	D
For Classes into	2	4	5	2
" Mathematics	6	7	10	4
" Natural Science	1	4	0	0
" Modern languages	3	4	6	2

There are two modern classes besides, one ranking with B, the other with C.

Question 2. Is science a necessary part of the school course, or is it taught only in special forms or departments?—Science is taught—

- To boys in sixth book who have evinced special capacity for it, or who desire it themselves, or whose parents wish it. They amount to about a fourth of the number.
- To all the boys in Senior Part V. This provides for boys who attain a fair position in the school two years' teaching while in this part of the school as a necessary part of their school work.
- To the two modern classes.

Question 3. Copy of time table

Question 4. Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately.)

	A	B	C	D	Modern
Classes	10	9	9	10	2
Mathematics	4	4	4	4	6
Modern languages	2	2	3	2	6
English subjects	2	2	3	4	4
Natural Science	2	2	—	—	2
Drawing	—	—	—	—	3

Composition is done besides this. Preparation has 20 hours provided in school times, and boys must usually find an hour a day for work besides out of time at their own disposal. About eight hours a day is the average work.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes.

- Mechanics and hydrostatics, sixth book No., 12 Age, 17.
- Geology No., 30. Age, 17.
- Physical geography { No., 40 Age, 16
- { No., 40 Age, 16.

Question 6. Amount of knowledge required before the study of science is commenced?—With the exception of the junior modern class, the boys who are taught science are in the higher parts of the school, and fairly advanced in classes and mathematics.

Question 7. Is any alternative or choice of subjects offered?—No, the classes have their subjects fixed. What departments of science are preferred?

a. By parents?

b. By the boys?—I do not think any one branch is generally preferred to others. Some like one, some another.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?

1. That of the surface of the earth

There is always a class in geology

in summer several in botany.

Other branches of physics are taken in a cycle.

2. I do not think there is any special educational value in the lessons different from what is derived from lessons in other subjects given in the same way.

The geological and botanical courses, which cause actual acquaintance with specimens, are the only ones that seem special.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—About one tenth of the whole marks in class work and examinations.

##### Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

- (a) Oral teaching and demonstration?—In the lower classes, the whole. In the two highest this is combined with book work.  
(b) Book work?  
(c) Practical work?

Question 11. Which form of lesson is found to be most effective?

Question 12. How are text-books used? e.g., Is book work supplementary or preparatory to the oral lesson?—Supplementary.

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Notes are required and taken during the lesson and written out after it. In all but the highest class they are encouraged by marks weekly in an effective degree.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?

Question 15. Describe any method of teaching some special branch of science which has been found successful in your school.

##### Instruments of Teaching

Question 16. What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used? (Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)—A special lecture room fitted for the purpose. A room for a museum and for the use of boys who collect objects of natural history.

Question 17. Number of assistants and curators, and annual cost.

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for instruments, and to replace materials used, &c.?

##### Mechanical models.

- Elementary electrical apparatus
- Apparatus for illustrating physics.
- Botanical plates.
- Maps and globes.
- Geological specimens.
- Botanical collections.

Question 19. Is there a workshop? and, if so, how and for what particular purpose, is it used?

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes.—They have varied. Ganot's *Physics* and Page's *Geology* are two which would represent them.

Question 21. To what books of reference, other than ordinary school books, have the scholars access?

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—A Natural History Society, limited to 50 boys, who adopt the members. It meets once in three weeks. Two masters help to manage it. Boys read papers, and collect and exhibit specimens.

In summer it gives a number of boys an interest which has been quite real and good.

The lists of plants and insects collected are growing satisfactorily.

Mr Griffith has created a considerable geological interest, and some boys have made good collections here and at home.

##### Tests of Progress.

Question 23. How often is the work tested?

Question 24. In what way? e.g., by examination of note books, or by oral or written questions?—In both these ways.

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?—Written examinations are held,—

- By the teachers several times a term.
- By independent examiner once a year.

##### Teachers.

Question 26. Is there any difficulty in procuring competent science masters?—Yes.

**Question 27.** Where are the best obtained? Have they been specially trained for the work, and, if so, in what does such training consist?—Our teachers are from Oxford and Cambridge. They have not been specially trained for the work

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?

**Question 29.** Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars.

(b) Influence upon the general studies and intellectual life of the school

(a) Several boys have gained University distinctions in Natural Science at Oxford

I cannot feel that the individuals who are carrying their studies further were led to do so by their school teaching, but by personal or professional interest in them

(b) I think there has been an interest created in botany and geology, which has altered the feeling of contempt for such things which used to be general.

I do not think it affects the other studies of the school either way.

The principal result is a more general spread of sensible estimates of the value of such knowledge. I don't expect to find individuals do more than e.g., Messrs F. Buckland and P. Slater, who were at the school when no regular teaching was given in science.

**Question 30.** Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes), open to successful students of science in the school?—Prizes are given by Lord Saye and Sele for each of the classes in Natural Science.

**Question 31.** What improvements, do you think, could be effected in the teaching of science in your own school?

—We are at present in such an elementary condition in regard to science teaching that the improvements possible in it, if it is settled that this is a school where it should be made a main branch of study, are endless. They would, e.g. involve the entire construction of a system of practical teaching and work

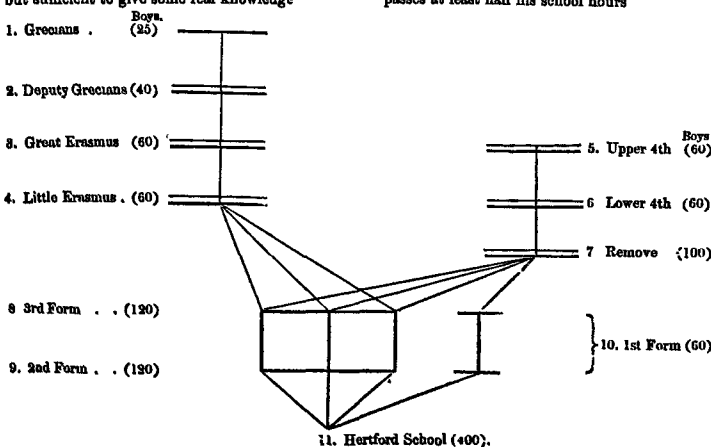
For the purpose of communicating the outlines of general knowledge of some branches of Natural Science in a popular way, and of starting interest and acquaintance with scientific ideas, our courses answer their purpose

**Question 32.** What are the principal obstacles to the teaching of science in your own school?—Those incident to a period of transition,—

1. The costliness of starting it, especially in such a branch as chemistry
2. The difficulty of finding teachers possessing actual knowledge of practical and experimental kinds, who are also able to manage a class of boys.
3. The past feeling of inferiority to other subjects, a feeling, perhaps, hardly past.
4. The feeling that it does not "pay" as well as other subjects

**Question 33.** How could the Universities best assist science-teaching in schools?—

1. By making it essential for their best men to know some rational amount of Natural Science
2. By framing some definite courses of natural science teaching.—a. Of a standard fitted for a boy's main study, b. Of a popular standard, fitted to be a universal study for all boys, subordinate in position, but sufficient to give some real knowledge



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**Question 34.** Can you suggest any way in which Government could assist Science-teaching in schools, as, for example, by inspection?—By carrying into other branches what has been done for botany by the preparation of sets of plates, i.e. by organising a system for supplying sets of typical specimens of zoology, geology, &c.

Nothing but a central organization can ensure schools, which have no special opportunities, the possibility of obtaining the necessary collections.

**Question 35.** Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?—The head masters of the principal schools have asked the Oxford and Cambridge Natural Science Boards to draw up outlines of Natural Science teaching fitted for schools, of the two standards mentioned above, and these bodies have consented to do so

G. RIDDING,  
Head Master.

Oct. 16, 1872

7. STONTHURST COLLEGE.

Stonhurst College,

Oct 16, 1872.

SIR,

In reply to your letter of the 27th ult., I beg to say that in the school or boys' department of this College so little Science is taught that it would be useless to attempt to fill up the paper sent, or to ask anyone to come down here on behalf of the Commissioners

I may say, in brief, that we teach the boys sufficient for them to pass the matriculation examination of the University of London. It is only the highest class that is specially prepared for this

This class (averaging about 16 in number, and, perhaps, 17 in age) has three hours weekly with a Science master. They are supposed to get up in the intervals what they were taught at their last lecture. The text books in use are Barff's Chemistry and Newth's Natural Philosophy

There is a laboratory where the boys may make a few experiments, if they wish, under superintendence, but this has not been insisted upon

The next two classes have one hour a week, just to give them first notions before actually studying for matriculation

There is no regular teaching in Science for any class below these

The more thorough and extended study of Science is reserved for young men who are also engaged in the study of mental philosophy. But this is in a department wholly independent of the school, and, therefore, I apprehend, not falling in any way within the scope of the Commissioners' inquiry.

I have the honour to be, Sir,  
Your obedient servant,  
E. J. PURBRICK, S.J.  
Rector of Stonhurst.

J. Norman Lockyer, Esq.  
&c. &c. &c.

8. CHRIST'S HOSPITAL.

DEAR SIR,

Oct 17, 1872

In answer to your questions I have to say

I The classification of the school will perhaps be understood from the annexed diagram of the classes in the "Grammar School" or language department, in which every boy (with the exception of the 50 naval boys) passes at least half his school hours



XII. In all these subjects the book is supplementary to the oral lesson, and is used to systematise and enforce the oral teaching, and to supply problems and examples.

XIII. In the Natural Philosophy class no note books are used. In Chemistry and Elementary Mechanics they are used during the lesson.

XV. I refer you to Dr. Russell for some account of his method of teaching Chemistry. [See this at the end.]

XVI. By the permission of the authorities of St. Bartholomew's Hospital, our Chemistry classes are allowed to make use of their admirable laboratory and lecture room, under the instruction of Dr. Russell.

There is no museum or special scientific lecture room in the school itself.

XVII. Two of the masters voluntarily help Dr. Russell by acting as *répétiteurs* to the Chemistry classes, and one of the Mathematical masters takes the Natural Philosophy class as one of the duties of his post.

XVIII. The Natural Philosophy class has been in existence only two years. Apparatus to the value of some 25*l.* has been supplied, sufficient for the elementary lectures given. No special sum is allowed annually.

XIX. There is no workshop.

XX. I. Mathematical Science:

(a) Todhunter's Elementary Mechanics.

Parkinson's ditto.

Todhunter's Analytical Statics

Besant's Hydrostatics.

Parkinson's Optics.

Godfrey's Astronomy

(β) Hamblin Smith's Hydrostatics.

Galbraith and Haughton's Hydrostatics and

Mechanics.

II. Natural Science:

(a) Deschanel's *Traité de Physique*.

Maxwell on Heat.

Tyndall on Heat.

Tyndall on Sound.

(β) Balfour Stewart's Lessons in Elementary

Physics.

Balfour Stewart's Science Primer.

Barth's Manual of Chemistry.

(Roscoe & Gill occasionally)

(a) Senior boys.

(β) Junior boys.

XXI. Books on science suitable to boys are added from time to time to the school library, on the suggestions of masters or boys.

XXII. There is no such society.

XXIII. Progress in every subject is tested by half-yearly examinations, by written questions, and in the Chemistry class by periodical examination of note books.

XXV. Progress in Mathematical Science is tested once a year by an independent examiner.

All the other classes have hitherto been examined by their own teachers.

XXVI-XXVIII. I have no answer to give to these questions.

XXIX. The Mathematical department has had considerable success at Oxford and Cambridge. See Report of Schools' Inquiry Commission, vol. III, pp. 56, 57, and vol. IV, pp. 837, 838.

The other classes are too young for us to be able to state any such results of them.

XXX. The Chemistry and Natural Philosophy classes get their share of the ordinary prizes. A considerable share of the exhibitions to the Universities has always been assigned to good mathematicians. Hitherto no special reward has been given to Natural Science, but I am at present trying an experiment which may be a precedent. A Grecian, who showed a marked inclination for Natural Science, has been excused the greater part of his classical and mathematical work, and is attending lectures at St. Bartholomew's, Kensington, and the College of Surgeons, on Physiology, Chemistry, &c. If he satisfies us that his aptitude and progress are commensurate with those of his contemporaries, who are studying classics and mathematics, I shall recommend him to the Governors for an exhibition at Oxford or Cambridge.

XXXI. I intend proposing to the Governors that we should have each spring a course of lectures on Botany (illustrated by specimens given to each boy in the class). I should further wish that the junior classes should have

at least one hour a week of oral instruction in some elementary physical subject, treated so as to stimulate their powers of observation and analysis.

XXXII. (1) Most of the boys leave before 16; at present there are hardly 30 boys in the school over 16. These are all aiming at University scholarships, and hitherto have found Classics and Mathematics the only (or at least the readiest) avenue to them.

(2) Want of time to fit in Natural Science by the side of the need for French, German, &c. for commercial positions, to which a very large proportion of our boys go off.

(3) Our position in the middle of London, which shuts our boys off from the many opportunities that country boys have, of observing nature. Recently, when Professor Tennant gave a course of lectures on Geology, several boys contrived to form little collections of chalk fossils from Charlton, but it is obviously difficult to find for them many such opportunities for observation of nature.

(4) The fact that the teachers of the existing staff are mostly unacquainted with Natural Science, at any rate in such a measure as to be adequate teachers of it.

(5) The fact that many teachers are without a clear knowledge of the best subjects and methods of teaching Natural Science to boys, &c. of such as have a real educational value, which would warrant our substituting them for, or adding them to, proved subjects and methods of education. I myself look hopefully to the Commission for information and guidance on this subject.

XXXIII.—(1) The most obvious suggestion is, that the Colleges should offer more encouragement in the shape of scholarships and exhibitions, and that the Colleges and the Universities should put Science more on a level with other subjects in their examinations.

(2) The universities might supply the deficiency of highly-trained scientific teachers by endowing a class of local sub-professors, who should further the teaching of Natural Science in the schools of a given district by lectures, examinations, and inspection, and by their advice and suggestions to the teachers of the several schools with regard to subjects and method of teaching, choice of apparatus, &c.

(3) If the scheme of organised examinations of schools by the Universities (suggested by the conference of head masters) should be adopted, Natural Science would find its place in such examinations.

XXXIV. The Government could assist in analogous ways:—

(1) By requiring natural science in its competitive examinations.

(2) By appointing local inspectors, and further by aiding in the formation of school museums and collections.

XXXV. My experience is but short, but I have found already that the plan often adopted of teaching Chemistry as the first subject, is not satisfactory. I attended an admirable course of lectures given by the late Dr. Matthiessen to a class of our boys, who had had no previous scientific instruction in Natural Science. It was obvious that most of it was lost upon them for want of familiarity with simple scientific notions, and we found it necessary to institute the Natural Philosophy class as an introduction to the Chemistry class.

G C BELL, M.A.\*

Head Master of Christ's Hospital.

#### Chemistry Classes at Christ's Hospital

There are certain special circumstances affecting these classes which should be first stated: they are that the laboratory and lecture-room in which the classes are held belong to St. Bartholomew's Hospital, and are larger and more complete than such buildings ordinarily are; that very large classes have to be taught, and, lastly, that only a small amount of time is devoted to this subject.

The chemistry class has been established about three years. The late Dr. Matthiessen was the first teacher, but the class was hardly organised when he died. I have had the honour of holding the appointment only about a year and a half, and consider the present system of teaching little more than tentative. Each half year considerable changes have been introduced, and further experience and consideration will undoubtedly suggest other changes. The present report is, therefore, only a sketch of what is now being done here, not an account of the established method of teaching chemistry at Christ's Hospital.

At the present time (October 1872), there are two chemical classes, the junior class, consisting of 49 boys, of the average age of 14.9, and the advanced class, consisting

\* These numbers represent the class of the School in 1872. Some modifications in details have since taken place.

of 21 boys, of an average age of 15.3. Beside these classes, three senior boys are working in my laboratory, and receiving from me special instruction.

**Junior Class.**—All the boys in this class have, during the last half year, attended a class of elementary physics, and commenced the study of chemistry at the beginning of the present half year. The teaching is at first of the most elementary kind; the simpler I have made it, the more efficient it has proved. To commence with, I prefer illustrating, explaining, and making the boys perform some very simple physical experiments, to purely chemical ones, choosing such as are of common occurrence in chemical operations. For instance, the effect of heat upon water, its rise of temperature, its conversion into a gas, and the recovery of the water from the gas (distillation); then passing on to the solution of bodies in water and the testing for them by evaporation. My special object being to begin with phenomena with which the class are familiar and really believe in, and then to pass systematically to others of a more technical character. A boy cares little about a chemical reaction which he can hardly understand, except it be as a pyrotechnic display, or for some reason of that kind; but if he has seen some salt dissolved in water he will be intensely interested in seeing the solution evaporated to dryness in a platinum basin, and the salt recovered. After studying simple phenomena of this kind, the properties of acids and alkalies are shown, the formation of a neutral salt, and in some detail a chemical change, such as the action of hydrochloric acid on chalk, the experiment being made quantitatively, and the products carefully collected and examined. Thus, gradually the boys gain familiarity with chemical phenomena, and then pass on to the systematic study of chemistry. In all the lectures the boys take notes, time being given them to write down in full the most important points. After each lecture certain of the boys are called upon to give up their note-books, and these are looked over. It is seldom that the notes are not sufficiently full and accurate, if not satisfactory, the boy has to render them complete by reference to the text-book, or to another boy's notes for what is not in the text-book. A *voix* examination precedes every lecture. At irregular intervals, depending on the subject in hand, the hour is devoted to practical work in the laboratory, instead of a lecture. During last half year the junior class did no practical work, but this half a considerable amount of practical work is being introduced. I feel now little doubt it will prove very advantageous even to the youngest beginner to have a certain amount of practical work introduced into the course of instruction.

In the advanced class the same system of teaching is carried on. The text-book used is Barff's *Chemistry*. The order of the subjects in it is followed, but the teaching is not a precise following of the substance of the book. In both classes I have been very much aided by the Rev. E. S. Carlos and Mr. Mackie, both of them masters in Christ's Hospital, who have volunteered their services and have attached themselves one to each class. They devote one hour a week to recapitulating to their class the subject of the last lecture, questioning the boys on the subject, and giving them further explanation if required.

The features of special interest in these classes are perhaps the large classes taught and the ample accommodation we have for teaching such classes. A practical class of 50 boys is perhaps unknown elsewhere. Notwithstanding its size, it works very satisfactorily, two boys work together and have a complete set of apparatus to themselves. On a day when practical work has to be done, the boys go first into the lecture room, and are shown the exact apparatus they have to use, and exactly how the experiments are to be made, then they pass to the laboratory and make the experiments for themselves. Order, care, and neatness are required from the boys and rigidly enforced, but without the slightest difficulty. In the practical teaching I have found the greatest advantage to arise from making the experiments as quantitative as possible. If they have nitric acid to prepare I give them a known weight of sulphuric acid, and make them calculate out and then weigh out the requisite quantity of nitrate of potash. In studying hydrogen I have made them reduce a known weight of oxide of copper and weigh the water obtained; this gives a definite interest to the experiment, they appreciate the quantitative nature of the reaction; it affords a most valuable check on the care and accuracy with which the experiment has been made, and excites a spirit of emulation to obtain the best results.

The senior boys not belonging to these classes work independently in the laboratory, and follow out their

chemical studies, under my direction, in the same way as any other students would do.

W. J. RUSSELL, F.R.S.,  
Lecturer on Chemistry at St. Bartholomew's Hospital.  
October 30th, 1872.

9. WELLINGTON COLLEGE.

General Arrangements.

**Question 1.** How is the school classified?—There are two main divisions or schools, the "Classical School" and the "Mathematical" or "Modern School." These are quite parallel and equal in position and status. There is a sixth form in each, and the prefects of the school may be indifferently in either school. Boys are not allowed to enter the Modern School unless they are distinctly qualified to do so. The masters are judges as to this. Boys may be transferred from one school to the other at any point of either school. Those whose classical work is important to their future (or who will, e.g., make classics serviceable in examinations, as Woolwich), but wish to end their work at school with a mathematical training, frequently enter the Mathematical School from the sixth or fifth. Conversely, good scholars in Modern School have some classical lessons with the classical sixth. There are 350 boys.—In Classical School one per cent, 8 in sixth, 19½ upper school, 26 middle school, 13 lower school, in Modern School one per cent, 5 in sixth, 13 upper school, 15½ middle school. For modern languages, mathematics, and science, the forms are rearranged into classes called "sets."

Classical sixth into	- -	{ 2 mathematical sets
		{ 2 German "
		{ 1 science "
" upper school into	-	{ 4 mathematical "
	(3 forms.)	{ 4 modern language "
" middle school into	-	{ 5 mathematical "
	(4 forms.)	{ 5 modern language "
" lower school into	-	{ 3 mathematical "
	(3 small forms)	{ 3 modern language "
Mathematical sixth and	-	{ 4 mathematical
upper school into	-	{ 2 science "
	(3 forms.)	{ 1 Greek "
Middle school	- -	3 mathematical "

[Modern languages being basis of form division]

**Question 2.** Is science a necessary part of the school course, or is it taught only in special forms or departments?—Necessary in the classical sixth. Necessary in the mathematical sixth, upper school, and highest form of middle school. There is also a voluntary class in chemistry (practical)

**Question 3.** Copy of time table?—Enclosed.

CLASSICAL SIXTH.

	7-9.	9½-10½	10½-11½	11½-12½	12½-13.	2-3.	4-5	6-6.	Special teaching or preparation for next morning's lesson.
S.	-	-	-	-	-	-	DL.	-	-
M.	DL.	-	C.	C.	-	-	-	C.	Exercise.
Tu.	C.	-	C.	M.	-	-	-	M.	[Private Tuition]
W.	O.	-	C.	G.	-	S.	-	C.	Exercise, Science Notes.
Th.	C.	-	C.	M.	-	-	-	-	Exercise.
F.	O.	-	Mod. History read in French.	C.	-	-	M.	C.	-
S. O.	-	-	Philology (Comp.)	G.	-	-	-	-	[Private Tuition.]



MATHEMATICAL SCHOOL. SIXTH AND UPPER SCHOOL.

	7-8.	9-10.	10-11.	11-12.	12-13.	4-5.	5-6
S	—	—	—	—	—	DL	—
M	DL	—	S or Gk	Dr.	—	—	M L
Tu.	M	—	H. or L	H. or L	M.	—	M L
W	M	M.	—	M L	—	M L	S or Gk.
Th.	M. L	M L.	—	H or L	M	—	—
F	M.	Dr (9-10)	—	M L	—	M.	—
S	H or L	—	S or Gk	—	M.	—	—

LOWER SCHOOL FORM.

	7-8	9-10	10-11	11-12	12-13	4-5	5-6	In addition advanced Lesson
M	DL	C	F	F	M	—	C	—
Tu.	Geog and Repetition	M	C.	—	C	—	Mod. Hist.	Exercise
W	C	C.	C.	—	Anc Hist.	Hist.	Exercise.	—
Th	Di and Repetition	M	C.	—	C.	Drawing [14 hr]	—	Exercise.
F	C	M	F	F	C.	C.	C	—
S	Di and Repetition	C	Geog Map	—	C	—	—	[Eng Essay]

CLASSICAL UPPER SCHOOL FORM

	7-8.	9-10.	10-11	11-12	12-13.	4-5	5-6	Evening, besides the next Morning's Lesson
S	—	—	—	—	—	Di	—	—
M	DL	—	M	—	C	—	Hist	Exercise
Tu.	C	9-10	M	—	C.	—	C	Exercise
W	C	9-10	—	F or G	—	Mus or Dr.	Hist	M.
Th	C	—	C.	—	C.	—	—	Exercise.
F	C	—	C	—	M.	—	—	Exercise.
S	C	—	F or G	—	C	—	—	—

Question 4. Summary of hours per week given in each class to different subjects (if playtime is utilized for preparation or practical work, this should be shown separately)

(Exclusive of preparation)	Classics.	Drama	Drawing	History and English and Geography.	Mathematics	Modern Lang	Science	Musica.
Classical Sixth	12 <sup>+</sup>	2	7 <sup>+</sup>	10 <sup>+</sup>	4	2	1	—
Upper School	14	2 <sup>+</sup>	12	11	4	2	—	—
Middle School	14 <sup>+</sup>	3 <sup>+</sup>	12	3	4	—	—	1
Lower School	16	3	12	5	4	—	—	1.
Mathematical Sixth	7	2	2 <sup>+</sup>	2 <sup>+</sup>	9	7	2 <sup>+</sup>	—
Upper School	7	2	2 <sup>+</sup>	2 <sup>+</sup>	9	8	2 <sup>+</sup>	—
Middle School	3	2	2	2	6	1	1 <sup>+</sup>	1

\* or Science † or Latin ‡ or Greek § one of the two forms Private tuition is also allowed 2 hours extra in the week In Classical Sixth, it is almost universal in Classes in Mathematical Sixth, almost universal in Mathematics. In rest of school it is usually to make up deficiencies

CLASSICAL MIDDLE SCHOOL FORM.

	7-8.	9-10.	10-11.	11-12.	12-13.	4-5.	5-6	Evening, in addition to the next Morning Lesson for next
S	—	—	—	—	—	S D	—	—
M	D.	—	F	—	C	—	H	Exercise
Tu.	C	M	10-11	—	12-13	—	C	Exercise
W	C	—	C.	—	Geogy	4-5 45	C	—
Th.	7-7.50 D 7.50-8 C.	M	10-11 Drg	—	12-13 C.	—	—	Exercise.
F	C.	—	C.	—	E	F	C.	Exercise.
S	C	—	10-11 M	—	C	—	—	Map.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes?

Classical sixth	17	057
Mathematical school, 1st set, 24 boys, average age	16	11
" " 2nd " 26 " " "	15	11
" " 3rd " (once a week only) " "	15	4

[Botany was taught for about two years in head form of middle school, has been discontinued]

Question 6 Amount of knowledge required before the study of science is commenced?—None specially but what is implied by having reached the form where it is begun In classical school this would imply four books of Euclid, algebra as far as quadratic equations. In mathematical school, about two books of Euclid, and algebra to simple equations; but before a boy gives more than one hour to it a week he has generally learnt sixth book of Euclid and done quadratics.

Question 7 Is any alternative or choice of subjects offered?—In classical school boys may draw instead of attending science, only 4 out of 29 do so The other 25 choose science, i.e., much harder work and involving great trouble in writing out notes. In mathematical school there is a choice between Greek and Science Science is chosen in about five cases out of six. No choice allowed between different departments of science.

What departments of Science are preferred?

- a. By parents?
- b. By the boys?—Boys when allowed to choose between botany and German chose German in three fourths of the cases. The German was harder work, and involved much more preparation out of school.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—Only the physical sciences, chemistry, heat, electricity, and a little astronomy, are at present taught.

Question 9 What weight is assigned to scientific attainments in determining a boy's position in the school?—In classical sixth the science lessons are 1-15th of the clas-

MATHEMATICAL SCHOOL. MIDDLE SCHOOL.

	7-8.	9-10.	10-11.	11-12.	12-13.	4-5.	5-6.
S	—	—	—	—	—	DL	—
M	DL	—	M L.	M L.	S.	—	M
Tu.	L.	—	M L.	—	M L.	—	4-5 D
W.	M. L.	Dr.	S. (write notes)	—	M	M. L.	—
Th.	M.	—	L.	—	M. L.	—	—
F.	M L.	—	M.	—	M L.	—	M. L.
S.	M	M	M L	—	H	—	—

sical lessons in hours, but have 1-10th of the marks of the classes.

Classics	-	-	-	600
Mathematics	-	-	-	350
German	-	-	-	180
Drawing	-	-	-	60
Science	-	-	-	60
In mathematical school—				
Mathematics	-	400	(lower forms (300)	
Modern languages	-	-	-	300
Latin	-	-	-	150
Science	-	-	-	100

#### Methods of Teaching

Question 10. What proportions of the lessons take the form respectively of—

- (a.) Oral teaching and demonstration?—Two of the three hours are lectures, generally experimental. The third is given to the working of numerical examples or written examinations.
- (b.) Book work?—Books used in preparation for examination. Otherwise not more than twice or three times in the term.
- (c.) Practical work?—With about two thirds of the first division two hours a week for five or six consecutive weeks in the year. Electrical measurements the subject at present (to be extended). Four boys are taken together. In the voluntary chemistry class 10 boys in two sets. Each set works 1½ hours in the laboratory.

Question 11. Which form of lesson is found to be most effective?—Oral teaching accompanied by experiments, at least as compared with book work.

Question 12. How are text-books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—Supplementary. Notes are exacted, written from the lectures and not from books; but in preparing for examination the use of text-books is encouraged.

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Boys take notes during the lesson, and are required to bring them fairly written out in a continuous form (and not as mere memoranda) at the next lesson, or when the lesson is weekly, next day. The note books are looked over, marked, and annotated after each lesson.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?

Question 15. Describe any method of teaching some special branch of science which has been found successful in your school?

#### Instruments of Teaching

Question 16. What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

One of the class rooms has a sink with water laid on, a large table (mercury), and cupboards of apparatus. Another has simply cupboards of apparatus. There is a laboratory with 10 places, and small ante-room, and a store-room. The cost of materials to start the laboratory was about 50*l.*, but less than this would have sufficed. The benches, furnace, cupboards, &c., fitted up in the laboratory, cost 27*l.* 18*s.* (The room existed before, and the gas had been laid on to each boy's place.)

Question 17. Number of assistants and curators, and annual cost?—None.

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—A fairly complete set of electrical apparatus; for chemistry and heat little more than what is absolutely necessary. The value of the electrical apparatus in use is from 50*l.* to 60*l.* In 1872 instruments and materials in science class-rooms have cost 21*l.* 11*s.*

	£	s.	d.
In laboratory	-	-	4
Botanical lectures have cost	-	11	0
Botanical diagrams	-	4	0
Other diagrams, about	-	2	0

No special sum is set aside beforehand.

Question 19. Is there a workshop? and if so, how and for what particular purpose is it used?

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes?—Barff's Chemistry, Orme on Heat, Deschanel's Electricity (Everett), Ferguson's Electricity (the latter two by seniors chiefly).

Question 21. To what books of reference, other than ordinary school books, have the scholars access?—There is a library, open to all the school at fixed hours, fairly stocked with books on natural history and science. Any boy in the mathematical or classical sixth may propose books, which are usually bought.

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—There is a society called "The Natural History Society." It meets once a fortnight. One of the masters is president. There are 13 members and 25 associates. Many of the masters are honorary members. Meetings open to school on introduction of members and associates. Communications are made, objects exhibited, papers read by master or boys indiscriminately. Two reports have been published at intervals of about 18 months, and accounts of meetings appear in the School Magazine. The number of those present varies from 40 to 80.

[Boys have read papers on Mosses, Hawks, Photography, Fortification, Electricity, Snakes, Manufacture of Alum, Natural History of Man. Masters (very much more frequent than boys) lately, on Coal Mines, Spiders, Recent Discoveries in Sea Bottom, Entomology, Botany, How a Spider spins its Web, A Walk to Finchampstead, The Eys, The Dolomite Formations in England and the Tyrol, Modern Artillery, Galls.]

#### Tests of Progress.

Question 23. How often is the work tested?

- (1) Note books of each lesson are looked over.
- (2) There is an examination every third or fourth week.
- (3) There is an examination at the end of each term.

Question 24. In what way? *e.g.* by examination of note books, or by oral or written questions?—All three.

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?—Twice in the year by the teacher of a different class in the school, and once by an independent examiner.

#### Teachers.

Question 26. Is there any difficulty in procuring competent science masters?

Question 27. Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—For teaching electricity and heat University men (especially now that more subjects are introduced into the traps), who have taken good mathematical degrees and have given attention to the practice of teaching in general. For chemistry it is desirable for men who have worked at the subject at school and at the University still to acquire manipulation in a laboratory, with a special view to exhibiting their experiments dexterously.

Question 28. What evidence of scientific qualification tendered by candidates is found to be of most value?

Question 29. Can you state any results of science teaching in the school? such as—

- (a) Success, professional or otherwise, of individual scholars.
- (b) Influence upon the general studies and intellectual life of the school.

Several boys have done very creditably in military and other examinations. No one has been very distinguished. The work has developed quickly of late. The chemistry teaching is very limited. The good effect on the school is undeniable, but for individual distinction we must look onward for some little time.

I introduced it into the classical sixth solely with the view of increasing the boys' interest in life (there is not enough to produce results in external examinations), and of improving their literary work by widening their interests. I think it succeeds in both respects.

Question 30. Are any special rewards or encouragements (*e.g.* exhibitions, scholarships, or prizes) open to successful students of science in the school?—Annual exhibition of 20*l.* a year for two years, tenable at school, at Woolwich, or at University. "Science" counts towards the Governor's prize annually for examination in a portion of a text-

book (prepared without assistance), and for practical work. [Last subject. Last five chapters of Tyndall's Heat, and to find in solution six specified metals.] Prizes twice a year for term work and examination in science to the head boys in this subject in the classical and mathematical schools. Two governor's prizes for botany, viz., (1) for collecting 40 plants only of at least 10 different orders, to be carefully dried, with descriptive schedule of each, (2) for preparing fixed portion of text-book and describing on schedule plants presented to them.

**Question 31** What improvements do you think could be effected in the teaching of science in your own school?—What we immediately want is (1) a larger laboratory, with (2) more hours of attendance from the teacher of chemistry, and (3) a laboratory assistant [A minor necessity is that in the mathematical school we want one more grade and one more class room. Each master teaching science loses time unless he has a separate class room, but he can perfectly well use such class room for different subjects.]

**Question 32** What are the principal obstacles to the teaching of science in your own school?—See 31

**Question 33.** How could the Universities best assist science teaching in schools?—The foundation of new scholarships and fellowships, as in former times, to encourage new studies, and meet the increasing number of persons who, to the great benefit of the country, seek higher education, would more than anything promote the devotion of years and of lives to scientific investigation, as distinct from commercial and semi-commercial aims. But the diversion of existing foundations of that nature from literary studies would at once injuriously affect all schools as well as the Universities themselves, and not ultimately promote the best interests of science.

**Question 34** Can you suggest any way in which Government could assist science teaching in schools, as, for example, by inspection?—It is important that all the subjects of a school education should be pressed forward with an even hand, and the relative values affixed to them should not be destroyed, though from time to time they may be carefully remodelled. The inspection of any one single branch of work would destroy undesignedly, but steadily, the balance

of studies. The examining power (whatever it is, Government or University) should be comprehensive, and provide for the inspection of all subjects.

**Question 35** Have you any other information to give or suggestion to make likely to be helpful to the Commissioners?—Dispensing with the book as much as possible saves time to the learner and gains for him impressiveness and clearness. As in mathematics familiarity with constructions should precede the learning of propositions, so in science the sight at least of experiments should anticipate the theory. Boys who go through a course of chemical lectures before laboratory work are less patient in experiments because they are aware of the result to come. It follows from this that apparatus need not be extraordinarily complete or costly, but may grow by degrees. Public examinations which boys enter from school need at least as careful attention, and central regulation or advice, as the schools do.

E. W. BENSON,  
Head Master.

Oct. 25, 1872.

10. CHELTENHAM COLLEGE.

General Arrangements

**Question 1.** How is the school classified?—There are three departments, viz., the classical, the military and civil, the junior (boys under 13 years of age).

**Question 2.** Is science a necessary part of the school course, or is it taught only in special forms or departments?—In the classical department science is taught as an alternative with German to boys in the four highest of the nine classes; and to select boys in first class a second scientific subject is also taught as alternative with French. Boys in the Latin class (no Greek) also are taught science. Total number learning science, 86.

In the military and civil department it is a necessary part of the school course for all boys in the four highest of the nine classes. Total number learning science, 128.

**Question 3** Copy of time table?—Time tables of science masters and of every division of the four highest classes:—

CLASSICAL DEPARTMENT. CLASS 1. A. B.—TIME TABLE.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY	FRIDAY.	SATURDAY
9—9 50	Greek Testament and Thursday's copy returned.	Horace, with fresh copy.	Œdipus Rex with 40 lines Repetition, and Saturday's copy returned.	Horace, with fresh copy	Œdipus Rex. with 40 lines Repetition, and Tuesday's copy returned.	Œdipus Rex, fresh copy.
9 50—10 40						
10 40—11 30	Unseen, fresh	Cicero	Composition without books; or English. (Alternatives)	Cicero	Unseen, returned.	German, Botany, Extra Classics, Chemistry (Alternatives.)
11 30—12 15	English, or Roman History (Alternatives.)	German, Botany, Extra Classics, or Chemistry (Alternatives.)		German, Botany, Extra Classics, Chemistry (Alternatives)	Composition without books, returned.	
2 30—3 20	French, Electricity, Extra Classics, Extra Mathematics. (Alternatives.)	- - -	History	- - -	French, Electricity, Extra Classics, Extra Mathematics. (Alternatives)	-
3 20—4 10	Mathematics or Extra Classics. (Alternatives.)	- - -	Mathematics or Extra Classics (Alternatives.)	- - -	Mathematics or Extra Classics. (Alternatives)	-
4 10—5						
6—6	English	-	-	-	-	-

CLASS 1. C.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY	FRIDAY.	SATURDAY.
9—9 50	Scriptures and Greek (Arnold) Composition.	Sophocles	Horace and Repetition	Sophocles	Horace and Repetition.	Sophocles.
9 50—10 15						
10 15—11 30	- - -	Cicero	- - -	Cicero	- - -	Cicero
11 30—12 15	- - -	German or Science.	- - -	German or Science.	- - -	German or Science.
2 30—3 30	French or Science	- - -	History	- - -	French or Science	-
3 30—5	Mathematics	- - -	Mathematics	- - -	Mathematics.	-

CLASS 2 A.

—	MONDAY.	TUESDAY	WEDNESDAY	THURSDAY.	FRIDAY	SATURDAY.
9—9 50	Mathematics	Mathematics	Geography, Natural Science, or German.	History	Mathematics	Shakespeare.
9 50—10 40	Mathematics	-		-	-	-
10 40—11 30	Divinity	Livy (10 45—11 45.)	Demosthenes (10 45—11 45)	Virgil	Virgil	Livy (10 45—11 45.)
11 30—12 15	-	Grammar			-	-
2 30—3 30	Demosthenes	-	-	-	Repetition (2 30—2 45)	—
3 30—4 30	French	-	French	-	(Latin Prose 3—4)	—
4 30—5	Go over corrected composition, L. P.	-	Go over corrected composition, G. I. or G. P.	—	—	—

CLASS II. B.

—	MONDAY	TUESDAY.	WEDNESDAY.	THURSDAY	FRIDAY	SATURDAY.
9—9 50	*Mathematics	*Mathematics	—	—	*Mathematics	—
9 50—10 40		—	—	—	—	—
10 40—11 30	Divinity	Livy and Gram- mar	*Science or Ger- man.	Virgil and un- seen transla- tions ex- amined.	*Science	Virgil and His- tory.
11 30—12 15	-		-		-	
2 30—3 20	Demosthenes	-	Livy	-	Demosthenes	—
3 30—4 10	*French	-	*French	-	-	—
4 10—5	English Lesson	-	Fair copies of composition.	-	Geography	—

\* Lessons by extra masters.

CLASSES III. and IV

—	MONDAY	TUESDAY.	WEDNESDAY	THURSDAY	FRIDAY.	SATURDAY.
9—9 50	iii. -	French	German or Na- tural Science.	Aristophanes	French	German or Na- tural Science.
	iv. Cicero	French	Homer	-	French	Cicero.
9 50—10 40	iii. Divinity	Mathematics	Aristophanes	Mathematics	Mathematics	Cicero.
	iv. Divinity	Homer	-	Homer	Homer	—
10 40—11 30	iii. Cicero	Mathematics	English Litera- ture.	Mathematics	Aristophanes	—
	iv. German or Na- tural Science	Greek Grammar	English Litera- ture	Greek Grammar	Mathematics	German or Na- tural Science.
11 30—12 15	iii. -	Aristophanes	History	Geography	-	History.
	iv. Mathematics	-	History	Geography	Mathematics	History.
2 30—3 20	iii. Unseen Latin or composition.	-	-	-	-	-
	iv. -	-	Mathematics	-	Ovid	-
3 20—4 10	iii. -	-	Virgil	-	Virgil	-
	iv. Ovid	-	-	-	-	-
4 10—5	iii. Cicero	-	-	-	Greek, unseen, or Composition.	-
	iv. -	-	Cicero	-	Latin, unseen	-

Repetition three times a week in both classes.

TIME TABLE of NATURAL SCIENCE CLASSES in the CLASSICAL DEPARTMENT.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY	SATURDAY	
9—9 50	- - -	- - -	- - -	Latin, Chemistry	—	—	
9 50—10 40	- - -	- - -	} (ii) Chemistry {	- - -	—	(ii A.) Chemistry.	
10 40—11 30	(iv) Chemistry	- - -		- - -	(ii B.) Chemistry	(iv) Chemistry	
11 30—12 15	- - -	(i) Chemistry	- - -	(i) Chemistry	- - -	(i.) Chemistry	
2 30—3 20	(i.) Electricity	} *Practical Work, Chemistry Two hours {	Latin, Chemistry	} *Practical Work, Chemistry Two hours. {	(i) Electricity	} *Practical Work, Chemistry Three hours {	
3 20—4 10	- - -		- - -		- - -		- - -
4 10—5	- - -		- - -		- - -		- - -

\* Optional and gratuitous on the part of the master, Mr Lewis, of Oriel.

CLASSICAL DEPARTMENT.—NATURAL HISTORY TIME TABLE

—	MONDAY.	TUESDAY	WEDNESDAY.	THURSDAY	FRIDAY	SATURDAY
9—9 50	- - -	- - -	Class III. Botany	- - -	- - -	Class III Botany.
9 50—10 40	- - -	- - -	- - -	- - -	- - -	- - -
10 40—11 30	- - -	- - -	- - -	- - -	- - -	- - -
11 30—12 15	- - -	Class I. Botany	- - -	Class I Botany	- - -	Class I Botany.
2 30—3 20	- - -	- - -	- - -	- - -	- - -	- - -
3 20—4 10	- - -	- - -	- - -	- - -	- - -	- - -
4 10—5	- - -	- - -	- - -	- - -	- - -	- - -

Class A.—MILITARY AND CIVIL DEPARTMENT.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY	SATURDAY.
9—10 15	Mathematics	Mathematics	Mathematics	English or Science	Mathematics	Mathematics
10 15—11 15	Mathematics	Mathematics	Mathematics	Mathematics	Geometrical Drawing	Latin, or German, or Science
11 15—12 15	English or Science	French	French	Divinity	English or Science	Free Hand Drawing
2 30—3 30	French	- - -	Mathematics	- - -	Latin, or German, or Science.	—
3 30—4 10	Mathematics	- - -	Mathematics or Latin	- - -	Latin, or German, or Science	—
4 10—5	Latin or Free Hand Drawing	- - -	Geometrical Drawing or Latin.	- - -	Descriptive Geometry	—

Class B.—MILITARY DEPARTMENT.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY	SATURDAY.
9—10 15	Mathematics	English	Mathematics	Mathematics	Euclid	Mathematics
10 15—11 15	Mathematics	Mathematics	French	Mathematics	Mathematics	Drawing
11 15—12 15	Geometrical Drawing.	English	German	Science	Mathematics	Mathematics.
2 30—3 30	German	- - -	Drawing	- - -	French	—
3 30—4 10	Scripture History	- - -	Geometrical Drawing	- - -	Mathematics	—
4 10—5	French	- - -	Science	- - -	English Literature.	—

## Class i C.—MILITARY DEPARTMENT.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
9—10 15	Drawing - -	Mathematics -	German - -	Drawing - -	Euclid - -	French.
10 15—11 15	English - -	Geometrical Drawing.	English History, &c.	Science - -	German - -	Mathematics.
11 15—12 15	Mathematics -	Science - -	Mathematics -	Mathematics -	Geometrical Drawing.	English.
2 30—3 20	English Language	- - -	Mathematics -	- - -	Mathematics -	—
3 20—4 10	Scripture History	- - -	Mathematics -	- - -	French - -	—
4 10—5	Mathematics -	- - -	French - -	- - -	Mathematics -	—

## Class i A.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
9—10 15	Divinity - -	Mathematics -	Euclid - -	Mathematics -	Plan Drawing -	Mathematics.
10 15—11 15	Drawing - -	English - -	French - -	Mathematics -	Natural Science	English.
11 15—12 15	Euclid - -	German - -	Natural Science	German - -	Euclid - -	—
2 30—3 20	History - -	- - -	Mathematics -	- - -	French - -	—
3 20—4 10	Plan Drawing -	- - -	- - -	- - -	Geography - -	—
4 10—5	French - -	- - -	History - -	- - -	Drawing - -	—

## Class 2 B.

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
9—10 15	Divinity - -	- - -	Plan Drawing -	Drawing - -	Mathematics -	French.
10 15—11 15	Euclid - -	English - -	Natural Science	Plan Drawing -	Mathematics -	English.
11 15—12 15	- - -	Mathematics -	Euclid - -	Euclid - -	- - -	Mathematics.
2 30—3 20	Natural Science	- - -	German - -	- - -	Drawing - -	—
3 20—4 10	German - -	- - -	Geography - -	- - -	French - -	—
4 10—5	History - -	- - -	French - -	- - -	History - -	—

—	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
9—10 15	{ m. A. Algebra - - iv A. Plan Drawing -	- - - History - -	Euclid - - Science - -	History - - French - -	History - - - - -	Geography. Drawing.
10 15—11 15	{ m. A. - - iv A. Arithmetic -	- - - Science - -	Euclid - - Plan Drawing -	German - - Arithmetic -	Algebra - - Drawing - -	- - Geography.
11 15—12 15	{ m. A. German - - iv A. Mathematics -	- - - Plan Drawing	Physical Geo- graphy Euclid - -	French - - Algebra - -	French - - German - -	- - Euclid.
2 30—3 20	{ m. A. Divinity - - iv A. Divinity - -	- - - - - -	Science - - Arithmetic -	- - - - - -	Algebra - - - - -	- - - -
3 20—4 10	{ m. A. Algebra - - iv A. French - -	- - - - - -	Drawing - - History - -	- - - - - -	Plan Drawing Algebra - -	- - - -
4 10 5	{ m. A. Drawing - - iv A. German - -	- - - - - -	Arithmetic -	- - - - - -	Science - - Algebra - -	- - - -

Class 3 B.

	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
9—10-15	- - - -	Euclid - -	French - -	German - -	Algebra - -	—
10-15—11-15	Science - -	History - -	- - - -	French - -	- - - -	Euclid.
11-15—12-15	German - -	- - - -	Arithmetic	Algebra - -	Algebra - -	—
2-30—3-20	Scripture History	- - - -	Physical Geo- graphy	- - - -	Algebra - -	—
3-20—4-10	Algebra - -	- - - -	Science - -	- - - -	Geography - -	—
4-10—5	- - - -	- - - -	Euclid - -	—	—	—

Class 4 B.

	MONDAY	TUESDAY,	WEDNESDAY,	THURSDAY.	FRIDAY.	SATURDAY
9—10-15	Arithmetic	Science - -	Algebra - -	Algebra - -	French - -	Euclid
10-15—11-15	Algebra - -	French - -	Euclid - -	Algebra - -	Arithmetic	- - - -
11-15—12-15	Euclid - -	Algebra - -	Arithmetic	- - - -	Science - -	Algebra.
2-30—3-20	- - - -	- - - -	History - -	- - - -	Geography - -	—
3-20—4-10	- - - -	- - - -	Algebra - -	—	—	—
4-10—5	Scripture History	- - - -	German - -	—	—	—

TIME TABLE of the SCIENCE MASTER in MILITARY and CIVIL DEPARTMENT  
SCIENCE.

	MONDAY.	TUESDAY,	WEDNESDAY	THURSDAY	FRIDAY.	SATURDAY.
9—10-15	- - - -	4 B Class	4 A. Class	1 A. Class	—	—
10-15—11-15	3 B. Class	4 A. Class	2 B Class	1 C. Class	2 A. Class	1 A Class.
11-15—12-15	1 A. Class	1 C. Class	2 A. Class	1 B. Class	4 B. Class	—
2-30—3-20	2 B. Class	- - - -	3 A. Class	- - - -	1 A. Class,	—
3-20—4-10	- - - -	- - - -	3 B Class	- - - -	1 A. Class	- - - -
4-10—5	- - - -	- - - -	1 B Class	- - - -	3 A. Class	- - - -

Question 4. Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately).—See Time tables, enclosed, in answer to Q. III.

Six boys in classical department are taken, two at a time, three evenings weekly, two hours each time, 4-30—6-30, purely voluntary gift of his time by the science master, for practical work. In all departments of the College much time is given out of school hours to preparation of work of every kind. All boys are in school 27 hours a week. Hard-working boys in the upper classes would give 25 to 30 hours a week to preparation out of school. The idliest boarder in the lowest class must give 14 hours a week, in the evenings, to preparation under supervision in large room. Elder boys work in their own study without supervision.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the natural science classes?

Classical Department:—		Boys.	Average age.
Class I.	Electricity	6	18 years 1 months.
	Chemistry	6	17 " 0 "
	Botany	20	17 " 8 "
" II.	Chemistry	18	16 " 9 "
	Botany	8	16 " 6 "
" III.	Chemistry	12	17 " 6 "
" IV.	Chemistry	16	16 " 2 "
Latin class.		16	16 " 2 "

Military Department:—		Boys.	Average age.
Class I.		39	17 years 0 months.
" II.		30	16 " 2 "
" III.		29	16 " 3 "
" IV.		29	16 " 1 "

Question 6. Amount of knowledge required before the study of science is commenced?—In classical department such an amount of knowledge is required as places the boy in some one of the four highest out of the nine classes, or in one of the two higher of the three divisions of the Latin class.

In the military and civil department a certain amount of knowledge of mathematics, viz., Euclid, four books; algebra, to binomial theorem; arithmetic, all the principal rules. A boy cannot well have got to Class IV. without this knowledge.

Question 7. Is any alternative or choice of subjects offered?—None, except such as appears in the time tables, see under Q 3. There is a settled order of subjects, especially in the military department, to meet the average capacity of boys in the classes taught.

What departments of science is preferred?  
a By parents?  
b By the boys?

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—See time tables, under Q. 3. The subjects chosen are practically determined by the examinations for which our boys are preparing, e.g., classical department for scholarships at the Universities and for Indian Civil Service.

Military Department for Woolwich and Cooper's Hill.

The military boys are first taught the chief facts and principles of physical science. Chemistry is not taught till a boy reaches the first class, and then it is studied theoretically and practically. In this class chemistry and heat are alternative subjects with magnetism and electricity, or with geology and physical geography.

**Question 9** What weight is assigned to scientific attainments in determining a boy's position in the school?—In classical department 7 per cent in marks of half year, in examination 12½ per cent. in military department not quite 20 per cent

*Methods of Teaching.*

**Question 10.** What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?—Speaking generally, especially of Military department,—

(a)  $\frac{1}{2}$   
(b)  $\frac{1}{4}$   
(c)  $\frac{1}{4}$  } would be correct.

(b) Book work?—But this varies with subject, and with master, e.g., in botany, practical work is confined almost entirely to summer months, when at least half of every lesson is (c) practical. In winter there would be occasional microscopic demonstration.

(c) Practical work?—The science master in the classical department makes lessons in electricity, principally (a) oral and demonstrative, with (c) practical work for voluntary pupils on half-holiday evenings, and in chemistry makes two lessons out of three (a) oral and demonstrative, the third lesson catechetical.

**Question 11.** Which form of lesson is found to be most effective?—Speaking generally, the combination of (a), (b), (c) of Question 10 is more effective than either (a) or (b) or (c) alone, but much depends on the nature of the subject and the character or genius of the teachers; and when diverse forms of teaching are used as supplementary to each other, it is impossible to contrast their efficiency.

**Question 12.** How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?—Masters and methods differ, subjects differ also. One master would reply, chiefly preparatory; both for first (or demonstrative) lesson, and also for last (or catechetical) lesson. Another master would say, simply preparatory, except so far as useful for revision of work before examination. The head master of the military department, a man of great experience and great wisdom in teaching, who himself taught science for many years before any special master for science was appointed, says, "The subject matter of each lesson should generally be explained in advance; it is then learnt from text-books during preparation hours, and tested at the next lesson time. If any points are not clearly understood, they are again explained, and notes made by the boys."

**Question 13.** Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Masters differ in their method slightly.—

A. "Both during and after their lesson, to a considerable extent" (a) and (b)

B. "Chiefly during lesson, as supplementary to text-books" (a) only.

C. "Short notes are taken during lesson (a) Fuller notes and explanations are made in note-books after the lesson" (b)

Where notes are taken after the lesson (b), it is that they may subsequently be produced to the master

**Question 14.** How far are boys required to prepare their own apparatus or experiment, or to collect specimens during the intervals between lessons?—Experiments are made in the presence of boys during lessons by the master; and are also made by the boys in the presence of the master at the practical voluntary work

Apparatus is not prepared by the boys except for botany, and for botany it is both for lessons and for holiday task

In the military and civil department, excellent laboratory experiments are made by the boys in the presence and under the superintendence of the master, but usually by the master himself

**Question 15.** Describe any method of teaching some special branch of science which has been found successful in your school?

*Instruments of Teaching.*

**Question 16** What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return)

There is an excellent laboratory and lecture-room for the military department; an excellent lecture-room for the classical department, which will gradually acquire many of the appliances of a laboratory. There is a museum, partly scientific in contents and arrangement, and there is a botanical garden of half an acre. The museum is barely three years old, the botanical garden just 12 months.

**Question 17.** Number of assistants and curators, and annual cost?—The museum is in charge of a resident member of council, without salary. A master, lately deceased, was curator, and a yearly grant of 60*l.* had been voted him by the council

The botanical garden is in charge of the natural history master in the classical department, without salary.

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c?—The necessary apparatus and diagrams are fully provided for the military department, and are being gradually provided for the classical department, into which science was introduced only three years ago. No yearly sum is allowed for new instruments or the replacement of materials, but grants of money are made by the council when asked for

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose is it used?—There is no workshop.

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes?

Classical department—

Roscoe's Elementary Chemistry.—Juniors.

Harcourt and Madan's Practical Chemistry.—Seniors.

Deschanel's Electricity.—Juniors.

Ferguson's Electricity.—Seniors.

Balfour-Stewart's Elementary Physics.—Juniors

Balfour's Elements of Botany.—Juniors.

Balfour's Manual of Botany.—Seniors.

Military department—

Balfour-Stewart's Elementary Physics.—Juniors.

Ganot's Physics (Atkinson)—Seniors.

Roscoe's Lessons in Elementary Chemistry.—Juniors.

Fresenius' Qualitative Analysis; Lavoeng's Tables—Seniors

Jukes' School Manual of Geology.—Juniors.

Lyell's Elements and Principles.—Seniors.

**Question 21.** To what books of reference other than ordinary school books, have the scholars access?—There are a few books of reference in the museum and college library, perhaps, 120 volumes, but the collection, though growing, is at present inadequate.

There are a few scientific volumes also in the house library of most or all of the boarding houses.

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—There is a natural history society.

Ten masters (of whom three are working members) and 40 boys. The secretary is a boy

The meetings are weekly or fortnightly during the winter, six months; and in summer there are fortnightly excursions

Subscription annual, 3*s.* with entrance fee, 2*s.* 6*d.* Influence is good decidedly; but does not act on a large number.

*Tests of Progress.*

**Question 23.** How often is the work tested?—Once a month, examination by master; once a year, examination by examiners appointed by the council of the college.

**Question 24.** In what way? e.g. by examination of note-books, or by oral or written questions?—Orally, in part; by written questions mainly, as regards the examiners appointed by the council.

In the same way, and also by examination of note-books by our own masters.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—By both. See 24.

*Teachers.*

**Question 26.** Is there any difficulty in procuring competent science masters?—Great difficulty in securing downright good men:—

Ours is not a rich school, and we cannot compete in salary with Eton, Rugby, Harrow, and Winchester.

The demand in schools for teachers of physics, chemistry, &c., has been very great for the last few years. Possibly there may be a fall in the demand when all the large schools are fully supplied; but there is no lull yet.

3 In appointing two out of our three teachers of science it has been necessary to secure first-rate mathematical teachers as well as first-rate teachers of science; but apart from this necessity in two out of three appointments, I believe that a scientific and thorough knowledge of mathematics is the



best basis if not the *sine qua non* of a scientific and thorough teaching of physics and the natural sciences.

4. The Universities offer now-a-days so attractive a home for men of science, whether married or unmarried, combining the advantages of ample leisure, fair emolument, splendid collections from museums and libraries for study and observation, that even large public schools, in pleasant positions, find it hard to attract first-rate teachers of science, except the man himself has a genuine love for boys.

*Question 27* Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—The best men are to be obtained at the Universities, or perhaps University graduates with some subsequent experience elsewhere. Taking our present staff of three teachers of science in the order of their joining our staff:—

(A.) Was seventh wrangler a few years ago, and after taking his degree attended several courses of the Cambridge Professor of Botany, attended chemical lectures, and practical work in the chemical laboratory of St John's College, Cambridge.

(B.) Under Professor Maine, first class in mathematics in moderations, and also in the final schools, first class in Natural Science, senior Mathematical Scholar in the University of Oxford, Fellow of Oriel. He has worked in the University chemical laboratories under Professors Brodie and Clifton, in the Christ Church laboratory, and subsequently in the British Museum under Professor Maskelyne.

(C.) Scholar of Sidney Sussex College, Cambridge; stood 25th in the list of successful candidates for the Indian Civil Service, scoring the highest mark ever scored in Natural Science (927 out of 1,000 maximum), was elected to an exhibition at the Royal School of Mines; was placed second in 1st class of the Natural Science Tripos at Cambridge; and since B.A. degree, has lectured in various branches of science in London.

*Question 28* What evidence of scientific qualification tendered by candidates is found to be of most value?—Success in the University examinations, successful experience in imparting his own knowledge, consensus of men of science, and of judgment that the man has the knowledge needed, the power of imparting it, and the gift of inspiring others, and the personal qualities of the man himself as seen in personal interview, after careful investigation of testimonials and confidential communication with trusted friends.

*Question 29* Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise of individual scholars?—Distinctions in the competitive examinations for commissions in the Royal Engineers, and at the Civil Engineering College at Cooper's Hill, have shown again and again the practical results of science teaching in the military department. As regards the classical department, science is of recent introduction (August 1869), but R Obbard went in straight from 1 A classical to the Indian Civil Service examination 1871, scored 476 in natural science out of 1,000 maximum, after only nine months' work, and stood 16th in the successful list.

(b) Influence upon the general studies and intellectual life of the school?

*Question 30* Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of science in the school?—There are prizes after the Christmas examination in both departments, there have been special prizes for barbers of boys' own collection, and for excellence in physical geography; and the "Old Cheltonian Society" gives a special prize for proficiency in physical science.

*Question 31* What improvements, do you think, could be effected in the teaching of science in your own school?—Ampler apparatus in some respects.

No other improvement seems possible, except by giving "more time" but that could only be given at the cost of other subjects.

More showy results might of course be produced by selecting three or four boys, turning them away from other work, and concentrating all their other time on science.

The selected boys would generally get a scholarship, but their education would be one-sided, and the school organisation would suffer.

*Question 32* What are the principal obstacles to the

teaching of science in your own school?—The competing claims of other subjects.

*Question 33* How could the Universities best assist science teaching in schools?

1. By offering more scholarships for knowledge in this subject.

2. By offering more fellowships for the same subject, as the absence of definite ulterior prospects deters many students of science from leaving the more remunerative lines of study.

*Question 34* Can you suggest any way in which Government could assist science teaching in schools, as, for example, by inspection?

1. Not by inspection, for which work the Universities are fitter, being less bureaucratic, more elastic, more truly educational.

2. In examination for Civil Service appointments, at home and abroad, science might be always an ingredient. But as a test of youthful intellect, science seems to me more capable of rapid cram than mathematics or linguistic subjects, and to that extent less trustworthy as a mere test.

*Question 35* Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

T. W. JEX-BLAKE,  
Head Master.

Oct. 26th, 1872

11. CHARTERHOUSE SCHOOL.

General Arrangements.

*Question 1.* How is the school classified?—The school is divided into 11 forms, viz. —

6th	} Upper school.
Upper 5th	
Under 5th	
Upper 4th	
Under 4th	
Upper Shell	} Under school.
Under Shell	
Upper 3rd	
Under 3rd	
2nd	
1st	

*Question 2* Is science a necessary part of the school course, or is it taught only in special forms or departments?—Science forms a part of the obligatory school course from the 6th form to the Under 3rd inclusive.

*Question 3* Copy of time table?

Monday	10 45 - 11 45 a.m.	Upper 3rd.
"	11 45 - 12 30 "	Upper Shell
"	3 - 4 "	Sixth Form
Tuesday	3 - 4 p.m.	Upper and Under Fifth.
"	4 - 5 "	Upper Fourth.
Wednesday	9 30 - 10 30 a.m.	Lower Shell
"	10 45 - 11 45 "	Lower Fourth
"	11 45 - 12 30 "	Lower Third
Thursday	- as on Monday	
Friday	- as on Tuesday	
Saturday	- as on Wednesday.	

*Question 4.* Summary of hours per week given in each class to different subjects (if playtime is utilised for preparation or practical work, this should be shown separately).—One subject only is taught in any given quarter, therefore, the two hours of each week are given exclusively to that one subject.

*Question 5* Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes?

6th Form	-	12	} Upper school {	17
Upper 5th	"	12		16
Under 5th	"	20		16
Upper 4th	"	19		14
Under 4th	"	15		14
Upper Shell	"	14		13
Under Shell	"	15		13
Upper 3rd	"	18	12	
Under 3rd	"	21	12	

*Question 6* Amount of knowledge required before the study of science is commenced?—For the branches of Natural Science which are for the most part descriptive (Botany, Geology, Physiology, &c.) a knowledge of mathematics is not required, but there is much difficulty in teaching these, owing to the multiplicity of hard names, which the memory cannot retain easily, if the mind succeeds in grasping them. For the branches of Natural Science which are grouped under "Natural Philosophy," viz.,

Chemistry, Electricity, Heat, Optics, Acoustics, Hydrostatics, &c., a knowledge of Arithmetic, including vulgar and decimal fractions, and of Algebra, including simple equations, and of elementary Geometry, is necessary. Some knowledge of Latin and Greek is also desirable for the explanation of terms. It is obvious that the boys in the Third Form are but scantily provided with such requisites.

**Question 7.** Is any alternative or choice of subjects offered?—No, not at present. Some communication has been held with the Universities, who have undertaken to supply the schools with a curriculum of Natural Science study, elementary and advanced. It is hoped that we shall thus be provided with an authoritative recommendation for our guidance. At Cambridge Dr Humphry, Professor Lavegne, and the Rev. Couits Trotter have the matter in hand.

What departments of science are preferred?—(a.) By the parents. (b.) By the boys.

**Question 8.** What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—Our experience is not sufficient to justify an answer to this and the preceding questions (a) and (b) of 7. As yet only Botany and Chemistry have been attempted.

Botany was taught in the summer quarter. It was not a popular subject.

Theoretical Chemistry is the subject for this quarter. It is popular with most of the boys. Practical chemistry must wait for the completion of the laboratory.

**Question 9.** What weight is assigned to scientific attainments in determining a boy's position in the school?—The amount of acquirement would not at present justify us in attaching any weight to scientific attainments for determining the position in the school, but as we make advance this will be remedied.

#### Methods of Teaching

**Question 10.** What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?—Each form has two lessons a week, each lesson being of one hour's duration.

(b) Book work?—For the senior boys. Two lessons in succession are devoted to oral teaching and demonstration. The rest of the time is occupied in answering questions, oral and manuscript. For the junior boys. One hour of oral teaching and demonstration. Half an hour of book work. Half an hour of questions, oral and manuscript.

(c) Practical work?—  
**Question 12.** How are text books used? e.g. Is book work supplementary or preparatory to the oral lesson?—Text books are used as supplementary to the oral lessons.

**Question 13.** Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Short notes may be taken during the lesson. At the end of the lesson, time is allowed for enlargement. The notes are then looked over and corrected by the master.

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—No facilities as yet for practical work.

**Question 15.** Describe any method of teaching some special branch of science which has been found successful in your school?—The natural science master finds that the plan above given is effective; but he wishes for the addition of opportunities of practical work.

#### Instruments of Teaching.

**Question 16.** What special provision (e.g. laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

As yet only a lecture room, with a limited chemical apparatus.

**Question 20.** What text-books are in use, distinguishing between those for the junior and senior classes?—Senior and junior, Oliver's First Lessons in Elementary Botany. Senior, Roscoe's Chemistry, junior, Barff's Introduction.

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—There will be a good supply in the general library.

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—No.

#### Tests of Progress.

**Question 23.** How often is the work tested?—Frequently.

**Question 24.** In what way? e.g., by examination of note books, or by oral or written questions?—By revision of note books, and by oral and written questions.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—By the Natural Science master.

It is contemplated that the school shall be examined by a duly qualified person from the outside.

#### Teachers

**Question 26.** Is there any difficulty in procuring competent science masters?—I have found none as yet. I know that this subject (i.e. the provision of qualified masters) is receiving attention at Cambridge.

**Question 27.** Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—The Natural Science master now at Charterhouse came from the London University, and was trained under Dr Williamson.

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?—The value of evidence in such a case depends on the character of the person by whom it is tendered. But I presume that no one would appoint a master merely on testimonials, without holding some communication, by speech or letter, with the writers of such documents.

**Question 30.** Are any special rewards or encouragements (e.g., exhibitions, scholarships, or prizes) open to successful students of science in the school?—An exhibition is to be given annually for proficiency in Natural Science. It will be of the value of 80*l.* for four years, and may be held at an University or anywhere else, provided that the holder satisfies the governing body that he is engaged in preparation for some career in life which meets their approval.

**Question 31.** What improvements, do you think, could be effected in the teaching of science in your own school?—There is room for much improvement, as will be gathered from previous answers. Attempts are being made to promote advancement.

**Question 32.** What are the principal obstacles to the teaching of science in your own school?—I know of none but those that have been already specified.

**Question 33.** How could the Universities best assist science teaching in schools?—(1) By offering scholarships for competition.

(2) By training qualified teachers.

(3) By providing examiners.  
**Question 34.** Can you suggest any way in which Government could assist science teaching in schools, as, for example, by inspection?—I think that the governing body of the school, with the aid of duly qualified examiners, can do all that is required for the advancement of science teaching.

WM. HAIG-BROWN,  
Head-master.

November 4th, 1872

#### 12. CLIFTON COLLEGE.

##### General Arrangements.

**Question 1.** How is the school classified?—The school consists of three divisions:—

- 1st. The classical side, containing 229 boys.
- 2nd. The modern side, containing 110 boys.
- 3rd. The junior school, containing 114 boys.

**Question 2.** Is science a necessary part of the school course, or is it taught only in special forms or departments?—(1) Science is taught as an alternative for German in the VI and V., that is, the four highest forms of the classical side. These forms contain 99 boys, of whom 31 are learning science.

In the remaining forms of the classical side and throughout the modern side, as also in the two highest forms of the junior school, it is taught, as a matter of course, to our boys without exception.

This part of the school comprises 294 boys. In the three lowest forms of the junior school, consisting of 60 boys between 10 and 12 years of age, science is not taught.

(2) In the VI. and V. forms, both classical and modern, boys who show special taste for science or who are likely to require it for professional purposes, or for some competitive examination, are also taught in special classes so arranged as to form alternatives for some other parts of the school routine.

(3) There are also voluntary classes doing practical work.

in the Chemical Laboratory, Botany, Geology, Physical Geography, Zoology, and Physiology *Question 3. Copy of time table?—Time table as follows—*

**SCHEMA of WORK.**

Days.	Hours.	Classical Side.			Junior School.	Modern Side.
		Sixth and Fifth Forms.	Fourth Forms.	Third Forms.	Fourth Forms.	All.
Monday	9-10	Divinity.	Divinity.	Divinity.	Divinity.	Divinity.
	10-11	Classics or special science.	Classics.	Classics.	English.	History.
	11.15-12.15	Do. do	Classics	Classics	Arithmetic	Mathematics.
	4-5	Classics.	Drawing.	Physics	Classics	Physics
	5-6	Mathematics	French.	Classics		Mathematics.
Tuesday	9-10	Classics	Classics	Classics	Arithmetic.	Chemistry
	10-11	Do.	Do	History.	Classics.	French
	11.15-12.15	Do	Chemistry.	Classics	French.	German.
	4-5	Do.	Classics	Classics	Classics	History.
	5-6	Do.	Classics.	Classics	Classics	Mathematics
Wednesday	9-10	Classics	Classics.	Classics	Classics.	Classics (Latin).
	10-11	Do or special science.	Classics.	Classics	Geography	Mathematics
	11.15-12.15	Do. do.	Classics	French	Arithmetic.	Drawing
	4-5	German, or natural science.	Mathematics.	Mathematics	Classics	German.
	5-6	Mathematics	French.	Physical geography or botany	Classics.	Geography
Thursday	9-10	Classics.	Classics.	Classics.	Arithmetic	Physics
	10-11	Do.	Classics.	French.	Classics	Mathematics.
	11.15-12.15	Do or special science.	English and	English.	History.	French
	12.15-1.15	Do. do.	Mathematics	Mathematics	Classics	German.
Friday	9-10	Classics.	Classics and	Classics.	Classics	French
	10-11	Do or special science	history.	History.	French.	Classics (Latin).
	11.15-12.15	Do, or ditto.	Classics	Drawing	Classics	Chemistry
	4-5	History	Mathematics.	Mathematics.	Classics	Geography
	5-6	Mathematics	Classics.	Classics	Classics.	Mathematics.
Saturday	9-10	English	Mathematics.	Mathematics	Drawing	French
	10-11	French.	Physics.	Geography.	Physics, or physiology or botany.	Classics (Latin).
	11.15-12.15	Classics, or special science	Classics.	Classics.	Classics	German.
	12.15-1.15	German, or science.	Classics	Classics	Classics	English
Sunday	10-11	Divinity	Divinity	Divinity.	Divinity	Divinity

*Those on the Modern Side who do special science have about the same amount of special lessons as those on the classical, in addition to the four hours given above*

**Question 4.** Summary of hours per week given in each class to different subjects (if playtime is utilized for preparation or practical work, this should be shown separately).—

(a) *Classical side.* VI. and V., first and second division arranged according to proficiency in science.

Do. do. upper and lower IV do do.  
Do. do. do. III do. do.

Each division, two lectures every week

*Modern side* First, second, and third division arranged according to proficiency in science.

Each division, four lectures every week

*Junior school.* In one division, one lecture every week

*Special science classes.* Consisting of boys in the VI and V. forms, seven or eight hours of class teaching every week in addition to the lectures mentioned above.

*Voluntary classes*

(1.) Boys working in the chemical laboratory are obliged to attend not less than three hours every week; many go much more than that. The hours of laboratory work are generally taken from what in our terminology is called "out-of-school hours," designated in the question as playtime.

The remaining voluntary classes mentioned under question 2 generally meet once a week. In the case of Botany and Geology

the lessons are supplemented by excursions from time to time on half-holidays. In all the various classes the boys are expected to keep note-books, and to give some time to the study out of school, either as preparation for the lesson or in the way of reading afterwards. It should also be added, that of Voluntary Botany, Geology, and Physical Geography classes, it seldom happens that more than two are going on during the same term, that the Zoology and Physiology classes are confined to a small number of the senior boys, and that none of these voluntary classes involve any extra payment excepting the work in the chemical laboratory

We also possess a small physical laboratory in which a few boys do some work with the physical master, but this is not yet sufficiently organised for me to be able to report upon it more definitely

**Question 5** Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes?

		Boys.	Average age.
Classical VI. and V.	- 1st division	19	16
	- 2d "	12	16
" IV. "	- 1st "	24	14½
	- 2d "	43	14½
" III. "	- 1st "	33	14
	- 2d "	30	13

			Boys.	Average Age.
Modern side	-	1st	31	16
"	-	2d	36	15½
"	-	3d	43	14½
Junior school	-	one	54	12
Chemical laboratory	-	one	64	18 to 16
Botany class (voluntary)	-	average No.	12	15 to 16
Geology	"	"	11	15 to 16
Physical Geography	"	"	10	15 to 16
Zoology	"	"	4	17
Physiology	"	"	4	17

Question 6. Amount of knowledge required before the study of science is commenced?—The average attainments of a boy of 12.

Question 7. Is any alternative or choice of subjects offered?—It has happened in a few cases that we have allowed boys to do physiology instead of physics, or, when preparing for a Government examination, to confine their attention for a little while only to those branches of science which they intend to present for examination, but our rule is to make all boys in any particular part of the school do the subject prescribed for that division.

What departments of science are preferred?

a. By parents?—I have never consulted parents on the subject of their preference as between one branch of science and another, and I should consider their opinion as a general rule quite worthless.

b. By the boys?—The preference of the boys, so far as they state any, is generally determined by some accidental circumstance. I should say that, on the whole, judging by the examination papers which pass through my hands, boys find physics somewhat easier than chemistry, so that, of the two, the duller boys would probably be found to give the preference to the former study.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—To the younger boys we teach elementary physics, physical geography, or botany. These subjects have been taken in turn. The elder boys learn chemistry and physics. So far as I have been able to arrive at any definite opinion, I consider this to be the best arrangement of subjects from a purely educational point of view, provided that it is supplemented, as with us, by an elastic system of voluntary classes to facilitate the development of individual tastes.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—Marks are assigned for each hour of scientific work just as for any other kind of work, and on the same scale, our principle being to award a fixed number of marks for every hour's work whatever the subject.

#### Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

- Oral teaching and demonstration?—A precise and definite answer to a question of this kind is not very easy. All the lessons consist mainly of oral teaching combined with more or less demonstration, excepting, perhaps, some of the special classes in chemistry and physics in which it often happens that the lesson is chiefly catechetical or taken up with the working out of examples and propositions.
- Book work?—The boys are generally expected to read certain portions of the text book in use as a preparation for each lesson.
- Practical work?—Practical work is confined, for the most part, to the laboratory classes, botanical and geological examinations, and the manipulation of flowers in some of the botanical lessons.

Question 11. Which form of lesson is found to be most effective?—I cannot describe any single form of lesson as likely to prove very effective.

In teaching boys of ordinary ability who possess but little knowledge, it is necessary in the first place to lecture a good deal and to impress important facts, principles, and methods as distinctly as possible by illustrative experiments. Without such help, owing to the great want of imagination, many boys would not discover their own tastes, and such conceptions as they might derive from their reading or catechetical lessons would be extremely confused and indistinct; besides that, good lectures greatly facilitate the progress even of those boys. On the other hand, however, it is at least equally necessary to guard against the passive attitude of the learner who is merely or chiefly a listener to lectures. Thus, a good lecturer will always take great pains to keep his class alive by means of test questions, or by insisting on well written notes, or such other method as may be most conveniently applied. A good deal of the

scientific instruction which has hitherto been given in schools has failed, comparatively, as a means of educational training, simply from the fact of the teacher or lecturer having allowed the boys to be too exclusively passive and receptive.

Question 12. How are text-books used? e.g., Is book work supplementary or preparatory to the oral lesson?—In some cases the master gives his lecture, and requires his class to take notes, and then expects them to read certain portions of bookwork bearing on the subject, on which he questions them at the beginning of his next lesson, before proceeding to his new lecture; in others, the bookwork is prepared beforehand, and the lecturer applies his test questions as he proceeds with his lecture. In this respect the master uses his own discretion, and his choice, as between the two methods, is necessarily, to some extent, dependent on the age and proficiency of his class, and on the nature of the subject.

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Every boy is required to make notes in his note book during each lecture, and he may at any time be called upon by the master to produce this book as a proof of attention. In the special classes, where the numbers are comparatively small, the lessons frequent, the boys more advanced, and the method, consequently, more catechetical, the note book is not always so much used, but paper work, in some shape or other, takes the place of notes.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—This kind of preparation is chiefly confined to Botany and Geology.

Question 15. Describe any method of teaching some special branch of science which has been found successful in your school?—I consider that every branch of scientific teaching which we have tried has been fairly successful, quite as much so as could have been expected in the case of new studies. More particularly, I should speak of Chemistry and Physics as having proved a valuable addition to our school work in the middle and upper parts of the school, whilst the same may be said of Botany, Physical Geography, and Elementary Physics among the younger boys, and of Geology as taught to a voluntary class.

Our methods are, I hope, sufficiently indicated in my answers to questions 10 to 13.

#### Instruments of Teaching

Question 16. What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for Scientific Instruction, and how is it used?—Our special provision for science is as follows.—

##### (1.) For Chemistry.—

Lecture room to seat about 60 boys.

Laboratory adjoining, fitted up so that 14 to 16 boys can work in it simultaneously.

Instrument room and store room attached.

These rooms were built and fitted up at a cost of about 600*l.*, exclusive of chemical apparatus and material.

The average annual cost of this branch has been for lectures about 15*l.* during the last two years, for laboratory about 30*l.* each student.

##### (2.) For Physics.—

Lecture room to seat about 60 boys.

Small class room and store room adjoining.

Laboratory adjoining.

These rooms were built and fitted up at a cost of about 200*l.*, exclusive of apparatus and material.

The average annual cost of this branch has been about 30*l.* for the last two years.

##### (3.) For Elementary Chemistry and Physics, i.e. for continuous courses of Chemistry and Physics, in which the text books used are Roscoe's Primer and Stewart's Primer, the lecturer adding a good deal to what is contained in these books as he goes along.

For this part of our teaching I have fitted up a lecture table with cupboard, laid on the gas and water, &c., in one of our ordinary class rooms large enough to seat from 50 to 60 boys at an expense of about 8*l.* to 10*l.*

The master at the outset expended also for chemicals and apparatus, such as a pneumatic trough, large retort stand, gas jars, flasks, &c., the sum of 7*l.* 5*s.*

Some things which he only requires occasionally, such as air pumps, models of pumps, &c., he has hitherto borrowed from the Physics room.

He informs me, however, that with a grant of from 3*l.* to 5*l.* a year, he can keep up and add to his stock of material and apparatus, so as to be able, in the course of about two years, to do all he requires without borrowing anything.

Our experience in connexion with this room shows that elementary instruction in science can be carried on at a much cheaper rate than is generally supposed, provided that the teacher will take the trouble to think for himself and expend a little time in preparing apparatus from simple materials.

(4) Botanic Garden and Museum —

For a description of these I may refer to the last report of the master who acts as curator, contained in our Scientific Society's Transactions, Part II, pp 93-102. (Copy enclosed)

It is not easy at this early stage to calculate exactly the current expenses of museum and garden, but they need not amount to more than 50l to 60l a year

They have been furnished entirely by means of private subscriptions amongst masters, boys, and friends of the college, and donations from some public institutions

**Question 17.** Number of assistants and curators, and annual cost?—The question of cost has been answered above. The Natural History master acts as curator of museum and garden. In the way of paid assistance, he has about one third of the time of a boy, and a gardener about two days every week.

**Question 18** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c?—Answered above, as far as possible.

**Question 19** Is there a workshop? and if so, how, and for what particular purpose, is it used?—We have a workshop, of which I enclose a ground plan. This being too small for our purpose we are about to convert it into class rooms, and build another on a larger scale, of which I also enclose a plan.

The object of the workshop may be described as being (1) to teach boys the use of all the common mechanical tools; (2) to give them some knowledge of different kinds of material, as wood, iron, &c.; (3) to teach them practical carpentering, fitting, turning, forging, &c

The present shop contains (1) four large carpenters' benches, to accommodate 16 boys, (2) eight vices, with steel chisels and other requisites for fitting, &c., (3) a forge, with the necessary appliances, (4) three turning lathes, with one slide rest, for the turning of both wood and iron

About 50 boys work in it, at such hours as they can spare during out-of-school time, each boy paying a fee of 15s a term, or 2l. 5s a year, to cover the expenses of superintendence, instruction, and material

Joining the workshop is quite a voluntary matter, and any boy can take home anything which he makes there.

The cost of the building, which is quite a plain one, and the fittings, tools, &c. was something under 250l

The superintendent informs me that he estimates the cost of material used, with wear and tear of tools, at about 15s. per week

It may be added that any school will find a workshop to involve very little expenditure, as the superintendent will be able at such times as he is not occupied with the boys to effect a considerable saving by attending to repairs, the making of desks, forms, &c

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes?

(1.) Chemistry —

Roscoe is at present the book generally used but we are about to replace it gradually by Miller's Text-book of Inorganic Chemistry

Cooke's First Principles of Chemical Philosophy, for special classes.

Miller's Elements of Chemistry, for special classes.

Harcourt and Madan's Practical Chemistry, with MS. Notes, Tables, &c., supplied by the Master in the Laboratory.

Roscoe's Primer, for the youngest boys.

(2) Physics —

Deschanel's Natural Philosophy, in the Upper Class.

Todhunter's Mechanics, in the Upper Class.

Balfour Stewart's Physics, in the Lower Class.

Do do. Primer, for the youngest boys.

(3.) Geology —

Page's Small Handbook.

Jukes and Geikie.

(4) Botany —

Oliver's Botany.

Balfour's Outline.

(5.) Physical Geography:—

34784

(6) Zoology:—

Nicholson's Manual.

Physiology —

Kirke.

Rolleston's Forms of Animal Life

**Question 21** To what books of reference, other than ordinary school books, have the scholars access?—See the Library Catalogue, enclosed

**Question 22** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—We have a flourishing scientific society, consisting of about 70 members, managed by one of the members as president and a committee of boys. It has exercised a valuable influence by stimulating the taste and intellect, and giving much enjoyment to many boys who would otherwise have lived a very obscure and dull life in the school, whilst it has also been of use in helping to give something of an intellectual tinge to the ordinary intercourse and conversation of the boys. Such institutions prevent the athletic side of school life from becoming too exclusively predominant

For a further expression of my opinion on this subject I beg to refer you to the answers I sent to the Commissioners two years ago [See p .]

I enclose a copy of the transactions of our society, from which it may be seen how it is worked.

Tests of Progress.

**Question 23** How often is the work tested?—In addition to the usual examination at the end of each term, we test our science teaching by giving a printed paper of questions once in three weeks. Every boy who fails to obtain a certain proportion of the marks awarded to this paper is kept in the following half-holiday to go over the various questions with the master

The note books which the boys are required to keep are examined, either at the time of their examination or at such intermediate times as the master may arrange

These tests are of course not intended to obviate the necessity of catechetical questions with which a master begins his lecture, or which are interspersed by him in the course of his lecture.

If any lecturer once stops to ask a boy picked out at random to repeat what he has been saying during the last two or three minutes, he will soon learn the necessity of such parenthetic questioning

**Question 24** In what way? *eg* by examination of note books, or by oral or written questions?—Answered above.

**Question 25** By whom? by the teachers of the subjects, or by an independent examiner?—At the end of the summer term, which completes our school year, the work is examined by an examiner from the University

At the end of each of the other two terms the masters examine and report upon each other's work, it being a rule with us that where it can be avoided no one examines his own work. For the other examinations, to which I alluded above as held once in three weeks, the teacher sets and looks over the papers on his own subjects. This I consider necessary as a means of showing him where his teaching is successful and where and how it is failing. These papers with the marks and report all pass through my hands when they have been looked over by the master, before being given back to the boys

Teachers.

**Question 26** Is there any difficulty in procuring competent science masters?—Undoubtedly there is as yet great difficulty in procuring masters equal in all respects to the best classical masters, and this is likely, for some time to come, to add considerably to the drawbacks in the way of sufficient science teaching in schools.

**Question 27.** Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?—Oxford seems, as yet, to produce more men suitable for the work in a school like ours than any other single place, but they cannot be said to be in any way trained for their work, having, in fact, to learn their business when they come to us, and the Oxford system has, at best, this very grave defect, that the men who are trained in it are apt to take away with them very extravagant notions about the apparatus necessary for teaching science in schools. They might, with advantage, be made a great deal more capable of helping themselves.

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?—Evidence of success in teaching, and good University degrees, as at Oxford or the London University. The testimonials of individuals I have found to be of little value, as many scientific men who write them seem to have

but little idea of the requirements for success as a school-master

**Question 29** Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars?—Besides various successes of an inferior sort, our boys have gained within the last two years four Natural Science Scholarships at Cambridge, and three at Oxford.

(b) Influence upon the general studies and intellectual life of the school?—I consider that the introduction of science has not in any way interfered with the successful pursuit of the old studies, whilst many of our boys who have gained distinction in Classics or Mathematics have thus acquired a sound elementary knowledge of two or three branches of science, and many others have had all their powers stimulated by thus finding out that slowness in learning languages does not necessarily mean general stupidity. Thus, the number of boys who do nothing well, and have no intellectual interests, has been materially diminished, and the general tone of the school life has been raised in proportion.

**Question 30.** Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of science in the school?—A fair share of all our prizes and scholarships is awarded for proficiency in Natural Science.

**Question 31** What improvements, do you think, could be effected in the teaching of science in your own school?—This is a wide question. I hope to improve it by getting the masters to enforce their methods, by developing more fully the system of classification according to ability and proficiency, by giving more time to the study of particular periods of a boy's school life, and thus producing the acceleration of progress which comes of concentration. Thus, and in many other ways, I hope to make the teaching considerably more effective than it has been hitherto, though I am well satisfied with our results, considering all the obstacles that beset any branch of new learning.

**Question 32** What are the principal obstacles to the teaching of science in your own school?—I want of previous training or experience on the part of the masters, each one having to a great extent to discover his method by experiment.

2. The difficulties in finding sufficient time without displacing some other study which the boys cannot afford to give up.

3. The difficulties in the way of classifying boys according to proficiency, and arranging the teaching so that the boys may be kept as active as possible, and not remain simply passive listeners to a lecture.

The difficulty in the way of a progressive arrangement of classes, at least in a large school, is that it necessitates the teaching of several classes simultaneously, in other words several scientific masters, and several rooms fitted up with the necessary apparatus.

I have succeeded so far as to be able to teach three or four sets simultaneously.

4. The prejudice against a new study which, to some extent, lingers long in the minds of both men and boys.

5. The want of good and cheap text books.

**Question 33.** How could the Universities best assist Science-teaching in schools?—By offering more inducements to the study of Science, by endeavouring to train men more thoroughly for school work, and teaching them how good experimental lessons may be given without the most expensive apparatus, by encouraging the writing of good text books, by instituting examinations such as those asked for by the Head-masters Conference, and modifying their general curriculum so as to offer a fair field for these new studies.

**Question 34.** Can you suggest any way in which Government could assist Science-teaching in schools, as, for example, by inspection?—My own belief is that if an efficient system of University examination and inspection can be established for first-grade schools, i.e., schools naturally in close connexion with the Universities, it would be preferable to a Government system, as it would be much more conducive, as things are at present, towards conducting the different branches of education, and thus curing the greatest educational defect of our time.

The Science Department under Government might, however, be of great service, by cheapening still more the supply of books, diagrams, apparatus, &c.

**Question 35.** Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?—The only other remark which it occurs to me, at

this moment, to make is, that I believe it to be deserving of serious consideration whether the true mode of conducting the numerous studies which now claim a position in the school routine will not be found to be by concentrating the attention of the boys on a small number of subjects at one time, and arranging that the subjects shall succeed each other in some fixed order, the retention of what has once been learnt being secured as far as possible afterwards by periodical examinations.

I incline to the belief that this is the true method in regard to all the secondary subjects of a boy's education; in other words the true method of teaching Science, Modern Languages, &c. in the classical department of a school, and in the same way the true method of teaching languages in the Scientific Department.

Our present methods give great facility and readiness, but tend towards producing a certain superficiality of mind, so that I cannot help feeling that the method which I have indicated, besides lessening friction and giving the increased momentum which results from concentration, would be altogether a more wholesome educational process.

J PERCIVAL, M.A.,

Head-Master.

November 12th, 1872.

### 13. RUGBY SCHOOL.

#### General Arrangements.

**Question 1.** How is the school classified?—For teaching purposes, the school is divided into—

- (1) The sixth form and upper school.
- (2) The middle school.
- (3) The lower school.

Each of these divisions has its own separate classification for Mathematics, Modern Languages, and Natural Science, except the lower school, in which Natural Science is not taught.

**Question 2.** Is Science a necessary part of the school course, or is it taught only in special forms or departments?—In the middle school, Natural Science forms a necessary part of the course. In the sixth form and upper school, the choice is allowed between Science and German. In the lower school, Science is not taught at all.

**Question 3.** Copy of time table?—See copy of time table in "Science work" [Given in p. .]

**Question 4.** Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)—Each subject is taught by two lessons per week of about one hour's duration each. The amount and kind of preparation required, differs in different "sets." In some, note books have to be made up from rough material taken down during the lesson. In others, definite questions have to be answered in writing, from time to time, or a certain amount of book work has to be prepared upon which oral questions are put at the commencement of the lesson, before proceeding to fresh matter; or, occasionally, a combination of the latter two methods is employed.

**Question 5.** Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes?—There are 10 Natural Science Classes or "sets" in the whole school. Three in the sixth form and upper school, and seven in the middle school. The number of boys and average age in each set are given below—

#### SIXTH FORM AND UPPER SCHOOL.

	No. of Boys.	Average Age
Chemistry - - -	50	16½
Electricity - - -	17	16½
Heat and Optics - - -	22	17½

#### MIDDLE SCHOOL.

1st Physics - - -	20	16½
2nd Physics - - -	51	16½
1st Geology - - -	34	16½
2nd Geology - - -	24	16½
1st Botany - - -	22	15½
2nd - - -	24	14½
3rd - - -	30	15½

The staff of masters employed in teaching these 10 sets consists of a Senior Natural Science Master and four

Mathematical Masters who give a portion of their time to Natural Science.

(N B.—The question how many masters are actually employed in teaching Natural Science in this school has evidently been overlooked, but it certainly should be stated somewhere, and, probably, as well here as anywhere.

**Question 6** Amount of knowledge required before the study of Science is commenced?—As Natural Science is excluded from the lower school, a boy must at least have reached the standard of the middle school before commencing it. The only additional limitation is in the case of Physics in the middle school. At the end of the first year of a boy's work, he is allowed to choose between Geology and Physics for the second year's study. But he cannot take Physics unless he is fairly high in Mathematics. It should be stated that a certain amount of Arithmetical knowledge is absolutely required before a boy can enter the school.

**Question 7** Is any alternative or choice of subjects offered?—Answer in (2) and (6) partly.

As much elasticity as possible is given to the whole system of Natural Science work in the school, so as to enable a boy to take the subject he has the greatest desire to learn, e.g., in the selection of Chemistry, Heat, or Electricity, in the upper school.

What departments of Science are preferred?

a. By parents?—Chemistry and Geology are the only subjects that have been specially mentioned by parents, so far as we can learn.

b. By the boys?—On the whole, the boys have shown most inclination for Chemistry and Geology or Physical Geography, but in many cases Chemistry has proved a disappointment, in consequence of the difficulty of the numerical examples and problems, which take up much of the time of the class.

**Question 8** What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—The subjects vary according to the position of a boy in the school. In the sixth form and upper school, Chemistry and Physics are the only subjects taught, with the exception of a short course of Physiology. Under Physics is at present included Heat, Magnetism and Electricity, and Geometrical Optics treated experimentally. Our experience goes to show that Physics can be taught successfully to a larger proportion of boys than Chemistry. Indeed, it would seem that a boy requires an almost special turn of mind to grapple successfully with the ideas involved in chemical affinities and reactions. In the middle school, and therefore with younger boys, the teaching of Physics has been found to be less satisfactory than in the upper school. The subjects that have been tried are Hydrostatics and Pneumatics, with the elements of Heat, but, although most of the boys have shown considerable interest in the facts and experimental illustrations, the power of grasping the principles and applying their knowledge to easy problems has been acquired comparatively by few. At present, the greater number of boys in the middle school are learning either Botany or Geology. It is hoped that in time better arrangements may be made for carrying on the instruction in the Natural History side of Science after a boy has reached the upper school.

**Question 9** What weight is assigned to scientific attainments in determining a boy's position in the school?—The proportion of the marks for different subjects, both for terms' work and examination, is given below:

Upper School.		
	Terms' mark.	Exam. mark.
Classes and English -	39	33
Mathematics -	6	6
German or Natural Science -	3	3
French -	2	2
Middle School.		
	Terms' mark.	Exam. mark.
Classes and English -	36	33
Mathematics -	6	5
Natural Science -	4	2
French and German -	4	3

In the higher part of the school, a boy who shows ability may be allowed to drop verses, together with a certain amount of general classical work, and devote the extra time to Mathematics or Natural Science. The important fact is, that, by so doing, he does not lower his position in the school or lessen the chance of future promotion, as he receives a full equivalent of marks for actual work.

*Methods of Teaching.*

**Question 10.** What proportions of the lessons take the form respectively of—

- (a) Oral teaching and demonstration?—All the lessons in Natural Science are a combination of oral teaching and demonstration
- (b) Book work?—Book work is only supplementary to a lesson
- (c) Practical work?—In Botany actual dissection of botanical specimens by each boy is a regular part of each lesson. In the laboratory, of course, all the work is practical.

**Question 11.** Which form of lesson is found to be most effective?—A combination of catechetical lecture and lesson, the boys themselves being often encouraged to ask questions upon any points not clearly understood

**Question 12** How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?—Partly answered in 4. In no set does the master confine himself entirely to a text-book; it is regarded rather as affording the data upon which a lesson is founded.

Book work is always supplementary to the oral lesson.

**Question 13** Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—Only rough notes are taken at the time of the lesson. There is nothing like *dictation*. The notes are worked up more fully afterwards, and shown up about once every fortnight or three weeks

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—The boys frequently assist in lecture experiments, but they are not required to prepare them. In the botany sets they are encouraged to collect specimens to illustrate the lesson.

**Question 15** Describe any special method of teaching some branch of Science which has been found successful in your school.—(Mr. Kitchener has drawn up the following sketch of the method of teaching Botany in the school. Mr. Wilson's lecture on teaching Botany and Geology is enclosed, in which the special plan pursued in teaching Geology is described.—[See p. . .] The botanical teaching, commenced in 1864, has been conducted on a rather novel method. Flowers are at once placed in the hands of each boy, and the class are asked to make each his dissections and observations. No facts or inferences are admitted, but such as arise spontaneously from the class themselves. Terms are only supplied as the class feel the want of them, and the terms are, where possible, taught in their English form instead of in esopipedan words derived from Greek or Latin, or both. The study of the tissues is postponed till the time of the year when no flowers are obtainable, but it is found that, for educational purposes, the first term's course, in which the tasks of observation and description come fresh to the boys, is the most valuable in results. A description of a first lesson in this subject, as taught at Rugby, is given by Mr. Wilson in his essay "On teaching Natural Science in Schools," in the essays on a liberal education, pp 272-276. Where flowers are not obtainable in sufficient quantities for the class, use is made of large models by M. Aurnoy of Paris. The scheduling method (introduced by Prof. Henslow) is much used, but the schedules are filled up in English terms, and scope is afforded for any boy to remark upon any peculiarity which especially strikes him. The description of actual specimens, with the aid of a small microscope, forms part of every examination in botany.

*Instruments of Teaching.*

**Question 16.** What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used? (Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

The special buildings devoted to Science at Rugby comprise a laboratory, two large lecture theatres, apparatus room, and private laboratory. These are described with plan and interior view in "Nature," Vol I., p. 485, by Rev. T. N. Hutchinson, the Senior Natural Science Master. There is also a museum containing a very fine collection of geological specimens, a large proportion of them being local, and collected by members of the school, also a good collection of minerals and numerous rock specimens. Lastly, there is an observatory (described by Mr. Seabroke). The way in which the laboratory is used is described in Mr. Hutchinson's account of "Science work at Rugby," pp. 14, 15. (Copy enclosed [given in pp. . .]) The expense of erecting and fitting the suite of Natural Science Schools at Rugby was,

as nearly as we can estimate, 2,000*l.*, exclusive of apparatus. The annual expenses of the laboratory and lectures are met partly by special grants of money, from time to time, for general Natural Science expenses, and partly by a payment of from 10*s* to 15*s.* a term by each boy in the laboratory for his share of chemicals and the use of apparatus.

**Question 17.** Number of assistants and curators, and annual cost.—There is one assistant in the laboratory with a salary of 136*l.* per annum, and a boy to wash bottles, &c., at 3*s.* 6*d.* per week.

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?  
—The school is supplied with an exceedingly complete set of chemical, electrical, and magnetic apparatus. A moderate amount for hydrostatics, pneumatics, and heat, and something for optics. There are also numerous models and illustrations for mechanics and mechanism. The collection of diagrams, which have been prepared chiefly by the lecturers and their friends, is considerable. The following botanical diagrams are in use.—

	<i>£</i>	<i>s.</i>	<i>d.</i>
(1) Henslow's botanical diagrams	-	2	9
(2) Balfour's -	-	1	10
(3) Oliver's series of dried plants, illustrating the families, &c.	-	-	0
(4) Marshall's physiological diagrams	-	3	15

For physiology there is a fine collection of prepared specimens to illustrate the typical forms of animal life. For geology, use is made of a collection of photographs of rock scenery, &c. &c. Within the last two years a complete set of standard meteorological instruments has been purchased, and regular daily observations are taken and recorded by volunteers from the school.

With regard to cost, the apparatus at present in the school must have cost between 700*l.* and 800*l.*

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose is it used?—There is no workshop at present; but premises exist under the new gymnasium building, which it is contemplated might serve for that purpose.

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes?—In the Upper School the text-books used are—

Roscoe's Chemistry  
Ganot's Physics, for Electricity and Magnetism  
Deschanel's Natural Philosophy, for Heat  
Ary's Geometrical Optics.

In the Middle School—

Balfour Stewart's Physics  
Jukes' School Manual of Geology.  
Lockyer's Astronomy  
Oliver's Elementary Botany, and, for advanced reading,  
Asa Gray's Class Book of Botany, and  
Bentham's British Flora.

In the laboratory, the books used are Harcourt and Madan's Practical Chemistry and Fresenius's Qualitative Analysis.

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—The Arnold Library, the different house libraries, and a small collection of books on Natural History, &c., in the room belonging to the School Natural History Society.

See 22

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—Yes. The Rugby School Natural History Society founded in 1867. It consists this term (Oct 1872) of nine honorary members (chiefly masters of the school), 39 corresponding members (chiefly old pupils), 15 members (present scholars, who have been elected full members for work done), 62 associates (present scholars not yet promoted to full membership). The society comprises at present nearly one fifth of the school. It is worked (1) by public meetings once a fortnight, the exhibition of objects of interest, reading of papers by masters or boys, &c.; (2) by sectional meetings of boys of similar tastes, as, for instance, the Botanists, the Geologists, the Microscopists, meet for work or discussion; (3) by occasional (though necessarily rare) excursions from Rugby—this year we visited (1) Charnwood Forest, and (2) several factories at Birmingham; (4) by the use of a special room to which the society alone has access. In it are kept collections of insects, plants, &c.; dissections and skeletons arranged for study, and a library of books on Natural Science is being formed for reference. A report of the Society is published annually at Mr. Billington's, Rugby, price 1*s.* Influence on the boys.—The meetings show that the society is popular, as there are

generally from 70 to 100 present, but great difficulty is found in getting the boys themselves to take part in the meetings, whether by reading papers or sharing in discussion; hence, greater real good is done by the smaller sectional meetings. The society is found to be very valuable in bringing to the surface any boy who has a speciality, which, in the hurry of school work, might have escaped notice. Such a boy is found out either by being introduced by his friends or by asking questions, and the President then introduces him to the other boys in the school who have kindred tastes, and brings him under the notice of the master who has charge of his subject. It is found that the boys are delighted to be of any use, and will undertake any scientific drudgery suggested to them, provided they can be told that it will do some good. Good work is done in meteorological observations, recording of floral dates sketches of geological sections, &c. (Answered by Mr. Kitchener.)

#### Tests of Progress.

**Question 23.** How often is the work tested?—Frequently during the term and always at the end.

**Question 24.** In what way? e.g. by examination of note books, or by oral or written questions?—By examination of note books as well as oral and written questions.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—By the teachers of the different subjects, except at the end of the summer term, when the sixth form are examined in Natural Science by one of the examiners for exhibitions appointed by the University.

#### Teachers.

**Question 26.** Is there any difficulty in procuring competent Science Masters?—I have never had yet to make such an appointment, but I should not anticipate any difficulty greater than in other branches of study pursued in the school.

**Question 27.** Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—I do not think I could improve upon the teachers who might be selected from Oxford and Cambridge.

They have been specially trained as students. As teachers their proficiency has been attained by practice.

As students, the University curricula with professional guidance, and the competition for the various distinctions open to them, have given them the necessary training.

I would here observe that a mere chemist, geologist, or naturalist, however eminent in his own special department, would hardly be able to take his place among a body of masters composed of University men, without some injurious effect upon the position which science ought to occupy in the school.

I would add that it seems to me highly important that a school teacher of these subjects should be thoroughly practical in his knowledge, skilful in experimenting, and ready in devising simple and inexpensive lecture illustrations.

In preferring the two older Universities, I do so only by reason of their stronger general sympathies with public school teaching. I am aware that, if I merely wanted a highly scientific man in any branch, I might find him equally at Dublin, London, or a Scotch University.

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?—Tripos class lists, and other similar distinctions, such as those enumerated below, would guarantee adequate attainments. To this might be added contributions to scientific periodicals and the like.

The qualifications of teaching and maintaining discipline, which are usually more rare to find and difficult to test than those of pure science, can only be ensured as experience of the man is gradually formed.

Any difficulties arising under this head might, I think, be met by probationary appointments.

**Question 29.** Can you state any results of Science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars.

(b) Influence upon the general studies and intellectual life of the school.

(a) The Natural Science Honours at the Universities since 1867 are as follow:—  
1867. Natural Science Studentship, Christ Church, Oxford.

1868. Natural Science Scholarship, New College, Oxford.

1869. Burdett-Contant's Geological Scholarship, Oxford.

" Natural Science Scholarship, Merton College, Oxford.



1870. Natural Science Studentship Christ Church, Oxford  
 " A Whitworth Scholarship  
 " Two in First Class Natural Science School, Oxford.  
 " One in First Class Natural Science Tripos, Cambridge.  
 1871. Natural Science Studentship, Christ Church, Oxford  
 " Burdett-Coutts' Geological Scholarship, Oxford  
 " Natural Science Exhibition, St. John's College, Cambridge  
 " Scholarship for Chemistry and Physics, Royal School of Mines  
 " First Class Natural Science School, Oxford.  
 1872. Scholarship for Chemistry and Physics, Royal School of Mines.  
 " Minor Exhibition in Natural Science, Ball College, Oxford  
 " Four in First Class Natural Science School, Oxford.  
 " Natural Science Exhibition, St. John's College, Cambridge.

In addition to these several have passed the matriculation examination for the University of London, and others have gained admission to various colleges by taking up some scientific subject for examination in addition to classics, when their classical knowledge alone would have been inadequate

(b) See p 18 of " Science Work."

Question 30 Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of science in the school?—Numerous prizes are offered for success in various branches of science, viz

Physics	-	-	One prize of 3 guineas.
"	"	"	2 "
Chemistry	"	"	3 "
Geology	"	"	2 "
Astronomy	"	"	3 "
Botany	"	"	2 "
Practical Chemistry	"	"	3 "

Prizes are also given for the best collections of wild flowers, butterflies, and moths, and fossils, made during the summer vacation.

Question 31. What improvements, do you think, could be effected in the teaching of Science in your own school?—

Question 32 What are the principal obstacles to the teaching of Science in your own school?

Question 33. How could the Universities best assist Science teaching in schools?—I think in no way so effectually as by maintaining a high standard of teaching and examining so as to send us the best possible teachers and examiners

Question 34 Can you suggest any way in which Government could assist Science teaching in schools, as, for example, by inspection?—I should be averse to Government inspection of the school as a whole; and the inspection of a single department seems to me likely to be more fraught with injury than benefit to the school at large considered as a place of general education

Question 35 Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?—A scientific career, as such, opened to the aspirations of candidates, such as, I believe, exists in some countries, might probably influence for good both pupils and teachers, by giving a definite object with tangible results.

This might, perhaps, have come in under 34, as a possible function of Government

HENRY HAYMAN,

Nov. 27th, 1873.

Head Master

#### 14. UNIVERSITY COLLEGE SCHOOL.

MR. ORME'S ANSWERS.

IV. 5th Class: Chemistry and Physics, one hour and a half per week.

Upper 5th. Chemistry, one hour and a half per week;

Chemical Physics, one hour and a half per week;

Upper 6th. Chemistry, one hour and a half per week;

Practical Chemistry, one hour and a half per week

VI. So far as I am concerned no previous knowledge is required for the lower 5th, beyond a power of taking short undictated notes. For the other classes, boys are expected to have learnt decimals.

The boys in the lower 5th do not seem to derive much benefit from the knowledge they may have acquired previously in other subjects.

X. Except in the class of practical chemistry, the subjects are explained solely by means of oral teaching and

demonstration, no portion of any lesson being ever devoted to bookwork. But in "oral teaching" I include the explanation of those portions of science which the boys are expected, by the Universities, to know, but which are not capable of experimental proof in the class-rooms of a school.

Any difficulty which a boy meets with in the bookwork at home is explained to him when the lesson is over

Practical work is done only in the practical class, it is accompanied by oral teaching, and, occasionally, there is added such further demonstration as is considered necessary to supplement the experiments made by the boys themselves.

XI. Bookwork has been tried as an experiment, but with signal failure, it would undoubtedly be the most effective form of lesson if external examiners were employed, unless, perhaps, their examinations were carried *à voet coe* before the science masters

Oral teaching and demonstration are far more effective than unaided practical work; hence their fusion in the class of practical chemistry

Practical lessons are, of course, the best form, the only true form, but much less ground is got over by this method, though the knowledge thus acquired is at once more valuable and more lasting.

XII As books of reference, and to enable the boys to recover lost ground after absence. They are altogether supplementary to the oral lessons.

XIII Rough notes are taken during the lesson; these are copied out into a note-book afterwards, the apparatus being sketched

XIV. Whenever it is possible—considering the small accommodation—the boys prepare their own apparatus and experiments. They also learn how to make their own re-agents

XV. The only answer, short of an essay, is to teach them only what they can comprehend, and, of all experimental truths, those only which are capable of experimental proof in the class-rooms of a school

It follows, almost as a corollary, that a boy should not be expected to learn the whole of any one sub-division of a natural science

XVI. *Laboratory*, for practical work. Work done consists of—(1) Preparation of common gases, acids, and ordinary re-agents (2) Examination of their properties (3) Qualitative analysis in connexion with non-metallic elements

*Lecture-room*, with experimental table. Work done consists of—(1) Chemistry of non-metallic elements (2) Heat (3) Electricity and magnetism (4) A very little metallic chemistry.

XVIII. Apparatus very simple at present, there not being sufficient accommodation for anything costly. We have the College to fall back upon, however, and, through the kindness of Dr. Williamsom, apparatus is often obtained from that source

The sum allowed is not limited, to my knowledge

Anything really required is purchased without delay or hindrance of any kind

XX. Gill's Chemistry for Schools is used for upper 6, chemistry

Orme's Science of Heat for upper 5, chemical physics

But text-books are of comparatively little use unless the master takes the subject in the same order as he finds it in the book.

XXIII. About once a month.

XXIV. By written answers to questions dictated at intervals of about five minutes.

XXV. By the teachers.

XXXI. A smaller quantity should be taught, but more perfectly. It should be more general in character, and should take in more of the every-day life of a boy, so as to make him think of science despite himself

It should be, throughout, entirely experimental, to the total exclusion of theories except the few very simple ones, which a boy can easily grasp, and these only sparingly and at long intervals. Far more stress should be laid on the practical work. Boys should be taught some scientific facts much earlier than they are at present, certainly before 13 years of age. As the master stands now, boys are allowed to acquire unscientific habits of thought before they begin to learn science, and when they do begin, the master has not to teach them science, but to eradicate the evil effects of past neglect—to undo, not to do.

XXXII. The requirements of the Universities, especially the University of London, which prevent the adoption of the improvements mentioned in XXXI. The Universities require more than can be properly learnt by a boy of 16;

they require that knowledge to be very special in character, and not by any means to have any connexion with the daily life of the boy; he is asked about chemical substances which he may never see or hear of again for the rest of his life; they seem to lay more stress on theoretical than on experimental knowledge, judging from their questions and from the candidates who pass, indeed, the boys will often leave the practical class for the purpose of preparing for the examination. Lastly, they require an inordinate amount of knowledge in other than scientific subjects, so that a boy cannot well begin science before 14 years of age.

XXXIII By altogether revising the regulations for their examinations.

XXXIV Inspection of the ordinary kind, especially Government inspection, I should think would encourage that sort of teaching which temporarily shows the best results, viz, bookwork. The masters would teach to satisfy the inspectors, not so as to benefit the boys or advance the school in the estimation of the public.

*Chemical Theatre and Laboratory. Fittings.\**

It is necessary to divide the following account into two parts—

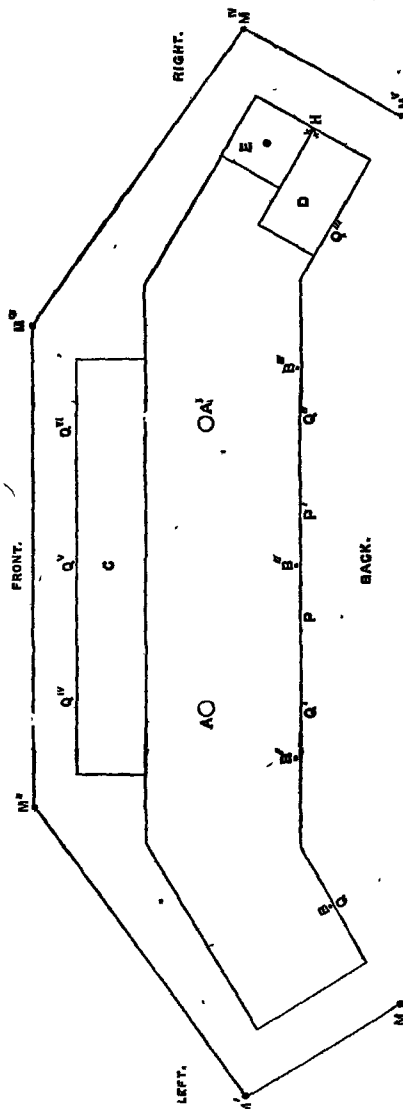
(A.) Those fittings which it would be highly desirable to have from the very commencement, regardless of those which may be put up hereafter as the necessity for them arises

(B.) Those fittings (selected from the above) which are absolutely necessary, with a very short account of makeshifts for the rest

(A)

1 Benches and Desks.—Three concentric arrangements of benches and desks within the hemicycle. Breadth of benches 9 inches, of desks 12 inches. A space of about 1 foot between each desk and next interior bench. Each bench to be raised at least 1 foot above the next interior bench

2 Lecture Table (see Sketch) —8 feet long parallel to the diameter of the semicircle, with two returns of 2 feet each, at an angle of 150° with the main body of the table.



Plan of Table, half on each to a foot  
 D Through with waste-pipe  
 E Sink  
 H Taps for water  
 M, N Uprights for rope or rail  
 O, P Cornices  
 Q, R Position of drawers

A, A' Doves draughts  
 B, B' Gas-pipes at edge of table.  
 C Specimen table.

\* Since this scheme was drawn up, the laboratory has been built, and some slight modifications have been made in the arrangements. The general plan, however, remains unaltered.

Breadth of table 2 feet 3 inches, height 2 feet 8 inches. The top of the table is to project about an inch over the face of the cupboard beneath; but there is also to be a groove along the surface all the way round,  $\frac{1}{4}$  an inch from the edge; this groove to be about  $\frac{1}{4}$  an inch broad and about  $\frac{1}{4}$  of an inch deep.

2a Drawers.—In the centre of the table (P and P') at least four drawers; if possible, two rows of three each. Each drawer to be about 2 feet long, 1 foot broad, and 3 inches deep.

2b Cupboards.—(Q, Q', &c.) to occupy the remainder of the space available for that purpose. These to be provided with one shelf about 1 foot above bottom of cupboard and coming to within  $\frac{1}{4}$  an inch of door; also with two sliding trays, 4 and 8 inches respectively from the top of the cupboard.

The cupboards should be as narrow as possible, say about 2 feet; the doors should revolve rather than slide, and the influx of dust should be prevented by having a protruding ledge within, which will overlap the cracks.

2c Trough (D).—In the right hand return, and at the back of the table, a pneumatic trough constructed of slate, dimensions, 1 foot broad, 1 foot and a half long, 1 foot deep. Interior to be quite plain, except that there must be a hole with plug at the bottom connected with waste-pipe. There should be a grating just below the tie plug to prevent stoppage, and a joint within easy reach.

The top edge of the trough (which will be about 1 inch thick) should be a little below the level of the table, and a wooden lid should be provided, which, when placed over the trough, will completely cover it and be flush with the table.

Tap (H) for water supply.

2d Sink (E) of glazed stoneware, 1 foot in diameter, placed in front of trough. Waste pipe and plug of stoneware, on account of acids, &c., joint within easy reach.

Tap (H) for water supply

2e Down-draughts (A, A') of glazed stoneware, to come out at right hand of furnace, where, on a level with the floor, a small air-tight door is provided, within which is a ring of gas jets; thence to pass into the flue of furnace.

2f Gas Pipes (B, B', &c.)—One pair in left-hand return and three pairs along the central portion. All these should be as close as possible to the back edge of the table.

3. Specimen Table (C), to be placed in front of lecture table. Length 6 feet, breadth 1 foot, height 2 feet. The upper surface will be used solely for the display of specimens.

3a. Cupboards, for storing apparatus, &c. Beneath this

table there should be a series of sliding trays, about 4 inches apart; doors to revolve; dust kept out as in 2b.

4. Rope and Uprights, round the lecture table and specimen table, as at M, M', &c., to prevent boys from coming near enough to handle specimens, &c. The uprights should be about 2 feet high, as far from the table as the benches in front will permit, and so placed as not to interfere with the cupboards, 3a. The rope should be removable at pleasure.

5 Blow-pipe Table, placed near the back wall on the left of the still (q. v.)

6. Slate, on movable frame and rollers, 4 feet square. Not black board.

7. Work Tables, 3 feet long, 1 foot 9 inches broad, 3 feet high. Upper surface of slate (if of wood, this to be quite plain, neither painted, paraffined, nor stained, &c.); groove as with lecture table, and to project 3 inches over the cupboards beneath; there is to be no partition between any two contiguous desks, since 7 a, b, d, and e will be quite sufficient to indicate the limits of each; but they should be numbered as indicated below.

7a. Cupboards.—Beneath each table, a cupboard similar to 2b; except that there should be only one sliding tray 4 inches from top, and two shelves, one of which is 1 foot from bottom and the other midway between this and the tray, both coming to within an inch of the door. The doors should work on hinges placed horizontally beneath the surface of the tables, so that they could not be left open, in case of necessity they could be looped up by a simple contrivance.

7b. Sinks, 1 foot in diameter, of glazed stoneware; waste pipes of same, with plug, beneath which is grating, joints within easy reach. One sink for every two tables.

7c Tap, for water supply, one for each table above sink.

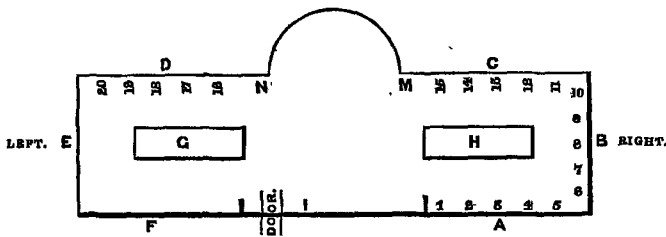
7d Gas Pipes.—One pipe dividing into two smaller ones (one for each table), placed alternately with the sinks. Also above each sink one fish-tail burner for lighting purposes.

7e Shelves. Four in number above each table; strongly fixed to the wall, about 4 inches deep. The first shelf to be 1 foot above table, the others 6 inches apart. The shelves of one table to be continuous with those of the adjacent tables, but to be separated from them by a narrow upright placed against the wall, these uprights may, but need not, come to the front.

7f N.B. Number and arrangement of work tables.

There will be space for the following—

Five each at A, B, C, D, E, and F, and 10 each a



G and H. At present not more than 20 tables will be required, these should be those at A, B, C, and D, and they should be numbered from A onwards in regular succession. There will be two spaces of about five feet each left at M and N; these will be appropriated as follows.—

8 Sink at N, on the left-hand side, with tap and arrangements for washing and drying bottles, &c.

9. Teacher's work table at M, on the right-hand side, 5 feet long, 1 foot 9 inches broad, and 3 feet high; cupboards beneath with revolving doors and two drawers about 4 inches deep. Desk grooved. Separate sink, tap, and gas supply (two gas pipes in middle, close to the wall, and one at each end). Shelves above to be the same as with the other tables. This table will be used for the preparation of class experiments.

10. Shelves for large apparatus, &c. Against the wall and extending as far as the structure will permit, all round the room (except over the furnace), there should be two firmly fixed shelves supported at intervals with strong brackets. The lower one to be about 1 foot above the top

shelf of the work-tables, and the other not less than 1 foot 3 inches higher. Depth about 8 inches.

11 Cupboard for specimens with glass doors fixed against the wall at a convenient height over the furnace. This cupboard should be very broad, and neither too high nor too deep, so that as many specimens as possible within it may be visible from outside, e.g. breadth 20 feet depth (internal) 6 inches, height (so that the top of it is) 9 ft. above floor. If it can be broader it can be lower in proportion, but the depth must not be less than 6 inches. If it cannot be so broad as 20 feet, it had better be a foot deep.

Uprights at intervals of 2 or 2½ ft. will serve to strengthen the shelves. The number of doors is immaterial. The shelves to be equidistant from each other, not less than 6 inches and not more than 8 inches apart.

12. Furnace and not a 6 ft. range, with plate and sand bath in the centre of the back wall. Facing the furnace there will be on the right of it the flue from the down draught of the lecture table. Still further on the right.

13. *Draught-cupboard* as long as possible, 2 ft. deep and 3 ft. high. Gas jet in flue at the back of a plate damper worked by pulley or spindle. The flue opens ultimately into the furnace flue.

14. *Stall*, on separate fire, to be placed on left of furnace and close to it. Stall further on the left will be the blow-pipe table.

15. *Gas burners* or chandelier to supply light during lectures on foggy days.

16. *Paint*, the last coating must be of zinc paint; the last two if not three coatings ought to be.

17. *Exercise chest*. A small wooden chest, similar to that in the mathematical theatre of the college, but with a sliding door which can be altogether removed at pleasure and containing about 200 partitions to be placed at the back of the class benches in the centre of the semi-circumference of the hemicycle. Each partition to be about  $2\frac{3}{4}$  inches broad, 4 inches deep and  $\frac{1}{2}$  of an inch high, ten in each horizontal row for the convenience of counting. The whole dimensions of the chest will, therefore, be about  $2\frac{1}{2}$  feet long,  $2\frac{3}{4}$  feet high, and 4 inches deep. To be placed about 3 feet above level of floor, so that an average boy can reach the top of it.

18. *Ladder*, self-supporting, and high enough to enable an average boy to reach the highest shelf in the room.

(B.)

Absolutely necessary—

The following —

1, 2, 2a, 2b, 2c, 2e, 2f, 5, 6 [7a, 7b, 7c, 7d, 7e], 8, 9, 10, 12, 13, 14, 15, 16, 18.

With regard to those omitted and group 7, 7a, &amp;c.,—

Makeshift for—

2d The teacher will have to go without till he can get one put in.

3 A plain wooden shelf, 6 feet long, 1 foot broad, fitted on the table at a height of 2 feet above the floor.

3a Go without till they can be obtained.

4 Do. do.

7, &c. If 20 cannot be put up, there should be as many as possible; and as the teacher's work table is indispensable, let those put up extend from it round the wall towards the furnace on the right-hand side of the room.

N B—The gas (7d) should be laid on, however, all round the room, and the shelves should be put up as described under 7e. The gas pipes round the room will be about 3 feet 1 inch above the floor.

As makeshifts for the remainder, the work-tables (so called) which have hitherto been used in the practical class; plain dissecting tables.

11 Almost indispensable, but the shelves (No 10) might be used for a time in place of the cupboard.

17 Go without till it can be obtained.

August 22, 1872.

*Remarks on Lecture Theatre and Laboratory of University College School.*

It is proposed to have the laboratory and the lecture theatre in the new building now being constructed in one, and besides a few minor reasons, mere matters of convenience—

(1) Because far more space will be thereby obtained for ventilating the lecture theatre, which would otherwise be of very small dimensions.

(2) Because in future boys will be able, if they choose, to work at their tables during wet weather in play time, or spare hours; the master being engaged in the preparation of class work in the same room.

(3) Because the laboratory will be larger than would otherwise have been the case.

(4) Because it is by no means improbable that laboratory work will become far more extensive than at present; it may, therefore, be necessary to convert the whole of the room into a laboratory, it would then contain at least 100 working-tables, and this could be effected at a slight expense; a small lecture room, or even two, could be fitted up at a moderate expense, and no inconvenience would then arise from the rooms being separate, for under the supposed circumstances the staff of sciences masters would be greater than at present is found necessary.

MR. J. J. WALKER'S NOTES OF REPLIES TO THE ROYAL COMMISSIONERS ON SCIENCE INSTRUCTION as regards the TEACHING OF NATURAL PHILOSOPHY :

*i.e., Experimental Mechanics, Hydrostatics and Pneumatics and Optics.*

X. (a.) All the instruction is oral; the lessons are alternately devoted to experimental demonstrations of general principles and to the working of illustrative exercises and problems on, or deductions from, these principles.

(b.) No books are used. Boys often ask for a book to be recommended, mostly such a one as shall be of most use in preparing for the matriculation examination of London University. They are advised to rely on their attentive observation of, sketches of the arrangements of the simple apparatus employed in, and careful notes on, the experimental demonstrations of all the fundamental principles of the parts of science which form the school course as actually exhibited.

(c.) Very little "practical work" is found possible under existing arrangements, and that is confined chiefly to the determination of specific gravity, actual observations and measurements for establishing the laws of reflection and refraction of light, and the effects of angle, or combinations of, lenses and prisms, as also rhombs of Iceland spar. In planning the rooms now in course of construction, the extension of practical instruction has been provided for, to be limited only by the time at command.

XI The best—indeed only thoroughly satisfactory—results are found to follow in the case of those boys who have not depended on books at all, but solely on the oral lessons and demonstrations.

XII. See answers to X. (b.) and XI.

XIII (a.) The making notes is insisted on; they are in fact skeletons of the lessons, with sketches of the apparatus as actually used. Formal statements, or enunciations, of fundamental principles are usually dictated by the teacher, where precision of expression is of essential importance, but this always follows, and is aimed at being made to take the shape of deduction from, the previous experimental demonstration.

(b.) It is required that the notes should be revised (at home) after each lesson, and, if only roughly taken down at the time, copied fairly.

XIV. Under existing arrangements they do nothing of this kind.

XV. The nature of the subjects precludes the possibility of introducing any air of originality in the teaching, unless it may be in small details in which the common experiments, as usually described in books, are varied so as to baffle any attempt to repair, by cramming from books, inattention to what has been presented to observation. If any part of our course might be specialized, in answer to the question, it should, perhaps, be the practical knowledge the boys get of the nature of images formed by single, or combination of, lenses, by viewing all the varieties directly with the eye or by means of the screen. This practical study of the lens is always preceded by that of the prism, as an instrument for producing refraction only, subsequently as a dispersive instrument.

XVI. For some time the lecture room (fitted with presses for containing apparatus and materials, a lecturing and working table, with water and gas served, and furnished with the means of completely excluding daylight when required, during experiments on light) has only been free for the teaching of science during afternoon hours.

XVII. The apparatus at command is sufficient in quantity for teaching the leading principles of mechanics, hydrostatics, pneumatics, and optics, but the greater part, bought some 15 or 20 years ago, is of a cheap description and consequently not as delicate or productive of as exact results as might be desired. Two years since the Committee of management authorized the outlay of from 15*l.* to 20*l.* in replacing some of this by improved apparatus, and about half that sum was actually expended in the department of optics chiefly, further outlay having been deferred until the completion of the new rooms. If the instruction of classes of from 20 to 25 were to become practical, a considerable increase in the quantity of apparatus would be necessary, but this chiefly of the less expensive parts. There is a small collection of well executed diagrams of sections and parts of the principal machines, and of some scientific processes of manufacture. It should be added,

that such parts of the apparatus provided for the college professor as can be moved without risk of injury are available for school use.

XIX. There is no workshop for the use of the boys. Such repairs or modifications of the apparatus as appear necessary or desirable during its arrangement for each lesson, and which can be executed with common tools in a few minutes, the teacher does for himself. When repairs of more importance are required, the services of the assistant of the college professor are available, or those of the carpenter of the college.

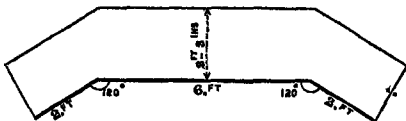
XXIII to XXV. By oral questioning, more or less, at every lesson. The demonstrations are, as much as practicable, drawn from the boys themselves by questions more or less "leading." The last two lessons of each month are devoted to a written examination, upon the results of which, chiefly, the "progress" of each boy is reported and his "place" in the class fixed. The note books at the same time are inspected and commendation for these given under the head of "diligence." If special occasion should seem to arise, the notes of particular boys are demanded for inspection at the close of the lesson, e.g., in the case of any whose manner, or failure to answer the oral test questions put during the lesson, should indicate deficiency of attention. These tests are exclusively applied by the teacher of the class, and form the most laborious part of his work.

XXXIII. Every improvement the Universities introduce into their examinations must be attended with improvement in our teaching, e.g., if the examinations of the University of London became partly practical in all departments of science, as they are, for instance, at University College in the case of botany, classes under instruction would be stimulated to much greater interest in, and attention to, the details of arrangement and manipulation of apparatus, and the substitution of practical instruction for teaching by the exhibition of experiments only must soon follow.

UNIVERSITY COLLEGE SCHOOL NATURAL PHILOSOPHY THEATRE FITTINGS.

1. Three concentric arrangements of benches and desks within the hemicycle. The breadth of benches 9 inches, of desks 12 inches. It is desirable that there should be a space of about 1 foot between each desk and next interior bench in order to allow of the master passing round to examine the pupils' work in the exercise class. It is very desirable that each bench should be raised at least 1 foot above the next interior bench, in order to give a clear view of the experimenting table to all.

2. The lecture table should be 6 feet long, parallel to the diameter of the semicircle, with two returns, at an angle of about 120° of about 2 feet each. Breadth about 2 feet 3 inches; height, 2 feet 6 inches; thus —



3. Under the tables should be cupboards in preference to drawers, but it would be convenient to have an upper drawer, about 4 inches deep, in each return. One shelf (besides bottom) would be sufficient. It would be convenient if the top of the table projected about three inches over the face of the cupboard.

4. Behind the table, of course, will stand the black-board or slate on a moveable frame. Dimensions 4 feet by 3.

5. Against the back wall a press about 7 feet high, 4 feet wide, and 2 feet deep.

6. Between the lecture table and the back wall four tables each, from 6 to 7 feet long, 2 feet 3 inches wide, for pupils' practical work. It might be desirable, in view of the possible appropriation of the theatre to examination purposes occasionally, that these should be moveable, or having feet screwed into the floor only.

7. It is understood that water would be laid on over a small trough or sink, and gas brought to the table.

8th July 1872.

34734.

FORM of MONTHLY REPORT.—UNIVERSITY COLLEGE, LONDON. SCHOOL.

—'s Report for the Second Month of Michaelmas Term, 1872.

Rank of Class.	Subject.	No of Boys in Class	Average Place.	Conduct.	Diligence	Progress.
	Greek - - -					
	Latin - - -					
	Latin Exercise -					
	Hebrew - - -					
	French - - -					
	German - - -					
	Italian - - -					
	Spanish - - -					
(Morning)	English - - -					
(Afternoon)	English - - -					
	Grecian History -					
	Roman History -					
	English History -					
	Geography - -					
	Social Science -					
	Chemistry - -					
	Chemical Physics -					
	Natural Philosophy -					
	Astronomy - -					
	Applied Mathematics					
	Trigonometry, &c. -					
	Algebra - - -					
	Geometry, Plane -					
	Geometry, Practical -					
	Mensuration - -					
(Morning)	Arithmetic - -					
(Afternoon)	Arithmetic - -					
	Book-keeping - -					
	Writing - - -					
	(Freehand) Drawing - -					
	Perspective - - -					
	Model Drawing - - -					
	Mechanical Drawing - -					

No. of times late at beginning of—  
 Morning Afternoon; M, Th. T F. W. S.

## SYMBOLS.—

1="Very Good." 2="Good." 3="Tolerably Good."

To express decided blame, a *verbal* entry is used, unaccompanied by a symbol.

When a boy is about to leave the school, a written notice to that effect must be sent to the secretary before the end of the last term of his attendance. In case of omission to give such notice, the payment of a half term's fee will be enforced.

The school breaks up for the Christmas holidays on Wednesday, 18th December, at 12.30.

SCIENCE CLASSES.—PROGRAMME OF WORK.  
CHEMICAL PHYSICS.

## TEXT-BOOK.—ORME'S "INTRODUCTION TO THE SCIENCE OF HEAT."

1st Term.—General properties of matter. Molecular forces. Metric system (introd.) Heat and cold (general notions). Expansion (Chap. I). Expansion of solids; metallic thermometers and pyrometers, relative weight (II). Conduction of heat (III). Expansion of liquids, thermometers; relative weight; barometer (IV).

2nd Term.—Expansion of gases, air thermometers; thermoscopes, convection of heat, absolute and relative weights of gases and vapours (V). Evaporation; potential heat; vapour tension. Liquefaction of gases; hygrometry (VI). Liquefaction of solids; freezing mixtures (VII). Effects of heat (VIII).

3rd Term.—Relative heat (IX). Theories of heat; laws of energy, work; mechanical equivalent of heat-unit (X). Relations between heat and chemical force (XI). Radiation, ether; theory of exchanges; formation of dew, diathermancy; transmission and absorption of heat (XII). Voltaic electricity. Electrolysis. Electro-magnetism. Ampère's theory. Magnets. Magneto-electricity. Electric telegraph. Frictional electricity. Leyden jar. Ohm's law.

The extent to which electricity and magnetism are treated depends upon the previous progress of the boys.

## CHEMISTRY.

## CLASS V

1st Term.—Examination of some natural phenomena: Evaporation, liquefaction, melting, and freezing; clouds, rain, snow, fog, &c.; expansion; thermometers; conduction and convection of heat; relative weights of liquids and gases; air and atmospheric pressure; the barometer; combustion or chemical combination; compounds and mixtures; chemical elements, respiration.

2nd Term.—Further study of the composition, properties, and uses of air and water oxygen, hydrogen, nitrogen; preparation, properties, and compounds of these elements. Animal heat, relative heat, potential heat.

3rd Term.—Practical study of the metric system; résumé of the work of the two previous terms; wood, coal, charcoal, coke, carbonic acid, coal gas, and flame, nitric acid, hydrochloric acid, and oil of vitriol, chlorine, sulphur, and phosphorus.

## CLASS V.—UPPER.

## TEXT-BOOK.—BARFF'S "INTRODUCTION TO SCIENTIFIC CHEMISTRY."

1st Term.—Oxygen. Hydrogen. Water. Nitrogen. Ammonia. Oxides of nitrogen. Nitrates. (pp. 1-26; 20; 98-119)

2nd Term.—Carbon. Hydrides and oxides of carbon.

3rd Term.—Chlorine, bromine, and iodine; their chief compounds. Carbonates. (pp. 27-38; 71-97; 121-160.)

4th Term.—Sulphur. Sulphides. Oxides of sulphur. Phosphates. Phosphorus. Phosphides. Oxides of phosphorus. Sulphates. Sulphites. Sulphuric acid. (pp. 166-205.)

Y

## CLASS VI.—UPPER.

## 1 Theoretical Course.

## TEXT-BOOK.—GILL'S "CHEMISTRY FOR SCHOOLS."

1st Term.—Oxygen. Hydrogen. Water. Nitrogen. Air. Ammonia. Oxides of nitrogen. Nitrates. (pp. 1-64; 131-166.)

2nd Term.—Carbon and its compounds. Chlorine, bromine, iodine, fluorine, sulphur; and their chief compounds. (pp. 213-252; 55-130)

3rd Term.—Phosphorus, arsenic, antimony, bismuth, boron, silicon, tin; and their chief compounds (pp. 167-212, 263-274). Principal properties and compounds of silver, mercury, lead, copper, iron, manganese, zinc, barium, calcium, magnesium, sodium, potassium.

The extent to which the metals are treated depends upon the previous progress of the boys.

## 2. Practical Course.

1st Term.—The metric system. Quantitative study of length, area, volume, weight, relative weight, and solubility; preparation of oxygen, hydrogen, water, ammonia, hydric nitrate; and examination of the properties of those bodies.

2nd Term.—Preparation of carbonic acid, hydric chloride, hydric sulphate, sulphurous acid, hydric sulphide; and examination of the properties of those bodies. Properties of nitrates, chlorides, iodides, carbonates, sulphates, sulphites and sulphides.

3rd Term.—Properties of phosphates, arseniates and arsenites, borates, silicates, of the salts of arsenic, antimony, tin, silver, mercury, lead, copper, iron, manganese, zinc, barium, calcium, magnesium, potassium, sodium, ammonium.

The extent to which the metals are treated depends upon the previous progress of the boys.\*

## NATURAL PHILOSOPHY (EXPERIMENTAL).

1st Term.—Properties of rigid matter. Inertia. Mechanical forces. Weight. Pressure. Tension. Reaction. Equilibrium of two, of three, forces. Resultants. Systems of parallel forces. Centre of weight. Stable and unstable equilibrium. Stability. Mechanical powers and simple machines.

Uniform velocity. Newton's first law of motion. Variable velocity and its measure. Atwood's machine. Mass. Momentum. Newton's second law. Uniformly accelerated movement. Laws of falling bodies.

2nd Term.—Oscillations. The pendulum and applications. Principles of clock and watch work. Newton's third law of motion. Impact and collision. Elasticity. The spring balance. The torsion balance. Circular movement. Work and energy, with principle of conservation of molecular forces. Capillarity.

Properties of fluids. Hydrostatic pressure. Pascal's principle. Hydraulic press. Surface of equilibrium. Levelling instruments. Archimedes' principle. Specific weight. Elastic properties of air and steam. Boyle and Mariotte's law. Engines and instruments depending on atmospheric pressure. Elementary principles of the steam engine.

3rd Term.—Vibrations. Outline of theories of sound and light. Laws of reflexion. Images formed by plane and spherical mirrors. Laws of single refraction. Total reflexion. The prism and dispersion of light. Images formed by refraction at the surface of water. Lenses. Simple microscope. Telescopes and eye pieces. The sextant. Camera obscura. Stereoscope. Elements of double refraction and of polarization of light. First principles of spectrum analysis. Rainbows and halos.

The lessons to be devoted alternately to experimental demonstrations and explanations of general principles, and to illustrative exercises on, and deductions from, these.

## MATHEMATICAL CLASSES.—PROGRAMME OF WORK.

## GEOMETRY.

## CLASS IV.—BEGINNERS.

## 1st Term.—Practical Geometry.

Such constructions as are required to work out the printed programme. Exercises involving the leading problems for home work, constructions drawn to scale, &c.

Three days a week for the first half term, two days a week for the second half term, when the class may begin.

\* This programme will not apply to work in the new building. Text-books of any kind are now (1873) no longer used, except that in the Practical Class, "Barcroft and Madan's Exercises" is recommended.

*Pure Geometry.*

(a.) Elementary notions. Straight lines. Angles. Properties of triangles (Wright's Plane Geometry, §§ 1-39).

2nd Term.—*Practical Geometry* One day a week.

(b.) Perpendiculars and obliques; equality of triangles; parallel lines; polygons; and easy exercises, pp. 12, 22, 30-39 (Wright, §§ 40-80) Two days a week.

3rd Term.—*Practical Geometry.* One day a week.

*Pure Geometry.*

(c.) Parallelograms; construction of triangles from given data, and other elementary problems, and exercises (Wright, §§ 81-86 126-134, or 138) Two days a week.

CLASS IV.—UPPER.

*Practical Geometry.* One day a week

*Pure Geometry.*

1st Term (b), running over (a) again.

2nd Term (c)

3rd Term (d) —Equivalence of rectilineal figures (Wright §§ 272-301, 307-311), with exercises. Plane mensuration.

CLASS V.—LOWER.

*Practical Geometry* One day a week.

*Pure Geometry*

1st Term (c)

2nd Term (d).

3rd Term (e).—Properties of the circle (Wright, §§ 87-125, 135-146, 302-306; and exercises). Plane mensuration.

CLASS V.

*Practical Geometry* One day a week.

*Pure Geometry.*

1st Term (d)

2nd Term (e).

3rd Term (f)—Ratio and proportion. Metrical properties of triangles and circles. Construction of proportionals (Wright, §§ 147-181, 201-224; and exercises). Plane mensuration.

CLASS V.—UPPER

*Practical Geometry.* One day a week during first term.

*Pure Geometry.*

1st Term (e)

2nd Term (f)

3rd Term (g)—Properties of similar figures. Regular polygons and their areas. Area of circle. Circular sectors and circular segments (Wright, §§ 182-200, 225-271, 312 to end). Plane mensuration.

CLASS VI

1st Term (f)

2nd Term (g).

3rd Term —Elements of solid geometry. Sphere, cone, and cylinder (see Rouché, livres v and vi.), Mensuration of solids

\* Two periods in each month shall be given to the solution of exercises with this class. The exercises to be worked out at home by the class from scant notes and shown at the next succeeding geometry lesson.

Syllabus of Work in Geometry.

CLASS.	1st Term.	2nd Term.	3rd Term.
Fourth (Beginners)	P <sub>1</sub> F <sub>2</sub> (a)	F <sub>1</sub> (b)	F <sub>1</sub> (c)
" (Upper)	F <sub>1</sub> (b)	F <sub>1</sub> (c)	F <sub>1</sub> (d)
Fifth (Lower)	F <sub>1</sub> (c)	F <sub>1</sub> (d)	F <sub>1</sub> (e)
" " " "	F <sub>1</sub> (d)	F <sub>1</sub> (e)	F <sub>1</sub> (f)
" (Upper)	F <sub>1</sub> (e)	L <sub>1</sub> (f)	T <sub>1</sub> (g)
Sixth " " " "	L <sub>1</sub> (f)	T <sub>1</sub> (g)	T <sub>1</sub> S
" (Upper).			

Plane Mensuration should be commenced with classes reading Wright (d), and be continued in the higher divisions as illustrative of the subject matter of the text-book.

P<sub>3</sub> stands for Practical Geometry three times a week.

(a) Wright, §§ 1-39

(b) " 40-80.

(c) " 81-86, 126-134, or 138.

(d) " 272-301, 307-311.

(e) " 87-125, 135-146, 302-306

(f) " 147-181, 201-224

(g) " 182-200, 225-271, 312 to end

L<sub>1</sub>, T<sub>1</sub> stand for Logarithms and Trigonometry, each one day a week.

S stands for Solid Geometry, as above.

ALGEBRA.

Syllabus of Work in Algebra.

CLASS.	1st Term.	2nd Term.	3rd Term.
Beginning Fourth	a	b	c
Upper Fourth	b	c	c
Lower Fifth	c	d	d
Fifth	d	e	f
Upper Fifth	e	f	g
Sixth	h	i	k
Upper Sixth			

(a) Elements, first four rules, with use of brackets, simple equations of one unknown quantity, and easy problems.

(b) Resolution into factors, G.C.M.; L.C.M., simple equations of one and two unknown quantities; easy problems.

(c) Fractions (easy); simple equations of two and three unknowns; square and cube root

(d) Fractions (higher), evolution; quadratic equations of one unknown, and easy problems; progressions.

(e) Simultaneous equations involving quadratics; ratio, proportion, variation.

(f) Notation; surds and indices

(g) Interest (without and with the use of logarithmic tables); annuities, indeterminate equations.

(h) Permutations and combinations; binomial theorem for positive integral exponent

(i) Binomial theorem (in its generality); multinomial theorem; Horner's method of solving equations and extracting roots.

(k) Practice in all the rules

N B—A letter accented thus (b) is intended to include practice in the earlier rules.

APPLIED MATHEMATICS.

1st Term.—Mathematical proofs of the principles of elementary statics and uniformly accelerated rectilinear movement. Examples and problems.

2nd Term.—Hydrostatics and pneumatics, as treated by elementary mathematics, with examples and problems. Repetition of, and advanced exercises in, the work of 1st Term.

3rd Term.—Geometrical optics. Statical friction. Couples and equilibrium of co-planar forces generally. Galileo's theorem. Impact and collision. Centrifugal force. Projectiles. Rectilinear vibrations. Simple pendulum. D'Alembert's principle, with easy applications. Problems.

UNIVERSITY COLLEGE SCHOOL.—MORNING TIME TABLE.  
Michaelmas Term, 1872.

PERIOD	I.			II.			III.			IV. (MON., WED., FRI.)			V. (TUES., THUR., SAT.)		
	Rank of Class	No of Boys.	Room.	Rank of Class.	No of Boys	Room.	Rank of Class	No of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys	Room.
LATIN CLASSES.	4b.	20	11	4b.	20	11	6a.	28	10	6a.	28	10	4a.	20	11
	4c.	20	11	4c.	20	11	6b.	28	10	6b.	28	10	4b.	20	11
	3a.	20	11	3a.	20	11	6c.	28	10	6c.	28	10	4c.	20	11
	Upper 2.	20	11	Upper 2.	20	11	7a.	28	10	7a.	28	10	5a.	20	11
	3c.	20	11	3c.	20	11	7b.	28	10	7b.	28	10	5b.	20	11
	2d.	20	11	2d.	20	11	7c.	28	10	7c.	28	10	5c.	20	11
	Upper 1a.	20	11	Upper 1a.	20	11	8a.	28	10	8a.	28	10	6a.	20	11
	Upper 1b.	20	11	Upper 1b.	20	11	8b.	28	10	8b.	28	10	6b.	20	11
	1b.	20	11	1b.	20	11	8c.	28	10	8c.	28	10	6c.	20	11
	1c.	20	11	1c.	20	11	9a.	28	10	9a.	28	10	7a.	20	11
1d.	20	11	1d.	20	11	9b.	28	10	9b.	28	10	7b.	20	11	
GREEK CLASSES	5a.	18	8	5a.	18	8	10a.	28	10	10a.	28	10	8a.	18	8
	4a.	18	8	4a.	18	8	10b.	28	10	10b.	28	10	8b.	18	8
FRENCH CLASSES	5a.	16	10	5a.	16	10	11a.	28	10	11a.	28	10	9a.	16	10
	4a.	16	10	4a.	16	10	11b.	28	10	11b.	28	10	9b.	16	10
	3a.	16	10	3a.	16	10	11c.	28	10	11c.	28	10	9c.	16	10
	2a.	16	10	2a.	16	10	12a.	28	10	12a.	28	10	10a.	16	10
	1a.	16	10	1a.	16	10	12b.	28	10	12b.	28	10	10b.	16	10
ENGLISH CLASSES	4a.	18	11	4a.	18	11	13a.	28	10	13a.	28	10	11a.	18	11
	1	20	11	1	20	11	13b.	28	10	13b.	28	10	11b.	20	11
MATHEMATICAL CLASSES	Upper 6.	10	N.	Upper 6.	10	N.	14a.	28	10	14a.	28	10	12a.	10	N.



University College School.—Morning Time Table. Michaelmas Term, 1872.—continued.

PERIOD.	I.						II.						III.						IV.			IV.			
	MON, WED, FRI.			TUES, THUR, SAT.			MON, WED, FRI.			TUES, THUR, SAT.			MON, WED, FRI.			TUES, THUR, SAT.			MON, WED, FRI.			TUES, THUR, SAT.			
	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	Rank of Class.	No. of Boys.	Room.	
GEOMETRY	Upper 5	7	R.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	5 a.	9	A.	—	—	—	—	—	—	—	—	—	5 b.	13	N.	—	—	—	—	—	—	—	—	—	
	5 (Euclid)	26	V.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Lower 5 a.	19	B.	—	—	—	Lower 5 b.	18	A.	—	—	—	—	Lower 5 c.	17	B.	—	—	—	—	—	—	—	—	—
	Upper 4 a.	17	P.	—	—	—	—	—	—	—	—	—	—	Middle 4 b.	15	B.	—	—	—	—	—	—	—	—	—
4 a.	23	X.	—	—	—	4 b.	19	B.	—	—	—	—	4 c.	23	A.	—	—	—	4 d.	18	N.	—	—	—	
4 a.	—	—	—	—	—	4 a.	23	N.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
ALGEBRA	—	—	—	Upper 5	14	R.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	—	—	—	5 a.	21	A.	—	—	—	—	—	—	—	—	—	5 b.	15	N.	—	—	—	—	—	—	
	—	—	—	Lower 5 a.	24	B.	—	—	—	Lower 5 b.	19	A.	—	—	—	Lower 5 c.	13	B.	—	—	—	—	—	—	
	—	—	—	Upper 4 a.	15	P.	—	—	—	—	—	—	—	—	—	Upper 4 b.	15	R.	—	—	—	—	—	—	
	—	—	—	4 a.	21	X.	—	—	—	4 b.	19	B.	—	—	—	4 c.	23	A.	—	—	—	4 d.	18	N.	
4 a.	—	—	—	—	—	—	—	—	4 a.	23	N.	—	—	—	—	—	—	—	—	—	—	—	—		
ARITHMETIC } CLASSES	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	26	R.	—	—	—	E.	
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Upper 2	23	A.	—	—	—	A.	
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	30	B.	—	—	—	E.	
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	7	H.	—	—	—	H.	
BOOK-KEEPING	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	27	P.	—	—	23	P.
WRITING	—	13	K.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

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APPENDIX TO SIXTH REPORT.

UNIVERSITY COLLEGE SCHOOL.—AFTERNOON TIME TABLE.  
Michaelmas Term, 1872.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION, ETC.

Period.	MONDAY AND THURSDAY						TUESDAY AND FRIDAY											
	I.		II.		III.		I.		II.		III.							
	Monday.	Thursday.	Subject.	No. of Boys.	Room.	Subject.	No. of Boys.	Room.	Tuesday.	Friday.	Subject.	No. of Boys.	Room.					
6	History Natural Philosophy (Exercises)	28 21 25	S W.	English	28	O	Applied Mathematics } Upper 6.	10	W	Geography Natural Philosophy (Experimental)	21 25 22	W. Y.	Arithmetic Chemistry (Upper 6)	17 18	V. Y.	Applied Mathematics } Upper 6.	10	W
5	History (a) Geography (e)	25 19	O M.	History (b)	24	S	History (c)	27	M	Geography (b) Eng. (c) 20 B Arithmetic (d)	20 22 25	M E. E.	Geography (a) English (d) Arithmetic (c) Arithmetic (d)	17 22 18 18	V. H. E. I.	Geography (d) English (e) Social Science Chemical Physics (Up-6)	21 16 27 27	V. O. I. F.
4	History (a) Geography (a)	21 22	R. A.	History (b) Geography (b)	23 14	D M	History (c) Geography (c)	29 14	O F	History (d) Geography (d) English (d) Eng. (g) 15 H	19 22 24 15	O Q. I. H.	History (e) Geography (e) English (e) Arithmetic (b) Arithmetic (d) Arithmetic (a)	17 27 22 22 22 21	S. Q. I. M. E. D.	History (f) Geography (f) English (e) Arithmetic (c)	16 22 22 22	B. M. I. I.
3	Eng. (c) 18 H Eng. (f) 22 B Arithmetic (e) Arithmetic (e)	18 22 21	H. B. I. D.	English (a) Arithmetic (b) Arithmetic (d)	18 25 25	J. X. E.	Arithmetic (a)	22	L	History (c) Geography (d) English (d) Eng. (g) 15 H	22 22 24 15	S. P. D. H.	History (d) Geography (d) English (e) Arithmetic (b) Arithmetic (d) Arithmetic (a)	17 18 19 21 21 21	O. M. I. I. E.	Geography (e) English (c) Arithmetic (c) Arithmetic (e)	17 24 19 25	I. C. H. E.
2	Geography (a) Arithmetic (a) Arithmetic (d)	17 22 24	P. G. I.	History (a) English (a) Arithmetic (b)	20 22 22	F. H. L.	History (b) English (b) Arithmetic (c) Arithmetic (d)	27 25 20 20	F. I. X. I.	History (c) Geography (d) English (d) Arithmetic (a)	22 22 24 24	I. I. G.	History (d) Geography (e) English (e) Arithmetic (b) Arithmetic (d)	17 22 22 22 22	O. M. I. I. I.	Geography (e) English (c) Arithmetic (c) Arithmetic (e)	17 24 19 25	I. C. H. E.
1	English Arithmetic (a)	22 13	J. I.	Geography Arithmetic (b)	22 15	J. G.	Arithmetic (c)	18	D	History Arithmetic (a)	22 13	F. I.	Arithmetic (b)	15	G	Arithmetic (e)	18	D.
	Writing (a) Writing (g)	22 22	K. F.	Writing (b)	22	K.	Writing (c)	22	K.	Writing (d)	22	K.	Writing (e) Writing (h)	22 22	K. F.	Writing (f)	22	E.
GERMAN CLASSES.	4 a. 2 a.	N C.	3 a. 3 a.	N G.	Upper 6 5 a. Upper 8	24 17 21	N C T.	4 a. 6 4 a.	20 11 16	N C T.	Upper 6 5 a. Upper 8	4 a. 6 4 a.	N C T.	21 22 22	N C C.	3 a. 3 a. 3 a.	22 22 22	N C C.

The Natural Philosophy Class consists of two Divisions, the one meeting during the hour of recreation, the other during the First Period of the Afternoon.

The Upper 6th Chemistry Class meets for Practical work in the Laboratory for two consecutive periods (=1 hour and a half) on Wednesday Afternoon.

The mode of classification adopted in University College School is explained in the "Special Prospectus," of which a copy is sent herewith.

It will be seen that each boy has his own programme of work, which, subject to the law of permutations, is not necessarily identical with that of any other boy.

The revision of all classes by promotion or degradation at the end of the session is universal. Each step, however, must be earned, that is, a boy must satisfy his master that he can and will follow the work of the rank of the class to which he is advanced.

Individual cases of promotion and degradation are of almost daily occurrence throughout the year. In future it is intended that no change shall be made during the last month of each term, but this will be the only limitation to the practice of *ad libitum* revision.

The advantages of the system are dwelt upon by the "School Committee" of the Council of the College in their recent report (*v. accompanying extract*).

The drawbacks are illustrated by a passage from Professor Key's report to the Council for the year 1853. (*Extract appended.*)

The School Honour List, now printing in a new form lately adopted by the Council, will show the exact programme of work of each boy attending the science classes, and his degree of proficiency in each subject of study. This is the nearest approach that can be made towards answering the Commissioners' questions.

It must be borne in mind that the school is not intended for boys above the age of from 16 to 17.

EXTRACT from the Report of the School Committee, adopted by the Council, Dec 7, 1872.

The Committee believe that this excellent state of things is to a considerable extent attributable to the system which prevails in the school of frequently revising the classification of the pupils in all the subjects of study, so that a boy is not, as in many public schools, kept for a long time in any class which is either too high or too low for him, but may at any time be removed from a class which experience has shown is not suitable for him to one adapted as closely as possible to his actual requirements. In this way the opposite evils of disheartening a boy or of making him careless are equally avoided, and his interest in every part of his work is constantly maintained.

EXTRACT from Professor Key's Report.

The problem of putting all the various classes together is one exceedingly intricate, and almost of a mathematical character, so that one head alone can successfully work it out, and that only when left to uninterrupted quiet. This will easily be understood when it is recollected that a given boy may have made such different progress in his several classes that it may be expedient, if possible, to place him in classes altogether incongruous for all his studies of mathematics, Latin, Greek, French, etc.

Form A.

UNIVERSITY COLLEGE, LONDON: SCHOOL.  
Programme of Work.

Boy's (1) Surname } \_\_\_\_\_  
and (2) Initials. } \_\_\_\_\_

MORNING.

Period.	M, W, F	Room.	T, Th, S.	Room.
1.				
2.				
3.				
4.				

AFTERNOON.

Period.	M, Th.	Room.	T, F.	Room.
1.				
2.				
3.				

Wed. \_\_\_\_\_  
Sat. \_\_\_\_\_  
"Between hours." \_\_\_\_\_

Form B.

UNIVERSITY COLLEGE, LONDON: SCHOOL.  
Programme of Work.

Boy's (1) Surname } \_\_\_\_\_  
and (2) Initials. } \_\_\_\_\_

MORNING.

Period.	M, W, F.	Room.	T, Th, S.	Room.
1.				
2.				
3.				
4.				

AFTERNOON.

Period.	M.	Th.	Room.	T, F.	Room.
1.					
2.					
3.					

Wed. \_\_\_\_\_  
Sat. \_\_\_\_\_  
"Between hours." \_\_\_\_\_

\*. Form B is for boys who attend different rooms, 1st period M Th. afternoons.

Form C.

UNIVERSITY COLLEGE, LONDON: SCHOOL.  
Programme of Work.

Boy's (1) Surname } \_\_\_\_\_  
and (2) Initials. } \_\_\_\_\_

MORNING.

Period.	M, W, F.	Room.	T, Th, S.	Room.
1.				
2.				
3.				
4.				

AFTERNOON.

Period.	M, Th.	Room.	T	F	Room.
1.					
2.					
3.					

Wed. \_\_\_\_\_  
Sat. \_\_\_\_\_  
"Between hours." \_\_\_\_\_

\*. Form C. is for boys who attend different rooms 1st period T.F. afternoons.

UNIVERSITY COLLEGE, LONDON.

SCHOOL

UNDER THE GOVERNMENT OF THE COUNCIL OF THE COLLEGE.

SPECIAL PROSPECTUS.

The object of the "specia prospectus," as distinguished from the "general prospectus," is to afford more detailed information to the parents of boys already entered in the school.

The paragraphs to which \* is prefixed occur in the general prospectus likewise.

The information that follows is intended to enable parents to gauge more accurately the attainments of their boys, to watch their progress, and to give instructions in due time as the season approaches for commencing new subjects.

Explanations are given with regard to the standard course of studies and sequence of subjects; the mode of classification, conditions of promotion, nomenclature of classes, and qualifications for admission into beginning classes, the requirements in respect of home preparation; and the regulations relative to school books and dinner tickets.

PROGRAMME OF THE NORMAL WORK OF BOYS IN THE UPPER SCHOOL.

SUBJECTS.	SESSION = Year.					
	First 10 years	Second 11 years	Third 12 years	Fourth 13 years	Fifth 14 years	Sixth 15 years
English	1	2	3	4	5	6
Arithmetic	1	2	3	4	5	6
Geography	1	2	3	4	5	6
English History	1	2	3	4	5	6
French	1	2	3	4	5	6
Latin	1	2	3	4	5	6
Drawing	1	2	3	4	5	6
Writing	1	2	3	4	5	6
German	1	2	3	4	5	6
Roman History	1	2	3	4	5	6
Mathematics (Pure)	1	2	3	4	5	6
Greek	1	2	3	4	5	6
Social Science	1	2	3	4	5	6
Astronomy (Elementary)	1	2	3	4	5	6
Chemical Physics	1	2	3	4	5	6
Greenland History	1	2	3	4	5	6
Chemistry (Theoretical)	1	2	3	4	5	6
Chemistry (Practical)	1	2	3	4	5	6
Natural Philosophy	1	2	3	4	5	6
Applied Mechanics	1	2	3	4	5	6

\* Boys are admitted to the upper school at any age under 15, if on examination found competent to enter. Applications for admission after that age are considered on their merits.

\* A boy entering the upper school at the age of 10 will, with ordinary industry, under favourable circumstances, have gone regularly through the entire curriculum of the school by the end of the session in which he completes his sixteenth year, and ought then to be qualified to pass the matriculation examination of the University of London, and to enter as a student of the college.

MODE OF CLASSIFICATION.

There is no formal division of the school into classical and modern departments.

Boys are examined at entry and classified, with a view to their requirements, in each subject separately according to individual proficiency. Thus the same boy may be classed high in one subject and low in another.

\* Parents are allowed to select the subjects in which their sons are to be instructed, as well subsequently as at entry. It is essential, however, in the former case, that their wishes should be made known before, or at latest, at the commencement of the session or term when beginning classes are formed. The head master, moreover, reserves the right of veto.

In most subjects beginning classes are formed as required at the commencement of each term.

Boys who purpose preparing for the matriculation examination of the University of London should give notice of their intention as early as possible.

Any subject can be omitted at the discretion of parents, provided that the filling up of the full period of the school hours is not thereby prevented.

The possibility of taking up the whole of the subject contained in the curriculum is of course subject to the limitation of school-hours.

The number of subjects taught in the junior classes is limited with the express purpose of preventing distraction.

The first day or two at the beginning of the session, which commences with the Michaelmas term, are necessarily spent almost entirely in the business of classification. The absence of boys at that time is a serious detriment to the whole school.

At that time each class below the sixth advances a step. Boys who are reported by their class masters as not having made sufficient progress during the foregoing session, lose their promotion and repeat the work of the previous year.

On the other hand, it is not unusual for boys of superior age, industry, or ability to be allowed to skip a class. Not unfrequently, in similar cases, two steps are taken, at intervals, in the course of a single session.

Boys who have already gone through the ordinary sixth classes, and who remain in the school for another year, either continue in the same classes or are formed into superior classes, distinguished as "upper" sixth. The "upper" sixth is thus virtually a seventh-session class.

The distinctions of "upper" and "lower" as applied to classes below the sixth, imply no difference of year, but simply signify that the general proficiency of the class in question exceeds or falls below the normal standard. This is generally accounted for by the time of the original formation of the class, according as it dates from the beginning of a session or from some later term.

Where there are several classes of the same denomination in one subject, the letters A, B, C, are added for distinction's sake. No priority of rank is implied.

The average number of boys in a class is about 20.

Latin.—It is considered an advantage in the case of boys under 11 years of age not to have commenced Latin before entering the school.

Greek.—Boys below the third class of Latin are not allowed to begin Greek. In regard to taking up this subject the initiative rests with parents.

German.—Boys below the third class of English and the third class of arithmetic are not allowed to begin German. In regard to taking up this subject also the initiative rests with parents.

Hebrew.—There is no fixed limit of age for beginning this subject. Boys are received at various ages and degrees of proficiency, according to circumstances.

Early English.—Boys wishing to compete for the annual prize offered to the school by the Early English Text Society for proficiency in this subject are formed into a voluntary class, meeting out of ordinary school-hours.

Mathematics.—Boys who have reached the fourth class of arithmetic (below which standard they are disqualified) are expected to begin mathematics, unless their parents object.

Applied Mathematics.—It is advisable to reserve this subject, where practicable, for the seventh session.

Chemistry, Chemical Physics.—Boys who have reached the fifth class of arithmetic (below which standard they are disqualified) are expected to begin these subjects, unless their parents object. It is, however, essential that they should join the classes from the time of their formation, and this will generally be at the beginning of the Michaelmas Term.

Practical chemistry is an essential part of the second year's science course in conjunction with theoretical chemistry. In exceptional cases only, as where a boy is preparing for matriculation, are members of the junior or first year's class allowed to attend the practical class.

Book-keeping is taught where desired, in a one-year course, to boys sufficiently advanced in arithmetic. They are required to be qualified for a fifth or, at lowest, a fourth class in that subject. The best time for commencing book-keeping is at the beginning of the last complete session of a boy's attendance at the school.

Writing may be continued when necessary, later than the fourth session, even during ordinary school-hours. There is likewise an extra writing class on the Wednesday afternoon, open to boys who are unable to attend at other hours, or who require special attention in this subject.

Drawing.—Drawing is treated as, to some extent, an essential part of education. The general system of teaching is arranged to meet, so far as practicable, the requirements of business and professional life. There are special classes for instruction in mechanical drawing. Promotion in the drawing classes is not confined to any particular session. A boy who produces a good drawing, provided his conduct in the drawing class gives satisfaction also, is advanced without delay to the highest class he is fit for.

Fencing and gymnastics can be commenced at any age without restriction.

Whilst most of the above regulations rest on principle, some have regard only to the general convenience of classification.

## HOME PREPARATION.

With a few exceptions (chiefly arithmetic and algebra classes, and some first-session classes in English subjects) every school class demands a certain amount of preparation out of school-hours.

\* A boy is expected to give to the home preparation of his lessons about two hours on an average every evening. The time will of course vary with the age of the boy. Below 12, an hour will generally be sufficient; above 15, more than two hours may be required. Where a much shorter or a much longer time than the average is actually bestowed, parents are earnestly recommended to consult with the head master upon the subject. Preparation out of school-hours on the school premises is wholly discouraged, except in the case of boys of undoubted industry. Copying exercises renders both giver and receiver liable to grave punishment.

It is impossible so to distribute a boy's time as to equalize absolutely the nominal amount of work to be prepared for the following day. Lessons will necessarily be more numerous on some nights than on others. But, as it is always possible to foresee the extra pressure, boys should learn to make provision accordingly. Many of the lessons follow in regular sequence, and are fixed in quantity: so that a boy may well anticipate on his slacker nights some of the work which falls on the busier ones.

It is of the highest importance that parents should familiarize themselves with the mode in which their sons' time at school is distributed, and so with the precise subjects of the lessons which have to be prepared at home each evening; and that, with the view of providing an additional incentive to steady industry, they should observe from day to day the actual numbers from which the "average place" in each class, as recorded in the monthly report, is deduced. This information is supplied by the "number register," which each boy is required to keep. A careful examination and comparison of the monthly reports will powerfully conduce to the same end, especially if accompanied by some specific acknowledgment or reward rising in proportion to their excellence. Reports containing throughout under the headings of "Diligence" and "Conduct," ("Progress" not included), the highest symbol, viz. "1" (= "Very Good"), are known as "Perfect Reports," and a record is preserved of boys obtaining them.

Boys are presumed to have fully prepared their home work, unless provided with an excuse.

A few words of explanation written on the parent's address card constitute the readiest and most convenient form of excuse. In the case of brothers, a separate card should be furnished to each boy.

All excuses must be countersigned by the vice-master, and parents are desired to grant them as sparingly as possible.

## SCHOOL BOOKS.

New books are furnished at the school, as required, to those boys whose parents desire it, much loss of time and misunderstanding being thereby avoided. It is desirable that all books used at the school, whether issued there or not, should be marked with the school stamp. Boys mislaying books or needing to have books bound, can be temporarily supplied with substitutes from the "loan library." No second copy of a book is issued without a written warrant from parents.

## DINNER TICKETS.

Boys wishing to dine at the school are required to provide themselves with dinner tickets. These tickets are supplied "between hours" in room L, on prepayment only.

Tickets are issued either singly or in sheets of twenty, ten, or five. By buying them in sheets, requiring their production at home, and intimating them, parents may secure their sons against all temptation to misapply the money given for payment.

To prevent the sale or transference of tickets from one boy to another, the name of the boy in whose favour they are issued must be inserted in each ticket at the time of delivery. The tickets are examined during dinner by the presiding master.

Unused tickets will be taken back, on the written request of parents, at a discount of twopence a sheet or part of a sheet.

Boys unprovided with money may borrow from the vice-master to the extent of the price of a single ticket. A specimen sheet of "Honour List" is given on the following page.

## USE OF THE TABLES.

The Tables show, term by term, for each boy —

(1) His subjects of study, and the rank of his several classes.

(2) The manner in which he acquitted himself at the examinations held at the close of the term, as evidenced by the number and degree of his honourable mentions.

(3) The numbers of exceptionally good monthly reports obtained by him during the term.

## (1.) Rank of Classes.

The rank of classes ranges from lower first, first, upper first (expressed in the tables by 1, 1, 1), up to lower sixth, sixth, upper sixth (expressed in the tables by 6, 6, 6).

It will be observed that in the case of certain subjects the rank of classes is not specified. In such instances the classes are either of *variable* rank or of *indefinite* rank. To the former category belong the following:—6 applied mathematics, 6 natural philosophy; 8 chemical physics; 5 astronomy, 5 Grecian history (ranked as sixth for sixth Latin boys only). Examples of the latter are social science, book-keeping, and writing.

The symbol — is employed to indicate *attendance* at a class, where this fact would not otherwise appear, as, for example, under the headings of natural philosophy and writing, and in the foot notes.

The rank of each boy's classes varies according to his proficiency in his several subjects of study.

Owing to the peculiarity of classification indicated, a boy's general standing in the school is not obvious at sight. To define this, the arrangement by so-called "forms" is introduced.

The "form" or *mean* position of each boy is determined by calculating the average rank of all his classes.

## (2.) Honourable Mentions.

Honourable mentions or "commendations" are of three degrees, viz. — "commended," "highly commended," "very highly commended" (expressed in the tables by C, H, V).

The "commendation" awarded to the first boy in the examination of any class, whether C, H, or V, is printed in larger type, thus, C, H, V.

In some subjects all classes of the same rank are combined for examination. The "commendation" gained by the first boy in such aggregate examinations is distinguished by larger and heavier type, thus, C, H, V.

Absence from examinations is denoted by the symbols \* and †, denoting respectively "wholly absent" and "partially absent."

Standing in the "term" column, these symbols apply to the examinations as a whole, elsewhere, the reference is limited to single specified examinations.

Absence from single examinations is then only indicated when commendations would in all probability have been earned.

\* rather than † is employed in the case of boys absent from all other examinations except those in which they obtained commendations.

## (3.) Monthly Reports.

In the last two columns of the tables are recorded the number of "perfect" reports and the number of "proxime" reports which a boy has obtained during the term. For each term three reports are given.

Monthly reports containing throughout, under the headings of "conduct," "diligence," the highest symbol, viz. "1" = "very good," are known as "perfect" reports. Those which, but for the presence of a single "2" = "Good," and have been "perfect," are recognized as "proxime" reports.



15. TAUNTON COLLEGE SCHOOL.

General Arrangements.

Question 1 How is the school classified?—Into upper, middle, and lower, each compartment being subdivided. The principle of classification is uniform, that is, there is no different arrangement of classes for different subjects; but each boy is placed according to his general fitness, and

his marks, in all the subjects taught, determine his position in his form.

Question 2 Is science a necessary part of the school course, or is it taught only in special forms or departments?—Necessary for all boys in the upper and middle schools.

Question 3 Copy of time table.—U., upper school; M., middle school.

		1st Hour.	2nd Hour.	3rd Hour.	4th Hour.	5th Hour.	6th Hour.
Monday	U.	Scripture	Mathematics Latin	Music	Mathematics Greek or German.	Greek or German. Chemistry	Botany Mathematics.
	M.						
Tuesday	U.	Mathematics	French	Latin	Mathematics	English	Greek or German.
	M.	French	Latin	Mechanics	Greek or German.	Latin	English.
Wednesday	U.	Practical Chemistry	Practical Chemistry	Scripture.			
	M.	Latin	Latin	Latin.			
Thursday	U.	Latin and Greek	Mathematics	Greek or German.	English	Latin	Botany.
	M.	Mathematics	French	English	Mathematics	Greek or German.	Chemistry.
Friday	U.	Mathematics Greek or German.	Latin Mathematics	Music	Latin Mechanics	Chemistry English	English. Latin.
	M.						
Saturday	U.	Mathematics	French	Latin and Greek			
	M.	French	Mathematics	Mathematics.			

Question 4. Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately)

In upper school:—

Scripture	-	-	-	2
English	-	-	-	3
Latin	-	-	-	5
Greek or German	-	-	-	4
Mathematics	-	-	-	7
Chemistry	-	-	-	3
Botany	-	-	-	2
Music	-	-	-	2
French	-	-	-	2
				30

In middle school:—

Scripture	-	-	-	2
English	-	-	-	4
Latin	-	-	-	6
Greek or German	-	-	-	3
Mathematics	-	-	-	6
Chemistry	-	-	-	2
Mechanics	-	-	-	2
Music	-	-	-	2
French	-	-	-	3
				30

Two papers in Latin, two in French, one in Greek or German, one in mathematics, and one in English, are done in the evenings of the week, and two hours a week are taken from playtime for the drawing classes.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes.

Advanced chemistry,	20 boys of about 16 years old.
Botany,	do. do.
Elementary chemistry,	50 boys of about 14 years old.
Mechanics,	do. do.

Question 6. Amount of knowledge required before the study of science is commenced.

The lower school has a weekly lesson with the headmaster on elementary scientific topics, introductory to the formal study of science.

For the commencement of the study no other condition is required than promotion into the middle school, which involves a knowledge of arithmetic to decimal fractions, and of algebra to simple equations.

Question 7. Is any alternative or choice of subjects offered?—No.

What departments of science are preferred?

a. By parents?—Having no option they manifest no preference.

b. By the boys?—In fact the most popular subjects are chemistry and botany. But I believe that this is due to the special enthusiasm displayed in teaching these subjects, not to any interest inherent in the subjects. The most zealous and effective teacher will make his own subject the most popular, or, teaching several subjects, the subject which he loves best.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—I have nothing to add to the answer just given.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—We have endeavoured to give exactly the same value in school marks to science, mathematics, and languages.

Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

(a.) Oral teaching and demonstration?—

Of physiology, at present the whole; of botany, one half.

Of chemistry, for the upper school, one third; for the middle school, the whole.

Of mechanics, the whole.

(b.) Book work?—

Books are used only out of school as an assistance to notes taken at the lectures.

(c.) Practical work?—

Physiology, at present none, but this is evil and temporary.

Botany, one half the time is given to dissections, schedule writing, and classification.

In chemistry, the upper school gives two thirds of the time to practical work.

Question 11. Which form of lesson is found to be most effective?—Practical work unquestionably, and we aim at extending it in all subjects as our means and our teaching power increase.

But, for junior boys, oral teaching and demonstration, accompanied by frequent examination, are, for some time, almost exclusively necessary.

**Question 12.** How are text-books used, e.g. Is book work supplementary or preparatory to the oral lesson?—Almost always supplementary. A boy uses his own text-book, or consults the larger works in the school library, in aid of what he has learnt in his last lesson, and towards its reproduction in the next.

**Question 13.** Is the use of note books encouraged (a) during, or (b) after the lesson, and to what extent?—Note books are used freely during the lessons, are used as text-books afterwards, and form the subject matter of periodical examinations.

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Very rarely between lessons, except in botany. In practical chemistry, each boy has his own apparatus and works his own experiments, but it is dangerous to give boys access to the laboratory without the presence of a master.

**Question 15.** Describe any method of teaching some special branch of science which has been found successful in your school?—A description of our botanical teaching, with copies of our schedules, list of natural orders, &c., is in the hands of the Commissioners. [See pp. . . .]

#### *Instruments of Teaching*

**Question 16.** What special provision (e.g. laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should if possible accompany this return.)

Probably the Commissioners will think that this question was sufficiently answered in my former communication. [See pp. . . .]

**Question 17.** Number of assistants and curators, and annual cost?—Probably the Commissioners will think that this question was sufficiently answered in my former communication. [See pp. . . .]

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—Probably the Commissioners will think that this question was sufficiently answered in my former communication.

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose, is it used?—Not at present; but I contemplate apparatus—

- (a) For turning
- (b) For casting and modelling
- (c) For microscopical mounting.

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes?—For seniors, Huxley's Physiology, Oliver's Botany, Landley's Descriptive Botany, Roscoe's Chemistry, Newth's Natural Philosophy and Mechanics, Twissden's Practical Mechanics.

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—

- a To Carpenter's Physiology, Cuvier's Règne Animal, the Ray Society's publications; many of the best works on Natural History
- b To Watson's Cybele, the works of Babington, Bentham, Balfour, Hooker, Sowerby, Moore
- c To the Microscopical Journal, the Micrographical Dictionary, many old and new works on the microscope
- d. To Miller's Elements of Chemistry, Ganot's Physics, Lardner's Handbooks, Harcourt and Madan's Practical Chemistry.

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—Not at present.

#### *Tests of Progress*

**Question 23.** How often is the work tested?—There are short examinations in the scientific work about once a month, longer papers in the examinations at the end of each half-year.

**Question 24.** In what way? e.g. by examination of note books, or by oral or written questions?—By written questions.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—By the teachers during the half-year, by independent examiners at its close.

#### *Teachers.*

**Question 26.** Is there any difficulty in procuring competent science masters?—

**Question 27.** Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?—

**Question 29.** Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars.

(b) Influence upon the general studies and intellectual life of the school.

**Question 30.** Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of science in the school?—I take care that at least one of the school prizes is given annually to some branch of science, but there is no special encouragement beyond this.

**Question 31.** What improvements, do you think, could be effected in the teaching of science in your own school?—

*First*, and by far the most important, the establishment of a science master. The subject suffers by being put into commission, however good may be the teachers who share it. It has been taken hitherto by the mathematical master and myself, and we have learnt, from our experience, that, of all possible topics of education, science most urgently requires a single representative professor, whatever aid he may receive from others.

*Secondly* Specially constructed rooms and much enlarged apparatus. Our laboratory is of the roughest, our museum cases, which are rapidly increasing, have no special home; we have outgrown our botanical garden, and we have no workshops.

The governing body of the school is keenly alive to our wants and eager to supply them; but the immense expense of new buildings has left them for the present without means, and though they will probably feel justified in shortly granting us a science master, I see no immediate prospect of the other improvements I have stated.

**Question 32.** What are the principal obstacles to the teaching of science in your own school?—Covered by the previous answer.

**Question 33.** How could the Universities best assist science-teaching in schools?—Most materially, by making a certain amount of science compulsory in the matriculation and little-go examinations.

Also, Cambridge might include science in the list of subjects on which the Syndicate offer to examine schools.

And Oxford might rescind the mischievous rule which limits junior candidates in the local examination to five optional subjects. A candidate takes up Scripture because he must, Greek, Latin, and mathematics, because they are supposed to count higher than anything else in the marks awarded. For the fifth subject there remain science, French, and German, and in all but a few cases French is preferred to science. Why should not all be taken if all are taught?

**Question 34.** Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?—For some years to come, until science is thoroughly established, I think an annual Government inspection, with grants or prizes of moderate value or a reward for attendance, would work exceedingly well. But I hope ultimately to see the day when all boys at all schools shall undergo a compulsory public examination in science, as in every other subject taught, at least once a year.

**Question 35.** Have you any other information to give, or suggestion to make, likely to be helpful to the Commission?—I venture to enclose a paper which I read ten years ago before the British Association. That paper brought upon me a great mass of correspondence, and made me acquainted with the feelings of a very large number of schoolmasters. In almost every case their communications tell the same tale, willingness to introduce science, absolute ignorance as to methods and systems, and eager desire for minute practical guidance from some



recognised authority I believe that a well-considered formula, laying down the hours demanded by science, the age when it should be commenced, the subjects to be taught, the order in which they must be taken, the text-books to be used, the apparatus necessary, would be immediately adopted and acted upon by a very large number of schoolmasters.

W. TUCKWELL,  
Head Master.

December 21, 1872

[See Supplementary Report in p. 199.]

### 16. KING'S COLLEGE SCHOOL, LONDON.

#### General Arrangements

Question 1. How is the school classified?

- (1) A. Classical Department.
- (2) B. Modern Department.
- (3) C. Preparatory or Lower school

The following is the distribution of the classes.—

Classical Side.	Modern Side.
Upper Sixth.	* Upper Sixth.
Lower Sixth.	* Lower Sixth.
Upper Fifth.	* Upper Fifth.
* Senior Matriculation Class.	* Middle Fifth.
* Junior Matriculation Class.	
Lower Fifth.	* Lower Fifth.
* Fourth.	* Upper Fourth.
	* Lower Fourth.
* Remove.	* Upper Remove.
	* Lower Remove.

Science Class.  
Commercial Class.  
Lower School.

\* Third.  
Upper Second  
Lower Second.  
\* Upper First.  
Middle First.  
Lower First.

The classes marked \* attend lectures on science and take up class-books on science.

Question 2. Is science a necessary part of the school course, or is it taught only in special forms or departments?

Science is a necessary part of the school course—

- (1) In the matriculation, fourth, and remove classes of the classical division.
- (2) In the whole of the Modern Department, excepting the commercial and special classes.
- (3) In the Third and Upper First classes of the lower school.

(a) The Elementary Physical Class is attended by the Fourth and Remove (A), the Upper and Lower Fourth, Upper and Lower Remove (B), the Third and Upper First (C).

(b) The Chemical Class is attended by the Matriculation Class (A), and Upper and Middle Mathematical Classes (B), and by a few boys who join for the Practical Chemistry.

(c) The Advanced Physical Class is attended by the First, Fifth, Upper and Lower Fourth Matriculation Classes (B).

Question 3. Copy of time table?

Question 4. Summary of hours per week given in each class to different subjects. (If playtime is utilised for preparation or practical work, this should be shown separately.)

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes.

- (1) Advanced class of natural philosophy.  
35 Average age, 16.
- (2) Chemistry class.  
64. Average age just under 16.
- (3) Elementary class in physics.  
160 Average age, slightly under 15.

Question 6. Amount of knowledge required before the study of science is commenced?

- (1) In the Elementary Class no special knowledge is required. It includes the bulk of the middle portion of the school.
- (2) In the Chemistry Class, boys must have done Euclid I., II., and algebra as far as simple equations.
- (3) In the Higher Physical Class, boys must have done Euclid I., II., III., and algebra as far as quadratics.

Question 7. Is any alternative or choice of subjects offered?—None, except in very special cases.

What departments of science are preferred?

a. By parents?

- (1.) Natural philosophy.
- (2.) Chemistry
- (3.) Practical work in the laboratories.

b. By the boys?

- (1.) Chemistry.
- (2.) Practical work in the laboratories and the workshop.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—Chemistry and natural philosophy.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—None in determining his position, but his marks for science are added to his class marks to obtain a prize.

#### Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

(a.) Oral teaching and demonstration?

In physical classes.

- (1) one lecture per week to each class, 1 hour and a quarter for higher classes,  $\frac{1}{2}$  of an hour for elementary classes.

- (2) In Chemistry Class, lecture and demonstration 1 hour

(b) Book work?

One hour and a quarter of book work with a class master.

(c.) Practical work?

20 boys do practical chemistry two hours per week. One special boy does considerably more during the week. A few boys go into the physical laboratory.

Question 11. Which form of lesson is found to be most effective?—Where the oral teaching of the lecturer is followed by the use of the text-book.

Question 12. How are text-books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—The text-books are used both for supplementary and preparatory work. The lecturer gives out the subject of the next lecture, and in the meantime the boys have to get up the subject in the text-book. They thus know something beforehand of the experiments which they see, and are also practised in working out chemical formulæ.

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?

- (a.) Every boy has to take notes of the lecture, and,
- (b.) From those he draws up a full account of the lecture out of school hours, and illustrates it with diagrams of the experiments. These "accounts" are marked according to merit.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—No boy is required to work experiments at home, but several do, and the demonstrator in chemistry assists them readily with advice, and supplies them with substances for testing, &c.

Question 15. Describe any method of teaching some special branch of science which has been found successful in your school.

*Instruments of Teaching.*

**Question 16.** What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how it is used?

(Plans and descriptions of these, with statements of their cost and annual expense, should if possible accompany this return.)

We have the use with the College of a third physical and chemical laboratory and three lecture rooms.

**Question 17.** Number of assistants and curators, and annual cost.

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose, is it used?—We have a workshop in common with the College. The regular workdays are the afternoons of the half-holidays, Wednesday and Saturday. The number of boys in attendance is 39. —Of these—

(a) 26 are engaged in wood-work, such as carpenters' and cabinet makers'.

(b) 6 do wood-turning.

(c) 7 are doing more advanced kinds of wood-work.

After completing a course in wood-work, they commence iron-work, and construct lathes and small steam-engines, boilers, and models of machinery of various sorts.

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes.

(1) For Chemistry—

Miller's Introductory Text-book.

Roscoe's Chemistry Class-book.

(2) For Natural Philosophy—

Ganof's "Physics."

Parkinson's "Mechanics."

Todhunter's "Mechanics."

Besant's "Hydrostatics."

Ferguson's "Electricity."

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—To the books kept by the senior mathematical master, and such books as they can get lent them at home.

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—No.

*Tests of Progress.*

**Question 23.** How often is the work tested?—By examination at the end of every term, and by questions at every lecture.

**Question 24.** In what way? *e.g.*, by examination of note books, or by oral or written questions?

1. By questions in lecture.
2. By examination of note books.
3. By written examination at the close of each term.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?

1. Both the Physical Science classes are examined by the lecturer himself.
2. In the Chemistry class—
  - (a) The lecturer examines at the close of term.
  - (b) A regular class master examines also each day.

As yet we have not employed an independent examiner.

*Teachers.*

**Question 26.** Is there any difficulty in procuring competent science masters?—The choice is very limited.

**Question 27.** Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?

**Question 28.** What evidence of scientific qualification rendered by candidates is found to be of most value?

**Question 29.** Can you state any results of science teaching in the school? such as—

- (a) Success, professional or otherwise, of individual scholars.

(b) Influence upon the general studies and intellectual life of the school.

1. A Natural Science scholarship at Christ's College, Cambridge.
2. Honours in Botany and Zoology at the London University.
3. Royal Exhibition at the School of Mines, and Exhibition of 50*l.* for three years.
4. Prizes and Exhibitions at King's College, London.
5. Science Scholarship at Owens College, Manchester.

**Question 30.** Are any special rewards or encouragements (*e.g.* exhibitions, scholarships, or prizes) open to successful students of science in the school?

A. Terminal prizes.

(a.) One to the best boy in each of the upper classes, rank being determined by the term's work and examinations.

(b) Three to the best boys in the large elementary class, one being selected from each of the three divisions, A, B, and C.

B. Annual prizes.

One for Natural Philosophy.

One for Chemistry.

**Question 31.** What improvements, do you think, could be effected in the teaching of science in your own school?—Improvements could be effected—

1. By the appointment of separate science masters for the school, independently of the College.
2. By the establishment of an independent laboratory, so that all who attend lectures and do the book work might also do practical work.
3. By the appointment of independent examiners to test the work.
4. By requiring of the lecturer in chemistry that he should also take the classes in their book work.

**Question 32.** What are the principal obstacles to the teaching of science in your own school?

1. The necessity of accommodating the hours of science lectures to the arrangements of the college.
2. The absence of science masters wholly devoted to the school and its interests.
3. The late age at which many boys join the school, especially the modern department.
4. The backward state in which they come to us.
5. The rapidity with which boys almost inevitably pass through the modern department.

**Question 33.** How could the Universities best assist science-teaching in schools?

**Question 34.** Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?—By donations of scientific books to form a school library of science, and scientific specimens and instruments of various kinds.

**Question 35.** Have you any other information to give, suggestion to make, likely to be helpful to the Commissioners?

G. F. MACLEAR, D D,  
December 21, 1872. Head Master

## KING'S COLLEGE SCHOOL, LONDON.

*ENGINEERING WORKSHOPS.*

1. Engineering workshops have been established for some years for the joint use of students at King's College and boys at King's College School.

2 They have recently been considerably enlarged by the addition of another floor for wood work, and have been also improved by the addition of a planing machine for metal work, and by the introduction of a steam engine.

3. The following is the general scheme of work:—

4 Students or boys of the first year, on joining the department, are made acquainted with the different tools, and their practical application to the purposes of carpenters' and joiners' work, by going through the processes

of preparing the wood, setting out and forming, from figured drawings prepared by themselves, the various joints used in constructions of wood, after which they are employed in making models in which the preceding joints are combined, so as to form frames for roofs, bridges, girders, and other framing, required for buildings and other purposes.

5. Students are then enabled in their third term to proceed with the construction of models of various sorts, in illustration of the different apparatus used in practical mechanics, manufactures, and philosophical experiments, which involve the necessity of turning, for which purpose they are instructed in the use of tools for turning soft wood, hard wood, ivory, and other substances, and also in the mode of preparing and fixing the work in the lathe. The formation of cycloidal, epicycloidal, and involute teeth, for wheels, pinions, racks, &c. They are also instructed in the method of working in sheet metals and soldering.

6. Second year's students commence metal work, the operations of which consist of the various processes of chipping, filing, fitting, turning, boring, screw-cutting, and planing, the construction of foundry patterns in wood or metal and core-boxes.

These students are also instructed in forging wrought iron and steel, and in Easter term a moulder attends who gives practical instruction in the art of moulding.

7. With proper attention to the foregoing routine of procedure, the students become sufficiently proficient to be enabled to make for themselves lathes, and the apparatus connected with them, tools of various sorts, working models of steam-engines, boilers, and other machinery, in the construction of which either metal or wood, or the two combined, are employed.

The third year's students continue the second year's subjects, and in addition they are encouraged to make experiments on the strength of arches, beams, and girders are constructed from working drawings made by the students themselves.

8. At the termination of the year a prize is given, in each year, for proficiency in the execution of some piece of mechanism, the subject of which is given out during the Lent or Easter term.

In order to obtain a prize in either the second or the third year, the student is required to send in with his model or machine a finished form, dry pattern, with core-boxes, &c., of at least one of the castings used in such machinery or models, which pattern he shall himself have made, accompanied by working drawings of such machinery, also made by himself.

Every student is expected to furnish himself with a set of the simplest tools requisite for working in wood and metals. In order to diminish the expense of these tools as much as possible, the student may purchase them at the College, and upon his leaving they will be repurchased from him at a reduction depending on the condition in which they are returned.

9. No student is allowed to obtain tools or materials in the workshop to a greater amount than 4*l*. in any one term, without the consent in writing of his parent or guardian.

#### REGULATIONS to be observed by STUDENTS in the COLLEGE WORKSHOPS.

1. No student is allowed to wear the college gown in the workshops, or a coat with long skirts or loose sleeves, or to work in shirt-sleeves without their being turned up so as to be out of the way. No aprons may be worn by students when using any of the machines driven by steam power.

2. No student is allowed under any circumstances to interfere with any of the machines, except the machine with which he is actually engaged at work.

3. No student is allowed to interfere in any way with the bell signals, or to give the signal for starting or stopping the engine, unless requested to do so by the superintendent or foreman, or in case of an accident.

4. The regular signal for starting or stopping the engine will be three distinct strokes of the bell, and whenever the signal is given for stopping the engine, all machines must immediately be thrown out of gear. The same signal will be given for the engine room, always previous to starting or stopping the engine.

5. No student is admitted to the engine room without the permission of the superintendent, and when admitted he is not to touch any of the gauge cocks, valves, or any of the gear belonging to the engine or boiler.

6. The stationary adjustments of the lathes and machines are not to be altered in any way, without application to the superintendent or foreman.

7. Students must be careful in using those tools which are provided by the college for general use, to preserve them from injury, and to return them to the places appointed by the superintendent in a clean state. Students will be charged on any damage done, or loss sustained.

8. No fresh materials are to be cut off or used without previous application to the superintendent or foreman.

9. No unnecessary noise must be made, and playing or throwing missiles of any kind is strictly prohibited.

10. No sawing or chiselling is allowed upon the benches, except with the use of the bench-piece provided for that purpose.

11. Students must be careful in the continual preservation of their own tools, for the good condition of which they are responsible.

12. All tool-boxes are to be kept under the benches as far as the space will permit.

13. Students are to keep to their own work, and not to walk about the shop so as to be in the way, or to hinder other students when at work.

14. No student can be admitted into the workshops at any other hours than those mentioned in the time table, without previous permission of the Dean of the department, as well as that of the superintendent. This sanction will only be given on condition that the applicant is not thereby neglecting other duties in the college.

No student can, however, be permitted to occupy the time of, or have any assistance from, the workmen out of the regular hours of attendance named in the calendar.

The infringement of this rule by any student will have the effect of causing him to be entirely shut out from the workshops during the period not specified in the calendar for regular attendance.

#### 17. MANCHESTER GRAMMAR SCHOOL.

##### General Arrangements.

Question 1. How is the school classified?—Classification of school for 1873.—There are 550 boys in the school, divided for the purpose of general instruction into 21 forms.

—Eleven are classical—

Parallel to the lower five of these are five modern language forms, and parallel to the upper half are four Science forms and one Mathematical form.

In the Science and Mathematical forms the boy has his choice between the study of classics and modern languages.

For the purpose of mathematical teaching all the forms below the Three Sixths, Science, Classical, and Mathematical are re-distributed into three groups, each consisting of five sets.

Question 2. Is Science a necessary part of the school course, or is it taught only in special forms or departments?—Science constitutes the principal part of the teaching of the four Science forms, and an essential part of the teaching of the Mathematical Sixth.

There are, besides, optional classes for the teaching of Mechanics, Elementary Chemistry, and Physical Geography, drawn from all parts of the school.

Question 3. Copy of time table, see pp. 180-182.

## TIME TABLE for 1873

	Hours.	Classical VI.	Mathematical VI.	Science VI.	Science Transina.	Science V.	Science Romova.	Classical Transina.	Upper Classical V.	Lower Classical V.	
MONDAY	1	9 15 to 10.45	Classics.	Classics or Modern Language.	Classics or Modern Language.	Physics.	Chemistry.	Mathematics.	Classics.	Classics.	Drawing
	2	11 to 12.30	Classics.	Mathematics.	Physics.	Classics or Modern Language.	Classics or Modern Language.	Chemistry.	French.	Classics.	Classics.
	3	1.45 to 3	Classics.	Physics.	Chemistry.	Chemistry.	Model and Machine Drawing.	Mathematics.	Classics.	English.	Classics.
	4	3 to 4	Mathematics.	Physics.	Chemistry.	Chemistry.	Practical Geometry	French.	Classics.	French.	English.
TUESDAY	1	9 15 to 10.45	Classics	Mathematics.	Mathematics.	Classics or Modern Language.	Classics or Modern Language.	English.	Classics.	Classics.	Classics.
	2	11 to 12.30	Classics.	Classics or Modern Language.	Classics or Modern Language.	Mathematics.	Mathematics.	Physics.	Mathematics.	Mathematics.	Mathematics.
	3	1.45 to 3	Classics.	Model and Machine Drawing	Physics.	Model and Machine Drawing.	Chemistry	Mathematics.	Classics	Classics	Drawing
	4	3 to 4	French	Practical Geometry	Physics.	Practical Geometry	Chemistry	French.	Classics.	French.	Classics.
WEDNESDAY	1	9 15 to 10.45	Classics	Mathematics.	Mathematics.	Classics or Modern Language.	Classics or Modern Language.	French.	Classics.	Classics.	Classics.
	2	11 to 12.30	Classics.	Classics or Modern Language.	Classics or Modern Language.	Mathematics.	Mathematics.	Physics.	Mathematics.	Mathematics.	Mathematics.
	3	1.45 to 3	German.	Physics	Chemistry.	Chemistry.	Model and Machine Drawing	Mathematics	Classics.	Classics.	Classics.
	4	3 to 4	Classics.	Physics.	Chemistry	Chemistry.	Practical Geometry	Drawing and Writing.	Classics.	Drawing.	French.
THURSDAY	1	9.15 to 10.45	Classics	Classics or Modern Language.	Classics or Modern Language.	Mathematics.	Mathematics.	Chemistry.	Mathematics.	Mathematics.	Mathematics.
	2	11 to 12.30	Classics	Mathematics.	Physics.	Classics or Modern Language.	Classics or Modern Language.	French.	Classics	Classics	Classics.
	3	1.45 to 3	Mathematics.	Model and Machine Drawing.	Chemistry.	Chemistry.	Physics.	Mathematics.	Classics.	Classics	English.
	4	3 to 4	Classics.	Practical Geometry.	Chemistry	Chemistry.	Physics.	Drawing and Writing.	Classics.	German	French.
FRIDAY	1	9 15 to 10.45	Classics.	Classics or Modern Language.	Classics or Modern Language.	Mathematics.	Mathematics.	Physics.	Mathematics.	Mathematics.	Mathematics.
	2	11 to 12.30	Classics.	Mathematics.	Model and Machine Drawing.	Model and Machine Drawing.	Chemistry	French.	German.	Classics.	Classics.
	3	1.45 to 3	French.	Mathematics.	Practical Geometry.	Practical Geometry.	Physics.	History and Geography.	Classics.	Classics.	French.
	4	3 to 4	Classics.	Mathematics.	Mathematics.	Classics or Modern Language.	Classics or Modern Language.	Drawing and Writing.	Classics.	Drawing.	Classics.

TIME TABLE for 1873.

Modern Language Remove.	Classical Remove.	Classical IV	Classical III	Classical II	Upper Classical I	Lower Classical I	French III	French II	Upper French I	Middle French I	Lower French I
English.	Classics	Drawing and Writing	Mathematics.	Mathematics	Mathematics	Mathematics.	Mathematics	Drawing and Writing	French.	French.	French
French.	Drawing and Writing	Classics	Classics.	English.	Classics.	Classics.	Drawing and Writing	Mathematics.	Mathematics.	Mathematics.	Mathematics.
German	Classics.	French	Mathematics.	Mathematics.	Mathematics.	Mathematics.	Mathematics.	English.	French.	Drawing and Writing.	Drawing and Writing
Drawing and Writing.	English.	English	Drawing and Writing	French	French.	English	French	Mathematics	Mathematics	Mathematics	Mathematics
French.	Classics.	Classics.	Drawing and Writing.	Drawing and Writing	Drawing and Writing	Drawing and Writing	English.	French.	English.	English	English
Mathematics.	Mathematics	Mathematics.	Classics.	Classics	Classics	Classics	French.	Drawing and Writing	Drawing and Writing	French	French
English	Classics.	French	Mathematics	Mathematics	Mathematics.	Mathematics.	Mathematics	English.	French.	French	French.
German.	French	Classics.	English.	History and Geography	English	French.	Drawing and Writing.	Mathematics	Mathematics.	Mathematics	Mathematics
French	Classics.	English.	French.	Drawing and Writing	Drawing and Writing	Classics	English.	Drawing and Writing	History and Geography.	History and Geography	History and Geography
Mathematics	Mathematics	Mathematics	Classics.	Classics	Classics.	Drawing and Writing	Drawing and Writing.	French	French.	French	Drawing and Writing
German.	Classics.	Drawing and Writing.	Mathematics.	Mathematics	Mathematics	Mathematics	Mathematics.	French.	French.	French	French.
History and Geography	English.	Classics.	Drawing and Writing.	French.	French.	English.	French.	Mathematics.	Mathematics	Mathematics.	Mathematics.
Mathematics	Mathematics.	Mathematics	Classics.	Classics.	Classics	Drawing and Writing	French	French.	Drawing and Writing.	Drawing and Writing.	French
French.	Drawing and Writing.	Classics.	History and Geography	English	Drawing and Writing	French.	Drawing and Writing	Mathematics.	Mathematics.	Mathematics.	Mathematics
German	Classics.	French.	Mathematics.	Mathematics.	Mathematics.	Mathematics.	Mathematics	History and Geography	French.	French.	Drawing and Writing.
Drawing and Writing	History and Geography	History and Geography	French.	Classics	Classics.	History and Geography	French.	Mathematics.	Mathematics	Mathematics.	Mathematics.
Mathematics.	Mathematics.	Mathematics.	Classics.	Classics.	Classics.	English.	English.	French.	French	French.	Drawing and Writing
German.	French.	Classics.	Classics.	Drawing and Writing	English.	Classics.	French.	Mathematics.	Mathematics.	Mathematics.	Mathematics.
Drawing and Writing.	Classics.	Classics.	French.	Classics.	History and Geography	Classics.	French.	Mathematics.	Mathematics.	Mathematics.	Mathematics.
French.	Drawing and Writing.	Drawing and Writing	English.	French	French.	Classics.	History and Geography	English.	English.	English.	English.

Question 4 Summary of hours per week given in each preparation or practical work, this should be shown class to different subjects. (If playtime is utilised for separately.)

TIME TABLE for 1873.

	Classical VI.	Mathematical VI.	Science VI.	Science Transitus.	Science V.	Science Transitus.	Upper Classical V.	Lower Classical V.	Classical Remove.	Modern Language Remove.	Classical IV.	Classical III.	Classical II.	Upper Classical I.	Lower Classical I.	French III.	French II.	Upper French I.	Middle French I.	Lower French I.
Classics	204	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Modern Languages	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
English	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
History and Geography	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Mathematics and Arithmetic.	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Physics	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Chemistry	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Drawing and Writing	24	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94
Total	204	74	74	7	7	174	14	19	104	134	94	94	94	94	94	94	94	94	94	94

1 In the highest forms the voluntary study of English is encouraged by the yearly award of two "Shakespeare Scholarships," and the Early English Text Society's prize.  
 2 The teaching of History and Geography is an essential part of the classical teaching  
 3 In all forms below the Vth a map is drawn each month as home work.  
 4 In all forms below the Vth the time given to languages is exclusive of the time spent on looking over exercises.  
 5 In the Mathematical Vth, Science Vth, Science Transitus, Science Vth, and Science Remove, the study of Modern Languages is alternative with that of the Classics  
 6 In the Classical Vth, Classical Transitus, and Modern Language Remove, the time devoted to Modern Languages is equally divided between French and German.  
 7 The Science Vth and Science Transitus receive instruction in Practical Chemistry four hours per week, exclusive of the usual school hours.

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science Classes:—

	Average Age.	No. of Boys.
Mathematical Sixth	17½	15
Science Sixth	16½	20
Science Transitus	15½	30
Science Fifth	15	30
Science Remove	14	40

Question 6. Amount of knowledge required before the study of Science is commenced.—Those boys who show an aptitude for Mathematics are specially urged to enter the Science forms. None would be permitted to enter them (except under special circumstances) who have not reached the Fourth form.

Question 7. Is any alternative or choice of subjects offered?

What departments of Science are preferred?

(a) By parents?

(b) By the boys?

In the Science forms the scientific subjects are fixed; as I have said before, there are voluntary classes for Chemistry, Mechanics, and Physical Geography, any, or all of which a boy may attend at his pleasure.

(a) There are several boys in the school whom their parents desire to become manufacturing chemists; in the case of some of these the wish has been expressed that special attention should be given to their Chemical studies

(b) Electricity and Chemistry

Question 8. What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—Physics and Chemistry receive an equal degree of care. Beginners seem to derive most profit from Acoustics, and the more advanced students from Optics and Chemistry; Electricity and Heat occupying an intermediate position.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—A boy's position in the Science forms and his prospects of promotion depend almost entirely on his scientific attainments. As I have explained in answer to Question 1, the Science and Mathematical forms are regarded as equal to the highest classical forms.

NOTE.—The answers signed "J. A." are written by Mr. Angell, the teacher of Physics at the Grammar School.

Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?

(b) Book work?

(c) Practical work?

(a) The whole of the time occupied in the class is given (with very few exceptions) to oral teaching and experimental demonstration. "J. A."

(b) Text-books are used only in the preparation of home work, excepting only where they are used in the absence of the necessary large diagrams or special apparatus, which may be well figured in the text book. "J. A."

(c) A very few only of the upper boys in the Sixth Science form do any systematic practical work, because of the want of a physical laboratory (a great defect) The boys are, however, often called down during an ordinary lesson and required (before the class) to arrange apparatus for a particular demonstration, or to perform an experiment. "J. A."

In the Chemical lessons practical work in the laboratory occupies twice as much time as oral teaching.

Question 11. Which form of lesson is found to be most effective?—I find the "Socratic" form of lesson the most efficient. In this form of lesson the information required to be taught is either educed or built up by series of logical questions systematically put to the boys, not on what they have acquired verbally from the book or the teachers, but put to them on the apparatus, the experiment, or the phenomena, or problems as they are actually before them. In this way the observing and reasoning processes, and those of scientific literary exposition are cultivated simultaneously. "J. A."

Question 12. How are text-books used? e.g., Is book work supplementary or preparatory to the oral lesson?—Text-books are mainly used for the purpose of recapitulation and revision, the book work is used as supplementary to the oral lesson, that is, not so much for the purpose of communicating information as for supplying a literary model of connected scientific exposition. "J. A."

Question 13. Is the use of note-books encouraged (a) during or (b) after the lesson, and to what extent?—

(a) Note books are used during the lesson, but only for the briefest possible notes, rather heads of subjects, apparatus, experiments, etc., than notes proper. But they are chiefly used after the lesson for making fuller home notes, in which case the boys are also encouraged to use the text-book as an auxiliary. In the "Socratic" form of lesson the work of the lesson itself keeps the teacher fully informed of the progress and attainments of his class "J. A."

My own experience has shown me that, in scientific teaching, where mere memory is the least important active faculty, but where the activity of the observing, reasoning, constructive, and investigating powers is continuously required, the mental condition essential to the taking of full notes is inconsistent with the real scientific progress which should be made during the course of any really well-reasoned out and demonstrated scientific lesson: the notes made after the lesson cannot, however, be too full or complete. "J. A."

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Boys are often required to construct at home, in the place of their ordinary home lessons, special pieces of apparatus, as—a polariscope, selenite figures for the same, an electrophorus, induction coil, diffraction apparatus, models of Nicol's prisms, electrotype apparatus, voltaic batteries, &c. Unfortunately, however, we have no proper physical laboratory. "J. A." The chemistry lecture room can accommodate easily 80 boys. The chemical laboratory accommodates 84 boys.

each of whom is provided with a cupboard, and drawer, and set of chemical re-agents, each boy is told at the beginning of the lesson what his work for the day is, and how to do it, he is then left to perform the experiments, and must do so to the satisfaction of the master. When sufficiently advanced, he is given a solution or substance to analyse.

Question 15. Describe any method of teaching some special branch of Science which has been found successful in your school?—The "Socratic" method (See 11.) "J. A."

*Instruments of Teaching.*

Question 16. What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?—

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

We have—

1. A chemical laboratory and lecture room, balance room, and preparation room.
2. A physical lecture room with preparation room attached.

Tracings of these rooms are sent herewith.

Question 17. Number of assistants and curators, and annual cost?—For physics, Mr Angell and pupil-assistant; for chemistry, Mr Jones and assistant. Gross cost 65*l.* a year.

To this should be added the cost of teaching experimental mechanics, on which one of the mathematical masters spends no small part of his time

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—Our most valuable and useful set of apparatus is our oxyhydrogen lantern, microscope and polariscope (reflecting and refracting). "J. A."

The annual cost seems to be about 100*l.* There is no fixed sum allowed yearly, but grants are made by the Trustees from time to time at their discretion.

LIST OF APPARATUS AND COST.

	£	s.	d.
One Five-cell Grove Battery, quart size	-	5	0
Parallelogram and Forces apparatus	-	6	15
Three sets of Pulleys, to order	-	6	10
Pneumatic apparatus, Air Pump, Mercuroal Gauge, &c., complete	-	18	10
One Attwood's Machine, complete	-	14	0
Marcel's Steam Apparatus	-	4	4
Pocket Spectroscope and case	-	4	7
Five Grove's Cells Battery	-	4	10
Model of Kater's Pendulum	-	3	3
Double Syren Organ and Bellows	-	16	10
Vibrating Prism	-	2	0
Wheatstone's Photometer	-	2	0
Gamut of Bells	-	1	10
Line Thermo File	-	2	15
Galvanometer	-	4	4
Monochord	-	5	5
Egg-shaped Vessel	-	2	5
Battery, Leyden Jars	-	5	0
Oxyhydrogen Lantern, complete	-	37	10
Polariscope	-	7	0
Coulomb Torsion Balance	-	4	10
Tangen's Galvanometer	-	6	10
Wheatstone's Bridge	-	3	10
Double Syren	-	12	0
Electric Lamp	-	10	10
Riot's Apparatus	-	2	2
Hot Air Bath and Regulator	-	3	0
Blow Pipe Table	-	4	4
Pair of Gas Holders	-	18	0
One No. 6 Balance and case, to order, complete	-	16	12
Set of Weights to 500 grammes	-	3	3
One No. 3 Balance, agate edges, to order, complete	-	12	6
Sets of Mahogany Cubes	-	10	0
Retort Stands, &c.	-	20	0
Model of Force Pump	-	1	15
Model of Lift Pump	-	1	5
Metronome	-	2	2
Pair of Reflectors	-	3	15
Electro Magnet	-	1	10
	£289	8	6

This list contains only the principal scientific apparatus in use at the Grammar School, the numerous smaller and less important articles have been omitted from the foregoing list.

Question 19. Is there a workshop? and if so, how, and for what particular purpose is it used?—We have unfortunately no workshop "J. A."

Question 20. What text-books are in use, distinguishing between those for the junior and senior classes?—Text-book, "Chemistry," *seniors*, Roscoe's Chemistry, Bloxam's Metallurgy, Fownes' Chemistry; *juniors*, Roscoe's Chemistry.

Our text-book for *juniors* is, "Lessons on Elementary Physics" by Balfour Stewart, but we probably next year may find a better illustrated work, one with a greater number of experiments, and pictures of apparatus.

The text-book for our *seniors* is, "Ganot's Physics" by Atkinson, many of the boys also use Balfour Stewart's "Treatise on Heat," also "Deschanel's Natural Philosophy," by Everett. "J. A."

Question 21. To what books of reference, other than ordinary school books, have the scholars access?

(a.) The boys' Philosophical Society has formed a small science library of its own, which within the last month or two has been augmented by the liberality of a friend

(b.) Watts' Dictionary of Chemistry, Miller's Chemistry, Tyndall on Sound, Heat, Diamagnetism, Humboldt's Cosmos, Roscoe's Spectrum Analysis, Lyell's Geology, Carpenter's Physiology, Darwin's Descent of Man, Ansted's Physical Geography, etc etc

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—Yes, "The Manchester Grammar School Philosophical Society," established in 1869.

It is composed of the boys of the sixth and other science forms, its officers are elected from among its members by ballot, it meets every Friday after school for the reading and discussion of scientific papers, written by its members, the subscription is 2*s* entrance fee, and 2*s* 6*d* per term. There are three terms per annum. The society is decidedly useful in promoting scientific reading and thought among the members "J. A."

*Tests of Progress.*

Question 23. How often is the work tested?—Progress is tested during each lesson (see Q. 11).

Special class examinations are also made about twice each term, note books are also examined. Progress is also tested by independent examiners, that is, by the ordinary yearly science examinations held each May by the Department of Science and Art (Professor Tyndall, examiner).

And by examinations conducted annually in July by an independent examiner sent from the University of Oxford. This year the examiner was Professor Chapman "J. A."

Question 24. In what way? e.g., by examination of note books, or by oral or written questions?—The independent examiners conduct their examinations by means of printed papers. Our own examinations also include that of note books. "J. A."

Question 25. By whom? by the teachers of the subjects or by an independent examiner?—In May by the Department of Science and Art at their ordinary annual science examination

At the end of July by an examiner from Oxford or Cambridge. Our last three examiners have been Mr. Eason of Merton College, Mr. Vernon Harcourt of Christ Church, and Mr. Chapman of Magdalen College, Oxford.

At Christmas by a general examination, by means of written papers, by the teachers of the subjects. "J. A."

*Teachers.*

Question 26. Is there any difficulty in procuring competent Science masters?—I have been concerned in the appointment of three science masters, and on each occasion there were several eligible candidates. The three gentlemen who were selected had each received a different kind of training, but had all proved themselves successful teachers.

Question 27. Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—See answer to preceding question.

**Question 28** What evidence of scientific qualification tendered by candidates is found to be of most value?—Success as a teacher is the qualification upon which I should lay most stress.

**Question 29** Can you state any results of science teaching in the school? such as—

(a.) Success, professional or otherwise, of individual scholars.

(b.) Influence upon the general studies and intellectual life of the school?

(a.) Ten or 12 boys from the school have taken Science scholarships at the University of Oxford, and a few have passed the first B Sc at the University of London, but we must not expect to see the tangible results of our science teaching for some years to come.

(b.) Since the introduction of the science teaching and the connected changes in our system the number of our boys has largely increased. By the side of the old classical forms, which remain at least as strong as before, there have grown up science and mathematical forms, training, for a life of study and an University career, boys who earlier would with difficulty have found a place for their special aptitudes. The number of prizes and certificates from South Kensington show that an influence for good has been at work upon the younger boys, and to name the result which (to the schoolmaster) is, perhaps, the most important of all, the number of utterly useless boys between 15 and 18, who seem incapable of being roused to take an interest in anything, has almost disappeared.

**Question 30.** Are any special rewards or encouragements (e.g., exhibitions, scholarships, or prizes) open to successful students of science in the School?—There are two Science exhibitions (lately founded by Miss Brackenbury) worth about 45*l.* a year each, tenable for three years at the University of Oxford, consequently there is a Science exhibition awarded two years out of three.

The Scienceforms take their full share of the general prizes of the school.

**Question 31.** What improvements do you think could be effected in the teaching of Science in your own school?—I believe an observatory, a physical laboratory, and a boy's workshop would be of great service, but what we most need is an increase in the teaching staff.

**Question 32.** What are the principal obstacles to the teaching of science in your own school?—The boys in the classical forms are fully tasked, I think overtasked, by their present work, so that under existing conditions they cannot be taught Science with any good results; many boys, however, are detained by their parents in the classical forms, who mentally would profit far more in a Science form, but this generally is done for the sufficient reason that a literary training is of vital importance to the boy's prospects in life.

**Question 33.** How could the Universities best assist science-teaching in schools?—The University of Oxford has done much towards the introduction of Science into school teaching, indeed, I have often been surprised by the ignorance men of science show at the vigorous efforts made in this direction, both by the University and the Department of Science and Art. Much additional good would be done if the Universities instituted a general matriculation or leaving examination, comprising—

(1) Mathematics, (2) Science, (3) Language and Literature, and allowing excellence in one subject to compensate for defects in another. School teaching ought to lay in the minds of the young a broad and a common basis for subsequent and more special culture. Many hindrances have hitherto lain in the way. A fear of superficial knowledge, the immediate demands of practical life, various competitive examinations, but chiefly the want of agreement as to the subjects to be taught. This last and principal obstacle is fast disappearing, and if the State and the Universities gave the schoolmaster their assistance we should soon see a more comprehensive and harmonious system of instruction introduced.

**Question 34.** Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?—Nothing in my judgment would be so beneficial to endowed schools as systematic inspection and subordination to some central authority. Whatever assistance scientific studies would receive from

such a change, and it would be great, Classics, Mathematics, and Modern Languages, would receive hardly less.

FREDK. W. WALKER, M.A.,  
High Master,  
(P. S. H. H.)

December 26, 1872.

### 18. HARROW SCHOOL.

#### General Arrangements.

**Question 1.** How is the school classified?—The School consists of two Sides: (1.) The Classical Side; and (2.) The Modern Side (which was established in September 1869). The Forms during the present Term are as follow:—

#### The Classical Side.

The Monitors and VI. 1	-	-	-	36 boys.
VI. 2	-	-	-	31 "
First Vth	-	-	-	35 "
Second Vth	-	-	-	32 "
Thurd V.	-	-	-	33 "
Upper Remove	-	-	-	33 "
Lower Remove	-	-	-	34 }
" "	-	-	-	29 }
Upper Shell	-	-	-	32 }
" "	-	-	-	33 }
Middle Shell	-	-	-	32 }
" "	-	-	-	31 }
Lower Shell	-	-	-	33 "
First IVth	-	-	-	32 "
Second IV.	-	-	-	33 "
Thurd IV.	-	-	-	17 "

(2.) The Modern Side (which was established in September 1869).

#### The Modern Side.

Vith	-	-	-	6 boys.
Upper Vth	-	-	-	9 "
Lower Vth	-	-	-	12 "
Modern Remove	-	-	-	10 "
Upper Shell	-	-	-	11 "
Lower Shell	-	-	-	4 "

**Question 2.** Is Science a necessary part of the school course, or is it taught only in special forms or departments?—Natural Science is taught to all boys on the Modern side, and to boys in the Vth forms and Upper Remove on the Classical side.

**Question 3.** Copy of time table?

**Question 4.** Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)

**Question 5.** Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes?—The Modern side have been taught in two divisions, each consisting of about 26. In future they will be divided into three divisions. The boys on the Classical side are at present taught in four divisions, each consisting of about 33 boys.

**Question 6.** Amount of knowledge required before the study of Science is commenced?—No boy is at present allowed to join the Modern side unless he has been one year in school, and is at least in the Lower Shell.

**Question 7.** Is any alternative or choice of subjects offered?

What departments of Science are preferred?

a. By parents?

b. By the boys?

**Question 8.** What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—Experimental physics is the only subject which has been taught in school. A few boys receive instruction in comparative anatomy and physiology during the half holidays, and other times which they can arrange with the teacher.

**Question 9.** What weight is assigned to scientific attainments in determining a boy's position in the school?—The same weight as to other subjects, the proportions being determined by the time given to the several subjects.

#### Methods of Teaching.

**Question 10.** What proportions of the lessons take the form respectively of—

(a.) Oral teaching and demonstration?—The boys on the Classical Side are present at one lecture a week. The boys on the Modern Side are



present at two lectures in each week. All the boys are required to take notes of the lectures, which are examined by the teacher.

(b.) Book work?—The boys who are in the Upper Division of the Modern Side are recommended to read a text-book out of school.

(c.) Practical work?—Practical work is attempted only with the Upper Division of the Modern Side one hour in the week. As soon as the new lecture rooms and laboratories are erected, it is expected that practical work in physics and chemistry will be found to be the most efficient means of teaching these subjects.

Question 11. Which form of lesson is found to be most effective?—As far as it has been attempted, a lesson in which the boys are made to repeat experiments which they have seen performed by the teacher at a previous lesson, or other simple experiments, is found to be by far the most effective.

Question 12. How are text-books used? *e.g.*, Is book work supplementary or preparatory to the oral lesson?—At present text-books are used in a few cases only, as stated in the answer to Q. 10.

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—The boys are recommended to take brief notes during the lesson, and afterwards to write these out at length, making careful drawings of apparatus, &c.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—In the summer, prizes are offered by the School Scientific Society for the best collections of plants, moths, butterflies, &c.

Question 15. Describe any method of teaching some special branch of Science which has been found successful in your school?—Comparative anatomy has been taught to a few boys, with some success, by making them read Professor Huxley's *Physiology*, as an introduction to the subject. The teacher gives one or two elementary lectures on the subject of each chapter before it is read. The issues are examined and carefully drawn. Comparative Osteology is then commenced. Specimens of every important order are examined and made out with the teacher's help, or by reference to such books as Professor Flower's *Osteology of the Mammalia*. Specimens of dissected animals are then examined, and dissections of all the classes of animals are made.

#### Instruments of Teaching

Question 16. What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

It is intended that the following rooms should be erected in 1873:—

One lecture room for physics, capable of holding 75 boys

One laboratory for physics, capable of holding about 20 boys at work

One apparatus room, and a small sitting room, for physics.

One lecture room for chemistry, capable of holding 75 boys

One laboratory for chemistry, capable of holding 25 boys.

These buildings will cost 4,300*l.*, exclusive of fittings.

It is also proposed at a future time to add a preparation room and a balance room for the chemical department. It is also proposed to have a room for typical specimens (illustrative of Botany, Zoology, Geology, and Mineralogy), and for practical work in comparative anatomy.

Question 17. Number of assistants and curators, and annual cost?—At present there is only one master. When the chemical lecture room, &c., referred to above, are ready, another master will be appointed.

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?

Question 19. Is there a workshop? and if so, how, and for what particular purpose, is it used?—Large workshops will be erected during the course of 1873.

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes?

Question 21. To what books of reference, other than ordinary school books, have the scholars access?—There is a good school library to which all boys have access during certain hours.

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—Yes. The rules of the society are appended. Meetings are held about once a fortnight. Papers are read by the members, or, occasionally, by strangers. It is almost impossible to estimate its influence on the boys generally. The members themselves undoubtedly receive benefit from the papers, and the discussions which follow. The society also exercises good influence on those who make botanical and other collections.

#### Tests of Progress

Question 23. How often is the work tested?—Once in each term. (Three times a year.)

Question 24. In what way? *e.g.* by examination of note books, or by oral or written questions?—By examination of note books once a week, or oftener, and by written questions at the end of each term.

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?—The examinations referred to above are at present held by the teacher, but, once a year, there is an examination in the work of the year for two prizes given by the Head Master. This is conducted by an independent examiner (generally from Oxford or Cambridge).

#### Teachers.

Question 26. Is there any difficulty in procuring competent Science masters?

Question 27. Where are the best obtained? Have they been specially trained for the work? and if so, in what does such training consist?

Question 28. What evidence of scientific qualification tendered by candidates is found to be of most value?

Question 29. Can you state any results of Science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars

(b) Influence upon the general studies and intellectual life of the school

Question 30. Are any special rewards or encouragements (*e.g.* exhibitions, scholarships, or prizes) open to successful students of Science in the school?—Two prizes are given annually by the Head Master.

Question 31. What improvements, do you think, could be effected in the teaching of Science in your own school?—At present all the teaching of Natural Science is carried on in a room which is used during certain hours of the day by one of the classical masters. As soon as the new rooms are finished, it is hoped that the teaching will be much more effective. No practical work, worthy of the name, is now attempted, except with a few boys, and without practical work no real progress seems to be possible, except in the case of boys of unusual ability.

Question 32. What are the principal obstacles to the teaching of Science in your own school?—Vide answer to question 31.

Question 33. How could the Universities best assist science-teaching in schools?—Probably by increasing the number of scholarships, and by making some branch of experimental physics or chemistry a necessary part of the first examination that is passed by every undergraduate.

Question 34. Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?—If "Leaving Examinations" were established, increased attention would necessarily be given to Natural Science at schools, if some branch of the subject were made compulsory in these examinations, whether conducted by the Government or by the Universities.

Question 35. Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

H MONTAGU BUTLER, D.D.,

Head Master.

January 23, 1873.

## 19. ETON COLLEGE.

ANSWERS BY REV. DR. HORNBY.

## General Arrangements.

Question 1. How is the school classified?—The nominal forms are the 6th (the highest), the 5th, the Remove, the 4th, and the 3rd, but these forms are, in some cases, very large, *e.g.*, the 5th contains about 480 boys. The 6th and 5th forms together are, therefore, split up into 14 divisions, each under a different classical master. These divisions are arranged in groups, called A. B. C. D.

The A group comprises divisions	-	1, 2, 3.
B "	"	4, 5, 6
C "	"	7, 8, 9, 10.
D "	"	11, 12, 13, 14.

For mathematics and science (and in some cases for French), the different groups are divided afresh, on a

different principle, among the mathematical staff (or the French staff).

A whole group, *e.g.* B. or C., goes to mathematics together, and the mathematical masters arrange them, according to their mathematical proficiency, in different classes. Ten mathematical classes can go on simultaneously.

A similar redistribution, but not so complete, is made for science teaching: see Mr. Madan's answer to question 31.

The Remove and 4th form are similarly arranged, but they have no science teaching.

Question 2. Is science a necessary part of the school course, or is it taught only in special forms or departments?—Science is taught as a necessary part of the school course from division IV to IX inclusive.

It is an alternative subject with modern languages, modern history, extra classics, or extra mathematics, in divisions I., II., III.

Question 3. Copy of Time Table.

## WOOLWICH DIVISIONS—LENT SCHOOL-TIME, 1873

## B.

Day of Week.	7.30.	9.45.	11.15.	3.	5.35.
Monday - -	Greek Testament -	- - -	Mathematics -	Mathematics -	Mathematics.
Tuesday - -	French - -	Political Geography	Mathematics -	- - -	- - -
Wednesday -	Version - -	- - -	Mathematics -	Latin Construng -	Latin Construng.
Thursday - -	French - -	Mathematics -	Political Geography	- - -	- - -
Friday - -	Mathematics -	- - -	Mathematics -	Latin Construng -	Mathematics
Saturday - -	Version - -	Latin Construng -	Mathematics -	- - -	- - -

1 Divinity, 6 Latin, 2 French, 2 Political Geography, 11 Mathematics.

## C.

Monday - -	Greek Testament -	- - -	Mathematics -	Geography - -	Mathematics
Tuesday - -	French - -	Political Geography	Mathematics -	- - -	- - -
Wednesday -	Mathematics -	- - -	Latin Construng -	Mathematics -	Latin Construng.
Thursday - -	French - -	Mathematics -	Political Geography	- - -	- - -
Friday - -	Version - -	- - -	Latin Construng -	Mathematics -	Latin Construng.
Saturday - -	Translation -	Mathematics -	Mathematics -	- - -	- - -

1 Divinity, 6 Latin, 1 Geography, 2 Political Geography, 2 French, 10 Mathematics.

## D.

Monday - -	Greek Testament -	- - -	Mathematics -	Mathematics -	Geography.
Tuesday - -	Mathematics -	Political Geography	Mathematics -	- - -	- - -
Wednesday -	Mathematics -	- - -	Latin Construng -	Mathematics -	French.
Thursday - -	Mathematics -	Latin Construng -	Political Geography	- - -	- - -
Friday - -	Latin Composition	- - -	Latin Construng -	Latin Construng -	French.
Saturday - -	Saying Lesson	Mathematics -	Mathematics -	- - -	- - -

Divinity, 5 Latin, 1 Saying, 1 Geography, 2 Political Geography, 2 French, 10 Mathematics.

A Boy in the Woolwich Class, if in his last year, will have three lessons a week in English History and Literature two of these lessons will be at hours in which he would not otherwise be in School; the remaining one will be at the Mathematical hour.

A (DIVISIONS I, II, III.)

TIME.	MONDAY	TUESDAY.	WEDNESDAY.	THURSDAY	FRIDAY.	SATURDAY.
7.30	Greek Testament	Construe Latin Poetry	Composition in School. Latin.	Saying Lesson -	Construe Greek Poetry.	Vernon. Translation.
9.45	Mathematics -	- - -	- - -	New Studies -	- - -	New Studies
11.15	Construe Greek Prose	Construe Greek Prose	Construe Greek Poetry	Construe Greek Prose.	Mathematics -	Construe Latin Poetry.
8.0	Saying Lesson -	- - -	New Studies -	- - -	New Studies -	-
5.15	Construe Latin Prose.	- - -	5 Mathematics -	- - -	Construe Latin Prose.	-

B. (DIVISIONS IV, V, VI)

7.30	Greek Testament	French - -	Vernon - -	French - -	Mathematics -	Translation. Vernion.
9.45	- - -	Saying Lesson -	- - -	Saying Lesson. Show up French Exercise.	- - -	Construe Latin Poetry.
11.15	Mathematics -	Physical Science	Mathematics -	Construe Greek Poetry.	Construe Greek Poetry	Theocritus -
8.0	Construe Greek Prose.	- - -	Construe Latin Prose.	- - -	Construe Latin Poetry	-
5.15	Construe Greek Prose.	- - -	Construe Latin Prose.	- - -	Physical Science -	-

C. (DIVISIONS VII., VIII., IX, X.)

7.30	Greek Testament	French - -	Mathematics -	French - -	Vernon - -	Translation. Physical Science.
9.45	- - -	Saying Lesson -	- - -	Physical Science	- - -	Construe Greek Poetry
11.15	Construe Greek Prose	Construe Greek Prose	Construe Latin Prose.	Construe Greek Poetry	Construe Latin Poetry	Construe Greek Poetry
8.0	Geography -	- - -	Saying Lesson -	- - -	Mathematics -	-
5.15	5. Mathematics -	- - -	Construe Latin Prose.	- - -	Construe Latin Poetry	-

D. (DIVISIONS XI., XII, XIII, XIV)

7.30	Greek Testament	Mathematics -	Saying Lesson -	Mathematics -	Latin Composition in School.	Saying Lesson.
9.45	- - -	Greek Exercise -	- - -	Construe Latin Prose.	- - -	Construe Greek Poetry
11.15	Construe Greek Prose.	Construe Greek Prose	Construe Latin Prose	Construe Greek Poetry	Construe Latin Poetry	Mathematics.
8.0	Mathematics -	- - -	Mathematics -	- - -	Construe Latin Poetry	-
5.15	Geography -	- - -	French - -	- - -	French.	-

The accompanying Scheme shows the arrangement of lessons for the first 14 school divisions, i.e., for the whole of the Sixth and Fifth Forms. The time table of the Lower boys is not given, as it is not proposed to admit any of them into the army class. Boys who join the army class can commute Greek for additional Mathematics and English, giving up five lessons in the week, and taking six, thus getting 22 lessons in the week as against 21 in the ordinary Classical course.

The proportion of studies in the Scheme is as follows—  
 In the A. Divisions—1 Lesson Divinity, 3 Latin, 6 Mathematics, 3 English History and Literature, 4 New Studies, i.e. French or German, or Italian or Geography, or Physical Science. Total—22.  
 In the B. C. D. Divisions—1 Lesson Divinity, 7 Latin, 6 Mathematics, 3 English, 2 French, 2 Physical Science, 1 Greek Total—22

Woolwich Divisions,  
Feb. 5th 1873.

J. J. HORNEY.

Question 4. Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately)

- A. Divisions - 1 hour Divinity.
- " - 3 Mathematics.
- " - 4 Alternative Subjects, Science, History, &c., &c.
- " - 13 Classics.
- B. " - 1 hour Divinity.
- " - 3 Mathematics
- " - 2 Science.
- " - 2 French
- " - 13 Classics.
- C. " - The same, except that there is *eg* geography lesson in place of one of the classical lessons
- D. " - The same as C., except that there is no Science, but five mathematical lessons instead of three

Exercises are done out of school, and other work, *eg* extra divinity, classics, English, &c., &c., are done with

the tutors in their houses. This is known as private business.

There is also voluntary work in the laboratory during play hours: see Mr Madan's answers

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes

See Mr Madan's answer for his own classes; other boys are learning physical geography, or elementary astronomy, or mechanics in the Science hours. See Mr. Dalton's answer.

Their ages range from 18 to 13.

Question 6 Amount of knowledge required before the study of Science is commenced.

Sufficient knowledge of classics and mathematics to get into the Lower Fifth form. This may be done by average boys of 13 or 14 years of age.

The examination for admission to the 5th form includes translation from such books as Homer, Virgil, Xenophon, Caesar, Latin (prose and verse) composition, ancient history, French

In Mathematics—  
Arithmetic, all, except the higher rules, e.g. discount, profit and loss, stocks.

Algebra, to simultaneous equations (inclusive).  
Euclid, first 12 propositions.

Question 7. Is any alternative or choice of subjects offered?

What departments of Science are preferred?

- a By parents?  
b By the boys?

Question 8. What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—In the "trials" for school promotion into the middle division of the 5th Form, and into the Upper division, one Science paper is set. The papers are 12 in all.

#### Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

- (a) Oral teaching and demonstration?  
(b) Book work?  
(c) Practical work?

Question 11. Which form of lesson is found to be most effective?

Question 12. How are text-books used? e.g., Is book work supplementary or preparatory to the oral lesson?

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?

Question 15. Describe any method of teaching some special branch of Science which has been found successful in your school.

#### Instruments of Teaching.

Question 16. What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used? (Plans and descriptions, of these, with statements of their cost and annual expense, should, if possible accompany this return.)

Question 17. Number of assistants and curators, and annual cost.

Question 18. What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?

Question 19. Is there a workshop? and if so, how, and for what particular purpose, is it used?

Question 20. What text-books are in use? distinguishing between those for the junior and senior classes.

Question 21. To what books of reference, other than ordinary school books, have the scholars access?

Question 22. Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?

#### Tests of Progress.

Question 23. How often is the work tested?

Question 24. In what way? e.g., by examination of note books, or by oral or written questions?

Question 25. By whom? by the teachers of the subjects, or by an independent examiner?

#### Teachers.

Question 26. Is there any difficulty in procuring competent Science masters?—I have hardly experience enough to answer this question, having only appointed one master, who was highly recommended by very competent persons, and has proved most able and efficient. But I think there is considerable difficulty in finding men of high scientific attainments who are also able and willing to teach boys.

Question 27. Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?

Question 28. What evidence of scientific qualification entered by candidates is found to be of most value?

Question 29. Can you state any results of Science teaching in the school? such as—

- (a.) Success, professional or otherwise, of individual scholars  
(b.) Influence upon the general studies and intellectual life of the school.

Question 30. Are any special rewards or encouragement (e.g. exhibitions, scholarships, or prizes) open to successful students of Science in the school?

Question 31. What improvements, do you think, could be effected in the teaching of Science in your own school?

Question 32. What are the principal obstacles to the teaching of Science in your own school?

Question 33. How could the Universities best assist Science teaching in schools?

Question 34. Can you suggest any way in which Government could assist Science teaching in schools, as, for example, by inspection?

Question 35. Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

January 24, 1873.

### ANSWERS by H. G. MADAN, Esq.

#### General Arrangements.

Question 1. How is the school classified?

Question 2. Is Science a necessary part of the school course, or is it taught only in special forms or departments?

Question 3. Copy of Time Table.

Question 4. Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately.)

Question 5. Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes.

	Optics.	Chemistry.	Hydrostatics.
Number of boys	5	64	22
Average age	17-18	15-18	16

[The above refers to Mr Madan's present classes.]

Question 6. Amount of knowledge required before the study of Science is commenced.

Question 7. Is any alternative or choice of subjects offered?—No alternative or choice of subjects is, as a rule, offered.

What departments of Science are preferred?

a. By parents?

Parents do not appear to have any decided preferences for particular subjects, being simply desirous that their boys should be taught Natural Science. Chemistry is sometimes mentioned, but whether on rational grounds or not, is hardly clear.

b. By the boys?

Boys seem to take most interest in the subjects of "Heat" and "Chemistry of the non-metallic elements." The former subject, treated in a simple way, is undoubtedly very attractive to the younger boys.

Question 8. What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?

#### Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

(a) Oral teaching and demonstration?

The work in school consists entirely of oral teaching and demonstration, the first 10 minutes, or more, being occupied in questions on the previous lesson.

(b) Book work?

(c) Practical work?

Practical work in the laboratory is done entirely out of school, the time devoted to it being from 3 to 3½ hours in each week. The time spent in regular school lessons is about one half of this.

Question 11. Which form of lesson is found to be most effective?—It is not quite easy to compare the oral instruction with the practical work. The latter is strictly supplementary to the former, and serves to fix in the mind what has been previously shown.

It is doubtful whether practical work by itself is sufficient. Without previous oral teaching a boy is apt to do an experiment mechanically, without realising its full meaning. During laboratory work the boys are advised to consult their text-books and note books, and constant reference is made to what has been shown in lecture.

**Question 12** How are text-books used? *e.g.*, is book-work supplementary or preparatory to the oral lesson?—Text-books are considered as subsidiary and supplementary to oral lessons. The latter follow the general course of the text-book, and the boys are told to refer to their books, in writing out their notes of the lessons, for explanations and details beyond those which can be given in school hours.

**Question 13.** Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—The use of note books is compulsory in all the classes.

In most cases the boys have to take rough notes during the lesson, and to show up once in each week an account or abstract of the two previous lessons, fairly written out in a larger book. These are looked over, corrected, and marked, the marks being read out in public.

In some of the lower classes the notes are written down, once for all, during the lessons, chiefly from dictation, many experiments, however, are left for the boys themselves to describe in their own words.

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Boys are required to make and set up their own apparatus as far as possible.

Nothing is done for them which they seem able to do for themselves. In making gases, for example, the tubes are bent, corks fitted, substances weighed out, &c., by each boy for himself. Prizes are given each year for collections of butterflies made by the boys themselves during play hours.

**Question 15** Describe any method of teaching some special branch of Science which has been found successful in your school.

#### *Instruments of Teaching*

**Question 16.** What special provision (*e.g.*, laboratory, lecture room, observatory, museum, botanic garden, &c.), is made for Scientific Instruction, and how is it used?

(Plans and descriptions of these, with statements of their costs and annual expense, should, if possible, accompany this return.)

The laboratory buildings are shown in the annexed plan. Their total cost, inclusive of apparatus and fittings, was about 4,000*l*. The annual expenses cannot yet be accurately estimated, but will be about 80*l*. or 90*l*., including coals, gas, insurance, rates, &c., but exclusive of servants' wages. There is one attendant at a salary of 1*l* per week.

The work in the laboratory is voluntary, and done during play hours. When a boy has attended chemical lectures for a term, he is allowed to put his name down for laboratory work, and may, to a great extent, choose his own times for working. Each boy comes for a period of 1½ or 2 hours twice a week. A place at a work table is allotted to him, and all necessary materials and apparatus are supplied. As much personal supervision as possible is given, and a full account of every analysis made (and, in many cases, of other experiments) is written out and looked over by the teacher.

The observatory contains an equatorial telescope (with 6 in. object glass), with divided circles, driving clock, &c., a sidereal clock, together with a few necessary books and diagrams. Its total cost was about 600*l*.

It is under the management of a committee of masters who take it in turns to be in the observatory from 9.30 to 10.30 p.m.

The names of boys who are recommended by their masters are entered in a book, and four or five are taken up on every fine night, as well as occasionally during the day.

**Question 17.** Number of assistants and curators, and annual cost: see the answer to the previous question.

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—The number of places fitted up in the laboratory, under its present arrangement, is 32. The number of names put down is never less than 30, and usually all the available places are occupied.

**Question 19** Is there a workshop? and if so, how, and for what particular purpose, is it used?—There is a workshop connected with the laboratory, containing two lathes, work-bench, forge, and a fair supply of tools.

84734.

It is chiefly used for preparing apparatus for lectures, but boys are encouraged to come there and taught to make things for themselves.

There are, besides this, two or three turners' shops in the town, to which many boys go.

**Question 20** What text-books are in use? distinguishing between those for the junior and senior classes?

Chemistry { Junior—Wilson's Chemistry, Chambers's Course, Harcourt and Madan's Practical Chemistry.  
Senior—Fownes' Chemistry; Fresenius's Qualitative Analysis  
Physics. Balfour Stewart's Elementary Physics; Ganot's Physics.

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—There is a good school library, containing many standard scientific works, *e.g.*, Waite's Dictionary of Chemistry.

**Question 22** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—

#### *Tests of Progress.*

**Question 23** How often is the work tested?—A part of each lesson is spent in putting questions on the previous lesson.

Note-books are looked over and marked once a week. Two (or more) papers of questions are set in the course of the half.

There is an examination during the summer half conducted by independent examiners, in certain specified subjects, a list of which is published about a year previously.

**Question 24.** In what way? *e.g.*, by examination of note books, or by oral or written questions?—Answered under previous question.

**Question 25** By whom? by the teachers of the subjects, or by an independent examiner?—Answered under previous question.

#### *Teachers.*

**Question 26** Is there any difficulty in procuring competent science masters?—

**Question 27.** Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?—

**Question 28** What evidence of scientific qualification tendered by candidates is found to be of most value?—

**Question 29.** Can you state any results of science teaching in the school? such as—

(a.) Success, professional or otherwise, of individual scholars

(b.) Influence upon the general studies and intellectual life of the school.

Science work has, no doubt, brought out some (but not many) boys who have previously shown no interest in, or power over, their school studies.

Generally speaking, however, the best boys in Classics are the best also in Natural Science.

**Question 30.** Are any special rewards or encouragements (*e.g.*, exhibitions, scholarships, or prizes) open to successful students of science in the school?—A prize of 10*l*. and another of 5*l*. are given upon the results of the annual examination alluded to under question 23.

**Question 31** What improvements, do you think, could be effected in the teaching of science in your own school?—It would seem better to re-arrange the divisions for science work more completely than is now done. At present the boys (below the first hundred) are arranged mainly according to their classical or mathematical work, and there is some difficulty in organising a consecutive course of instruction for the boys.

A large room for a museum is also much wanted. There is a good nucleus for a geological collection, but no means of displaying it properly.

**Question 32** What are the principal obstacles to the teaching of science in your own school?—The natural unwillingness of parents and tutors to allow boys to give up much time to a subject which has not hitherto had much influence on a boy's place in the school, and which does not often serve as an introduction to any recognised career or profession. This unwillingness is quite justifiable, as also is the objection made, that boys ought not to be taught too many subjects at once.

**Question 33** How could the universities best assist Science teaching in schools?—By offering scholarships and prizes for Natural Science.

B b

By giving increased facilities for the training of men as Science masters. Lectures might be given (as occasionally at South Kensington) on modes of teaching. This would indirectly assist in the numerous cases where boys are never intended to go to the University, but enter at once a profession, such as engineering or applied chemistry, where a knowledge of science is requisite.

**Question 34.** Can you suggest any way in which Government could assist Science teaching in schools, as, for example, by inspection?—By grants or loans of apparatus, diagrams, &c. (as is done in the case of Art schools).

By occasionally sending lecturers, who might also be inspectors.

**Question 35.** Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

### ANSWERS BY REV. T. DALTON.

#### General Arrangements.

**Question 1.** How is the school classified?

**Question 2.** Is Science a necessary part of the school course, or is it taught only in special forms or departments?

**Question 3.** Copy of time table?

**Question 4.** Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)

**Question 5.** Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes?

Divisions I.—III. — { 3 classes in Chemistry  
1 class in Physical Geography.

IVth division, Chemistry

Divisions V.—XIV. formed until last schooltime { 6 classes in Physical Geography,  
3 classes in Astronomy  
8 classes in Mechanics and Hydrostatics.  
1 class in Heat.

Last schooltime.

Divisions V.—VIII. formed { 2 classes in Physical Geography,  
3 classes in Mechanics

Divisions IX.—XIV. had no Physical Science.

In Divisions I.—III there are 100 boys, whose ages vary (generally) from 17 to 19. They are allowed to choose two extra subjects out of about 10, and to each subject they give two hours a week. As I have said in my answer, three classes are formed in Chemistry, and one class in Physical Geography. The number of boys in each, last schooltime, was as follows:—

4 in 1st Chemistry class  
14 in 2nd " "  
8 in 3rd " "  
6 in Physical Geography class.

Division IV. consists of 34 boys, of ages varying generally from 16 to 18.

Divisions V.—XIV have generally all the same number of boys,—in most terms, 35 each.

The 13 classes into which I have said they are divided for Science Teaching, are on the average of the same size, which gives (33×10) boys for 13 classes, or about 25 boys in each class. Their ages usually vary from 14 to 18, though occasionally a boy of 12 is so advanced as to have reached this part of the school.

**Question 6.** Amount of knowledge required before the study of science is commenced.

**Question 7.** Is any alternative or choice of subjects offered?—Only in divisions I.—III.

What departments of Science are preferred?

(a.) By parents?—Chemistry has attracted most interest; perhaps, owing to the perfect arrangements for it.

(b.) By the boys?—My experience is in favour of elementary astronomy; but probably teachers of other subjects could produce equally favourable instances.

**Question 8.** What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?

**Question 9.** What weight is assigned to scientific attainments in determining a boy's position in the school?

#### Methods of Teaching.

**Question 10.** What proportions of the lessons take the form respectively of—

- Oral teaching and demonstration?
- Book work?
- Practical work?

I can best answer this and the following questions together.

I have generally taught elementary astronomy for two consecutive schooltimes to the same class. The first schooltime no text book is used; I usually give a general explanation of the lesson, then I dictate a brief resumé of this explanation, which the boys take down in their note books; the next lesson is begun by a thorough examination, *word voc.*, of what was learnt the previous time; this probably occupies one-third of the time of the lesson, the remainder being used as before in explanation and dictation of the next part of the subject.

The second schooltime we use Mr. Lockyer's Astronomy. My method with this is to give a short explanatory account of what the lesson contains, and the next time to question thoroughly upon it.

One hour in about 7 or 8 is given to an examination paper.

In explaining, I, of course, make considerable use of the black-board.

I may add that, as far as my experience goes, rigorous oral questioning is most important, and is much more necessary in teaching Physical Science than other subjects.

**Question 11.** Which form of lesson is found to be most effective?

**Question 12.** How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?

**Question 13.** Is the use of note books encouraged (a) during, or (b) after the lesson, and to what extent?—During the lesson. See answer to Q. 10.

**Question 14.** How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Two prizes are given for the best collection of wild flowers and of insects. The boys collect for these during the schooltime.

**Question 15.** Describe any method of teaching some special branch of science which has been found successful in your school.

#### Instruments of Teaching

**Question 16.** What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden &c.) is made for Scientific Instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible accompany this return.)

I send with this a small photograph of the telescope. It was made by Cooke of York. It is of 6-inch aperture, and cost 350*l.* The observatory is on the top of a school tower, the expense of strengthening the tower by girders, and of the dome and fittings, &c., was between 250*l.* and 300*l.*

**Question 17.** Number of assistants and curators, and annual cost?

One assistant helps in the laboratory; part of his duty is to clean out the observatory, and look to the instrument.

**Question 18.** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?

There is no fixed sum; the school fund bears the expense of keeping the observatory in order. It also pays for whatever is required at the laboratory beyond a payment of 10*s.* made by each boy who is making experiments.

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose, is it used?

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes.

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?

**Question 22.** Is there any Scientific Society or Club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?

#### Tests of Progress.

**Question 23.** How often is the work tested?—Once in three or four weeks by a written examination. Three times a year by a paper on the work of the school time; also once a year by the examination (trials) for change of form.

**Question 24.** In what way? e.g. by examination of note books or by oral or written questions?—By written questions.

The note books are examined frequently during the schooltime.

*Question 25.* By whom? by the teachers of the subject, or by an independent examiner?

*Teachers.*

*Question 26.* Is there any difficulty in procuring competent Science masters?

*Question 27.* Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?

*Question 28.* What evidence of scientific qualification tendered by candidates is found to be of most value?

*Question 29.* Can you state any results of Science teaching in the school? such as—

(a.) Success, professional or otherwise, of individual scholars.

(b.) Influence upon the general studies and intellectual life of the school.

The subject has hardly been introduced long enough to produce success at the Universities. I think it has had a beneficial result upon the school, both generally, and in the case of individuals. Almost all boys have had a certain amount of interest excited in them for this branch of knowledge; in several cases boys who have shown no aptitude for classics or mathematics have done extremely well in, and really worked at, Physical Science, but as a rule, boys who are good in classics or mathematics, are good also in Science.

*Question 30.* Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of Science in the school?

*Question 31.* What improvements, do you think, could be effected in the teaching of Science in your own schools?

*Question 32.* What are the principal obstacles to the teaching of Science in your own school?

The whole tone of the school has, until lately, been so absolutely classical, that Science had to start with a certain amount of prejudices against it; this, I think, it has certainly overcome, it being now generally allowed that the subject has done good work for the boys. The rewards for success in classics are, however, so great that a boy must hesitate about endangering his progress in them, and it is difficult to reward him adequately for success in Science.

*Question 33.* How could the Universities best assist Science teaching in schools?

*Question 34.* Can you suggest any way in which Government could assist Science teaching in schools, as, for example, by inspection?

*Question 35.* Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

ANSWERS BY REV. E. HALE.

*General Arrangements.*

*Question 1.* How is the school classified?

*Question 2.* Is Science a necessary part of the school course, or is it taught only in special forms or departments?

*Question 3.* Copy of Time Table.

*Question 4.* Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately.)

*Question 5.* Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes.

*Question 6.* Amount of knowledge required before the study of Science is commenced.

*Question 7.* Is any alternative or choice of subjects offered?—Yes.

What departments of Science are preferred?

a. By parents?—Parents require Science, but seem to have no preferences.

b. By the boys?—I think physical geography and chemistry (when this latter is not taught in a large school division).

*Question 8.* What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?

*Question 9.* What weight is assigned to scientific attainments in determining a boy's position in the school?

*Methods of Teaching.*

*Question 10.* What proportions of the lessons take the form respectively of—

(a.) Oral teaching and demonstration?—There are two sorts of classes in physical geography. One a

small select class of boys who are older, the other divisions of 30 boys or more. In the former, text-books are used, but in the latter no text-book is used except a physical atlas.

(b.) Book work?—The teaching is oral, maps, diagrams, and photographs, and specimens of fossils (or prints) being used to exemplify the teaching. There are two lessons weekly. Each boy brings weekly an abstract of the two lessons. These abstracts are returned to them looked over and marked. After eight or 10 lessons an examination paper is set and carefully looked over and marked.

(c.) Practical work?—

*Question 11.* Which form of lesson is found to be most effective?—For a large class, oral teaching.

*Question 12.* How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?—When text-books are used (as for the small select class mentioned), a portion of the text-book is explained, further illustrations are given, and before the next lesson the pupils bring an analysis of that portion which has been already explained to them.

*Question 13.* Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—The use of note books during the lesson is encouraged. Some notes are dictated to the pupils, others are taken by the boys.

*Question 14.* How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—Prizes are given for the best collections (systematically arranged) of wild flowers and insects.

*Question 15.* Describe any method of teaching some special branch of science which has been found successful in your school.

*Instruments of Teaching.*

*Question 16.* What special provision (e.g., laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

*Question 17.* Number of assistants and curators, and annual cost.

*Question 18.* What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c.?

*Question 19.* Is there a workshop? and if so, how, and for what particular purpose, is it used?

*Question 20.* What text-books are in use? distinguishing between those for the junior and senior classes?—Keith Johnston's Physical Atlas for Schools (for all boys). In the small select class individual boys have used Mrs. Somerville's Physical Geography, Herschel's Physical Geography, Lyell's Elements and Principles, Tyndall on Heat.

*Question 21.* To what books of reference, other than ordinary school books, have the scholars access?—There is an excellent school library, to which the boys have access, and any books recommended by the science teachers are purchased for the library.

*Question 22.* Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—A literary and scientific society, managed by the boys, and the members elected by them. The members read papers, and a discussion takes place. Occasionally lectures are given by persons not resident at Eton, by invitation of the Society.

*Tests of Progress.*

*Question 23.* How often is the work tested?—Yearly, a general examination is held for deciding places in the school, and a paper on the scientific work of the school for that year is set.

There are frequent class examinations, by printed papers, and every week the note-books or abstracts of lessons are looked over.

*Question 24.* In what way? e.g., by examination of note books or by oral or written questions?—As stated before, in both ways.

*Question 25.* By whom? by the teachers of the subjects, or by an independent examiner?

## Teachers

Question 26 Is there any difficulty in procuring competent Science masters?

Question 27. Where are they best obtained? Have they been specially trained for the work; and if so, in what does such training consist?

Question 28 What evidence of scientific qualification tendered by candidates is found to be of most value?

Question 29. Can you state any results of Science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars

(b) Influence upon the general studies and intellectual life of the school

(a) The time since which Science has been taught is too short to admit of any professional success, but of three candidates in 1872 for the medals of the Royal Geographical Society, two of the four medals were gained by them, and the other boy received honourable mention.

(b) Intellectual activity is promoted, and habits of thought and observation are gained. Proofs of this are, that boys not remarkable for proficiency or the interest they take in their usual studies, are sometimes full of interest in learning science, and in rarer instances enthusiastic.

Question 30. Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of Science in the school?

Question 31. What improvements, do you think, could be effected in the teaching of Science in your own school?—By a systematic division of subjects, allotting a certain course for certain school periods, and by making this course progressive

I think, for efficient Science teaching, every boy should be taught Erd-kunde, in some such course as the following—

- (i.) The earth's position in the Solar system.
- (ii.) The Atmosphere, Solar Heat (Rain, Snow, &c.).
- (iii.) Very elementary Geology.
- (iv.) Changes in the physical features of the Earth's Surface caused by Rain, Rivers, Ice, Snow, &c.
- (v.) The Sea, Tides, Winds, Climate.
- (vi.) Various divisions of animals and plants on the earth's surface, and their distribution

After each boy has gone through a course of this, he should choose one of three divisions.

Div. (a) Astronomy, Mechanics, Hydrostatics, &c., and a boy choosing this division should give extra time to mathematics

Div. (b) Chemistry, Heat, Electricity, &c.  
Div. (c) Geology, Zoology, Botany, &c.

Question 32 What are the principal obstacles to the teaching of Science in your own school?

(i.) The divisions of the school being made with reference to the classical work only.

(ii) The want of a museum and lecture-room.

(iii.) The belief among parents and masters that Science does not "pay," and is more play than work.

Question 33. How could the Universities best assist Science teaching in schools?—By offering better rewards to successful scientific men at the University, e.g., by more Fellowships. (I refer more to Cambridge than to Oxford)

Question 34 Can you suggest any way in which Government could assist Science teaching in schools, as for example, by inspection?—By inspection, but not by examination.

Question 35 Have you any other information to give or suggestion to make, likely to be helpful to the Commissioners?

## 20. DULWICH COLLEGE.

(UPPER SCHOOL.)

General Arrangements.

Question 1. How is the school classified?—The school is divided into three sections (the junior section, the senior section, and the sixth form), within each of which an independent classification is made for each subject or group of subjects in which instruction is given.

The subjects of instruction are grouped as follows:—

In the junior section—

1. Form work, including English, Latin, and French.
2. Arithmetic.
3. Drawing

In the senior section and sixth form—

1. Form work, including English, Latin, and French.
2. Mathematics.
3. Greek
4. German.
5. Physical science
6. Drawing.

Question 2. Is science a necessary part of the school course, or is it taught only in special forms or departments?—Instruction in science is open to all boys in the senior section and in the sixth form, but is not compulsory, except so far that all boys not learning Greek and the higher classes are required to take up at least one subject in science.

Question 3 Copy of time table?

GENERAL TIME TABLES.—SIXTH FORM, 1ST TERM, 1873

Day.	A. (1)—CLASSICAL.		A. (2).—MATHEMATICAL AND MODERN.	
	Time.	Scheme	Time.	Scheme.
MONDAY	9-11	Form Work.	9-11	Form Work.
	11-12 30	Mathematics.	11-12 30	Mathematics.
	2-2 30	Higher Classics	2-3 30	Mathematics.
TUESDAY	3 30-4 30	French.	3 30-4 30	French.
	9-11	Form Work.	9-11	Form Work.
	11-12 30	Higher Classics	11-12 30	Physical Science.
WEDNESDAY	2-3 15	Higher Classics (or German).	2-3 15	German.
	3 15-4 30	Higher Classics.	3 15-4 30	Mathematics.
	9-11	Form Work.	9-11	Form Work.
THURSDAY	11-1	Special Classes	11-1	Special Classes.
	9 10	Form Work.	9-10	Form Work.
	10-11	Mathematics.	10-11	Mathematics.
FRIDAY	11-12 30	Form Work.	11-12 30	Form Work.
	2-3 30	Higher Classics.	2-3 30	German.
	3 30-4 30	French.	3 30-4 30	French.
SATURDAY	9-10	Form Work.	9-10	Form Work.
	10-11 30	Higher Classics.	10-11 30	Mathematics.
	11 30-12 30	Form Work.	11 30-12 30	Form Work.
SATURDAY	2-3 15	Higher Classics (or German).	2-3 15	German or Mathematics.
	3 15-4 30	Higher Classics.	3 15-4 30	Mathematics.
	9-10 30	Form Work.	9-10 30	Form Work.
SATURDAY	10 30-11	Higher Classes.	10 30-11	Physical Science.
	11-1	Special Classes	11-1	Special Classes.

NOTE.—Form work includes Latin, English, and Divinity.

Special Classes from 11 to 12 and 12 to 1. The choice is offered between Drawing, Greek, French, German, Physical Science, and Mathematics.



## DETAILED TIME TABLES.—SIXTH FORM, 1ST TERM 1873.

CLASSICAL.			MATHEMATICAL AND MODERN *	
Day.	Time	Scheme.	Time	Scheme.
MONDAY	9-10	Grammar Paper (Latin or Greek)	9-10	Grammar Paper (Latin or German)
	10-11	Divinity	10-11	Divinity
	11-12 30	Mathematics.	11-12 30	Mathematics.
	2-3 30	Greek	2-3 30	Mathematics.
	8 30-4 30	French	3 30-4 40	French.
	Evening Work.	Greek Rep Mathematics. Latin Verse	Evening Work.	Mathematics German
TUESDAY	9	Greek Rep	9-11	Latin
	9 15-11	Latin	11-12 30	Physical Science.
	11-12 30	Greek	2-3 15	German
	2-3 15	First-sight Trans. (or German)	3 15-4 30	Mathematics
	3 15-4 30	Greek Prose.	Evening Work.	Latin with Rep French.
	Evening Work.	Latin with Rep French		
WEDNESDAY	9	Latin Rep.	9	Latin Rep
	9 15-10 30	Latin.	9 15-10 30	Latin
	10 30-11	Correction of Paper Work in Class	10 30-11	Correction of Paper Work in Class
	11-1	(Special Classes.)	11-1	(Special Classes.)
		Evening Work.	Evening Work.	Science Mathematics. History Latin
THURSDAY	9-10	Latin.	9-10	Latin.
	10-11	Mathematics.	10-11	Mathematics.
	11-12 30	History	11-12 30	History
	2-3 30	Greek	2-3 30	German or Mathematics
	3 30-4 30	French	3 30-4 30	French
	Evening Work.	English Literature and Rep Latin	Evening Work.	English Literature and Rep Latin
FRIDAY	9	English Rep	9	English Rep.
	9 15-11	Latin.	9 15-10	Latin
	10-11 30	Greek	10-11 30	Mathematics
	11 30-12 30	English Literature	11 30-12 30	English Literature.
	2-3 15	Greek Prose (or German)	2-3 15	Mathematics.
	3 15-4 30	First-sight Translations	3 15-4 30	German.
	Evening Work.	Greek with re-translation French Greek Verse.	Evening Work.	Mathematics. German
SATURDAY	9-10 30	Latin	9-10 30	Latin
	10 30-11	Greek.	10 30-11	Physical Science
	11-1	(Special Classes.)	11-1	(Special Classes.)
	Evening Work.	Latin or Greek Grammar. Divinity (English Essay).	Evening Work	Science. Mathematics. Grammar (Latin or German). Divinity English Essay

The English Essay is set on Saturday, and is delivered up on the following Saturday

Essays and Classical Compositions are looked over with each boy separately during Preparation Time.

In the Special Classes a "Classical" boy will generally take up either Classics entirely, or Classics and German, but he has the option, under the usual restrictions, of any of the other Special Subjects.

In the Special Classes a "Mathematical" boy will generally take up Science and Mathematics; but he has the option, under the usual restrictions, of any of the other Special Subjects.

\* *Science Students*—On Wednesday afternoons (after ordinary school hours) a lesson is given in Analytical Chemistry, with practical work in the laboratory 1 to 2 hours

If a Science Student wishes to take up an additional subject, he can do so on Tuesday and Friday afternoons. In this case the necessary time (2½ hours for instruction, and 1½ hours for preparation) is obtained either by relinquishing German, or by reducing the time devoted to Mathematics.

GENERAL TIME TABLES.—SENIOR SECTION, 1ST TERM, 1873.

TABLE B—SENIOR SECTION.			
Day.	Time.		
MONDAY	9-12 30 2-3 15 3.15-4.30	Form Work French Form Work.	
TUESDAY	9-11 11-12.30 2-3 15 3 15-4 30	Mathematics. Form Work. Greek } German. } Physical Science.	
WEDNESDAY	9-11 11-1	Form Work. (Special Classes.)	
THURSDAY	9-10 10-11 11-12.30 2-3.15 3.15-4 30	Form Work Greek } German or } Science. Mathematics. French. Form Work.	
FRIDAY	9-11 11-12 30 2-3 15 3 15-4.30	Mathematics. Form Work. Greek } German. } Physical Science.	
SATURDAY	9-11 11-1	Form Work. (Special Classes)	

Form work includes Latin, English, and Divinity (also writing in the Lower Forms)

Special Classes from 11 to 12 and from 12 to 1 The choice is offered between Drawing, Greek, French, German, Physical Science, and Mathematics.

\* Science Students.—On Wednesday afternoons Laboratory Work as for the Sixth Form.

If a Science Student wishes to take up an additional subject he can do so during the time assigned to "Special Classes" on Wednesdays and Saturdays

Question 4 Summary of hours per week given in each class to different subjects (If playtime is utilized for preparation or practical work, this should be shown separately)

TABLES indicating the distribution of time among the several Subjects of Study, with an estimate of the time spent in Evening Preparation

SIXTH FORM.

Classical.	School Work Hours	Evening Work Hours.	Hours.	Mathematical.	School Work Hours.	Evening Work Hours.	Hours.
English - - -	4½	6½	11½	English - - -	3½	5	8½
Latin - - -	7½	7	14½	Latin - - -	7½	4	11½
French - - -	2	1½	3½	French - - -	2	1½	3½
Mathematics - -	2½	1½	4	Mathematics, including } Special Class - - - }	11½	5	16½
Greek and Higher Classes	11	3½	14½	German Class - - -	3	2½	5½
Special Classes— Either Classics or German - - -	4	0	4	Science - - -	4	—	4
	32	20½*	52½		32	18	50

\* Evening Work includes a Divinity Lesson (presumed to be learnt on Sunday) and Composition.

Science Students.—During School hours (as above) - - - 4 hours.  
After School hours - - - - - 2 "

Do. Additional Branch of Science - - - - - 4

Time available for Science Study - 10 hours.

SENIOR SECTION.—Distribution of time in one of the Forms of the Senior Section

Classical	School Work.	Evening Work	—	Mathematical.	School Work.	Evening Work.	--
English - - -	8½	8	11½	English - - -	9	7	10
Latin - - -	11	4½	15½	Latin - - -	11	4½	15½
French - - -	2½	2	4½	French - - -	2½	2	4½
Mathematics - -	5½	1½	7	Mathematics - -	9½	2½	12
Greek - - -	—	—	—	German - - -	2½	2	4½
Do (Special) -	2	2	9½	Physical Science -	3½	—	3½
One Special Class	—	—	2				
	32	17½	49½		32	17½	49½

Science Students—During Schools hours (as above) - - - - 3½ hours.  
 After School hours - - - - - 2 " "  
 Do. Additional Branch of Science - - - - 5½ " "  
 Time available for Science Study - - - - 7½ " "

Question 5 Summary of the number and average age of boys learning each of the various subjects in the Natural Science classes?

	Average age
Chemistry, 1st class - -	21 boys. 15½
" 2nd class - -	18 " 13½
Practical chemistry, 1st class	9 " 15½
" 2nd class	12 " 13½
Electricity and magnetism	32 " 14½
Geology - - -	35 " 14½
Physical geography - -	16 " 14½

I have stated the actual average age, but the return in this respect is illusory, since the recent increase of the school (from 130 to 500 boys), and the excess in consequence of young boys lately admitted, reduces the average of age below its normal amount.

Question 6. Amount of knowledge required before the study of science is commenced?—Instruction in science is open to all boys in the senior section and in the sixth form.

Boys entering the senior section are presumed to have a fair elementary knowledge of English, French, Latin, and arithmetic.

Question 7 Is any alternative or choice of subjects offered?—The science subjects are grouped as follows—

- I. Chemistry, with laboratory work.
- II. Physics (at present elec- } alternative subjects taught
- tricity and magnetism) } at the same time by dif-
- Geology - - - } ferent masters.
- III. Physical geography

Boys have the opportunity of receiving instruction in one or more of these groups.

What departments of science are preferred?

- a. By parents? I have no sufficient data at present
- b. By the boys? ] for answering these questions.

Question 8. What branch of science receives most attention in the school, or is found by experience to have the greatest educational value?—A continuous course of instruction is given in chemistry.

Instruction is given from time to time in other branches of science—heat, electricity, magnetism, geology.

I am decidedly of opinion that chemistry possesses the greatest educational value.

Question 9 What weight is assigned to scientific attainments in determining a boy's position in the school?—The classification for science is entirely independent. Prizes are awarded in each class at the annual examination. In the award of exhibitions 200 marks are assigned to science as against 220 to English, 220 to Latin, 150 to each modern language, 150 to elementary mathematics, and 300 to the higher mathematics.

Methods of Teaching

Question 10. What proportions of the lessons take the form respectively of—

- (a.) Oral teaching and demonstration?—Each of the classes receives two lectures per week of an hour or an hour and a quarter each.
- (b.) Book work?—Book work is got up during the "preparation time," which, for the more advanced pupils, amounts to about two hours for chemistry and one hour and a half for physics.
- (c.) Practical work?—One hour a week, for advanced pupils two hours.

A course of evening lectures (generally four or five lectures) on some branch of science is also given in each

term. Attendance at these lectures is voluntary. They are open to all boys, whether pupils in any of the science classes or not.

Question 11. Which form of lesson is found to be most effective?—No one of them can be dispensed with, without impairing the efficiency of the entire system of instruction.

Question 12 How are text-books used? e.g. Is book work supplementary or preparatory to the oral lesson?—Generally as supplementary to the oral instruction.

Question 13 Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?—All boys are required to take notes at the lecture, and to get up the substance of their notes during preparation time in the intervals between the science lessons.

The note books are examined from time to time by the science master.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—At the practical chemistry class the boys prepare their own apparatus and experiments.

At the lectures the boys are told off in turn, one from each class, to assist the science master in preparing the apparatus and making the experiments.

Question 15 Describe any method of teaching some special branch of science which has been found successful in your school?

Instruments of Teaching.

Question 16 What special provision (e.g. laboratory, lecture room, observatory, museum, botanic garden, &c) is made for scientific instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

(1) A very complete laboratory, with all the most approved appliances, and capable of accommodating 36 students. To this is attached a smaller laboratory for a few more advanced pupils.

(2) A lecture theatre, fitted with moveable desks for taking notes, and with pneumatic trough, Bunsen burners, and appliances for experimental purposes at the lecturer's table. The theatre will accommodate about 230 boys at the desks, and 300 when the desks are removed.

(3.) The formation of a museum of geology and natural history has been lately commenced.

The laboratory is used for practical work, under supervision of the instructor in chemistry, two hours per week.

The theatre for lectures on chemistry or physics four hours a week, and for the courses of evening lectures.

No plans are available.

The cost of construction being included in the general contract for the erection of the new buildings, is not on record, and could not, I fear, be estimated without much difficulty.

Question 17. Number of assistants and curators, and annual cost?

A teacher of chemistry, 120l. a year

A teacher of physics (who is also a form master), part of salary apportioned to science, 80l. a year.

The services of the working engineer and of one or more of the college servants are employed in this department as required.

Separate payment is made for the evening lectures.

**Question 18** What apparatus, diagrams, and special fittings are in use? what was their cost? and what sum is allowed yearly for new instruments, and to replace materials used, &c?—Apparatus, diagrams, &c are being gradually provided. 75l was expended in 1871 on the purchase of apparatus, and about 30l last year.

There is no fixed sum appropriated for this purpose.

**Question 19.** Is there a workshop? and if so, how, and for what particular purpose, is it used?—Not at present.

**Question 20.** What text-books are in use? distinguishing between those for the junior and senior classes?

**Chemistry**—

1st class—Miller's Inorganic Chemistry.  
Gill's Chemistry for Schools.  
Harcourt and Madan's Practical Chemistry.  
Fresenius's Qualitative Analysis.

2nd class—Roscoe's Chemistry ("Science Primer").

**Physics**—

Balfour Stewart's Elementary Physics.  
Deschanel's Natural Philosophy.

**Geology**—

1st class—Jukes's Student's Manual of Geology.  
2nd class—Page's Introductory Text Book.  
Jukes's School Manual of Geology

**Question 21.** To what books of reference, other than ordinary school books, have the scholars access?—A few scientific books in the College library (to which the boys have access by special leave) and in the boys' school library

**Question 22.** Is there any scientific society or club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—No.

*Tests of Progress.*

**Question 23.** How often is the work tested?—At the end of each term, and also by partial examinations two or three times during the course of the term

**Question 24.** In what way? e.g., by examination of note books or by oral or written questions?—At the terminal and general examinations by printed papers, at the intermediate examinations orally and by dictated papers

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—At the end of each term by one of the masters in the College not being the teacher of the class examined; and at the general examination of the school in June by an independent examiner, at the intermediate examinations by the teacher of the class.

*Teachers.*

**Question 26** Is there any difficulty in procuring competent science masters?—There is at present some difficulty, but (I think) a decreasing one, in obtaining as science masters highly cultivated men who have received an university education.

**Question 27.** Where are the best obtained? Have they been specially trained for the work; and if so, in what does such training consist?—I have been able to obtain two well-qualified masters who have been educated at German universities, and one who has taken first-class honours in the science tripos at Cambridge.

**Question 28.** What evidence of scientific qualification tendered by candidates is found to be of most value?

**Question 29.** Can you state any results of science teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars?

(b) Influence upon the general studies and intellectual life of the school?

The science classes are of too recent formation to justify me in speaking definitely of the results.

With respect to the influence of science teaching upon the general studies and intellectual life of the school, I expressed my views in a statement which I had the honour to submit to the Commissioners in February 1871 (see p. ) My subsequent experience has not led me in any way to modify the favourable opinion which I then entertained.

**Question 30** Are any special rewards or encouragements (e.g., exhibitions, scholarships, or prizes) open to successful students of science in the school?—Prizes are given for each branch of science and in every class. The marks obtained in the science examinations are combined in a fixed proportion with those for other subjects of study, to form the aggregate upon which the award of exhibitions is made.

**Question 31** What improvements, do you think, could be effected in the teaching of science in your own school?—The system is now in process of development, and is receiving further extension and improvement every term.

**Question 32** What are the principal obstacles to the teaching of science in your own school?

**Question 33.** How could the universities best assist science-teaching in schools?—Most effectually, I believe, by offering rewards to science students within the universities themselves.

If the proposed scheme of examination of schools by the universities is adopted, the science-teaching must of course be subjected to the same tests as the other subjects of study

**Question 34** Can you suggest any way in which Government could assist science-teaching in schools, as, for example, by inspection?

**Question 35** Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

ALFRED J. CARVER,  
Master of Dulwich College.

April 7th, 1873

21. FRIENDS' BOYS' SCHOOL, YORK.

*General Arrangements*

**Question 1.** How is the school classified?—Into four classes for the general English instruction. The language classes are to some extent distinct; for drawing, also, and partially for science, classes are occasionally thrown together, or the arrangements are modified.

**Question 2** Is Science a necessary part of the school course, or is it only taught in special forms or departments—To some extent it is taught to all the boys.

**Question 3.** Copy of Time Table?—

SENIOR CLASS.

TIME.	MONDAY	TUESDAY	WEDNESDAY	THURSDAY.	FRIDAY	SATURDAY.
7-8 A.M.	French	Science	Mental Arith- metic.	Latin	French	Arithmetic.
9-10½	German	Greek	Writing	Latin	German	Latin.
10½-11½	French	Dictation and Writing.	Meeting for Di- vine Worship	English	Physics or Arith- metic.	Greek.
12-1 P.M.	Mensuration	Drawing	Greek or Drill	Science	Drill, Mental Calculation.	Drawing.
3-3½	Euclid	History	-	History	Euclid	-
3½-4½	Algebra	Do	-	Do	Algebra	-
4½-5	Reading	Compound Ad- dition.	-	Compound Ad- dition	Reading	-
Evening Work.	Lecture	Prepare Greek (or Dictation).	Prepare Latin	Prepare German, and ditto ½ hour's Arith- metic or Phy- sics.	Prepare Latin and Greek.	Prepare French and German.

SECOND DIVISION

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
7-8 A.M.	German or Writing	Latin - -	Mental Arithmetic.	Latin - -	German or Writing	Prepare Latin.
9-10½	French	Greek - -	Writing - -	Latin - -	French - -	Latin
10½-11	Dictation	Drawing	Meeting for Divine Worship.	Writing and History	Dictation	Science
11-11½	Science	Drawing	- - -	History	Arithmetic	Spelling and Writing
12-1 P.M.	Geography	English Grammar	Arithmetic and Drill.	Geography	Drill and Mental Calculation.	History
3-4½	Mensuration	Arithmetic	- - -	Drawing and Reading	Algebra	- - -
4½-5	Reading	Reading	- - -	Euclid	Etymology	- - -
Evening Work	Prepare Greek and Latin, &c.	Prepare Greek	Prepare Latin	Prepare French and German, &c	Lecture	Prepare French, German, &c

Question 4 Summary of hours per week given in each class to different subjects. (If playtime is utilized for preparation or practical work, this should be shown separately.)

In the Senior Class—  
 Latin - 3½ hours + 1½ hour (say) preparation.  
 Greek - 3½ " + 1 " "  
 French - 3½ " + ½ " "  
 German - 2½ " + 1½ " "  
 Arithmetic and Mensuration, 4, or for boys not taking the Theoretical Physics, 5½

Euclid, 1½  
 Algebra, 1½, or, including the Physics, 2½  
 Writing, Spelling, &c., 2½  
 History, 3  
 Science Lecture, 1½, Classwork, 2; total 3½  
 Junior Class—Few of these boys learn German, and none Greek, the time being mostly given to Arithmetic and Writing, approximately

Latin 3½ hours + 1½ preparation.  
 French 3½ " + 1 " "  
 English Grammar, 1½ hour  
 Scripture, 1 hour (besides Sunday)  
 Arithmetic, 6 hours  
 Writing and Spelling, 4½ hours.  
 Reading, 2 hours  
 Drawing, 2 hours.  
 Geography, 1½ + ½ hour preparation.  
 History, ditto.

Science, 1½ hour, lecture; 1½ hour, class.  
 The Second Division can be deduced from Table above  
 The Third Division is nearly as the Junior Class

Question 5 Summary of the number and average age of boys in the different Natural Science Classes learning each of the various subjects?

Senior class	- 20	Average age	- 15½
Second "	- 21	" "	- 14½
Third "	- 15	" "	- 13
Junior "	- 8	" "	- 11½

The subjects vary from year to year, the Senior Class are now taking Physiology and Optics, the Lower Class, Acoustics and Physiology. Chemistry forms a regular part of nearly every year's course

Question 6. Amount of knowledge required before the study of Science is commenced?—No fixed line laid down

Question 7. Is any alternative or choice of subjects offered?—Not in the regular lectures and lessons. A good deal of leisure time is often devoted by some of the boys, voluntarily, to different departments of Natural History (e.g. Botany, Entomology, &c.), or to Astronomy or Chemistry

What departments of Science are preferred?  
 (a) By parents?—Beyond incidental remarks, we have no means of judging as to this point.  
 (b) By the boys?—Chemistry and Physiology; also, by a few of the elder boys, Astronomy.

Question 8. What branch of Science receives most attention in the school, or is found by experience to have the greatest educational value?—In different sessions our Science instruction is directed to different branches, but probably, on a general view, we might say that Chemistry, Mechanics, and Astronomy receive the largest share of attention, as direct school subjects, to which we must add Botany and Entomology for the pursuits of leisure time.

Question 9. What weight is assigned to scientific attainments in determining a boy's position in the school?—The

Science classes rank on equal terms with those on any other subjects. A boy at the top of his class in the Science lessons for any month, takes as much advantage as if he were at the top of his Latin or French class, or his class in Arithmetic or Geography.

Methods of Teaching.

Question 10. What proportions of the lessons take the form respectively of—

- (a.) Oral teaching and demonstration?
- (b.) Book work?
- (c.) Practical work?

One experimental lecture weekly to the Senior Class of about 20 boys, one ditto to the rest of the school (about 45 boys). The notes taken in these lectures are studied afterwards, and either the special Science teacher, or one of the regular class teachers, questions upon these in class. The boys have some elementary manual to refer to in preparing for these questionings. The practical work is pretty much confined to two or three elder boys, who assist in preparing for the lectures, except in regard to Astronomy, where the Observatory affords opportunity to a good many boys belonging to the Senior Class, to learn the use of instruments.

Question 11. What form of lesson is found to be most effective?—We think the combination described in answer 10 the best adapted to our circumstances

Question 12. How are text-books used? e.g., is book work supplementary or preparatory to the oral lesson?—Supplementary to the lectures, preparatory to the questioning

Question 13. Is the use of note books encouraged (a) during or (b) after the lesson, and to what extent?

- (a.) During the lecture the boys take as copious notes as may be, and these they are expected to study afterwards.

Only the Senior Class take notes in ink, the rest in pencil, copying them out afterwards under the direction of a teacher.

Question 14. How far are boys required to prepare their own apparatus or experiments, or to collect specimens during the intervals between lessons?—See answer 10.

The collection of Botanical, Conchological, Entomological, Geological, and other specimens, has long been encouraged as a pursuit for leisure time, and very successfully practised

See reports of N'H Society accompanying

Question 15. Describe any method of teaching some special branch of Science which has been found successful in your school?

Instruments of Teaching

Question 16. What special provision (e.g. laboratory, lecture room, observatory, museum, botanic garden, &c.) is made for Scientific Instruction, and how is it used?

(Plans and descriptions of these, with statements of their cost and annual expense, should, if possible, accompany this return.)

We have a lecture room, seating about 43 comfortably, with writing desk in front of the forms, much like the desks at University College, London. The room is rarely used for scientific lectures with more than about 40 at a time, but the whole school can be accommodated. A small laboratory adjoining is used by the Science teacher and any boys engaged in assisting him. The observatory, contain-

ing an equatorially-mounted refracting telescope of 41-inch aperture, by Cooke of York, a small transit instrument, and sidereal clock, cost altogether about 250*l*. A room fitted up as a museum contains a portion of the specimens belonging to the school Natural History Society, embracing a large and valuable series of Geological and Mineralogical specimens, a herbarium, a collection of shells, insects, eggs, &c. We have also a number of mechanical models, working models of steam engines, and the like, some the property of the school, some belonging to one of the teachers, who has occasionally lectured on the steam engine and kindred subjects.

**Question 17** Number of assistants and curators, and annual cost?

**Question 18.** What apparatus, diagrams, and special fittings are in use, what was their cost; and what sum is allowed yearly for new instruments, and to replace materials used, &c.?—See answer 16, *supra*.—The Science teacher has been accustomed to provide what he deemed needful, within moderate limits, for his lectures, and charge the amount to the school funds, any special outlay being first proposed to the superintendent for his sanction. The cost last year of the lectures, as to materials, wear and tear, breakage, &c., may be roughly estimated at 6*l*. 6*s* to which should be added about 4*l* for repairs of observatory instruments, and some connected with the workshop (refitting of part of a lathe).

The apparatus, diagrams, &c., have accumulated through a long series of years, and it would be difficult to give an estimate as to cost.

**Question 19** Is there a workshop, and, if so, how and for what particular purpose is it used?—There is a workshop, much used by some of the boys in their leisure time. It is provided with two lathes, a fret saw machine, carpenter's bench, and suitable tools. A small subscription from the boys meets current expenses, with occasional grants from the school funds for any special outlay required. Usually at the end of a session, when an exhibition of the results of out-of-school work is held, a large number of specimens of turning, fret-cutting, and the like, are produced; not, perhaps, anything very elaborate, as a general rule, but often evincing a good deal of painstaking effort.

**Question 20** What text-books are in use, distinguishing between those for the junior and senior classes?—Most of the junior boys are supplied with Nos. 2 and 3 of the recently issued Science primers. The upper boys use such books as Roscoe's or Williamson's Chemistry, Balfour Stewart on Heat, Herschel's Astronomy, Newth's and Wornell's books on Theoretical Physics (Mechanics, Hydrostatics, Optics, &c.), Barff's Chemistry.

**Question 21** To what books of reference, other than ordinary school books, have the scholars access?—Some of those mentioned in answer 20 are perhaps rather used as books of reference than as "school books." In addition to them the school library contains, among others,—  
Ary's Lectures, &c.  
See catalogue of books, pp. 13-19.

**Question 22.** Is there any Scientific Society or Club in connexion with the school? and if so, who compose it, how is it worked, and what is its influence on the boys?—The Natural History and Polytechnic Society consists practically, and has done for many years, of all the scholars and teachers, the subscription being purposely kept almost nominal, about 2*s* per annum as a minimum. There were times, 20 years ago, or more, when only a small part of the boys joined it, it is now a matter of course for every one to do so. A Committee of elder scholars and teachers, annually elected, manage the affairs, and take care of the collection belonging to the Society. A yearly exhibition is held of collections of plants, shells, insects, &c., made by members during the year, small prizes being given from the Society's funds for them, as well as for Essays, Natural History diaries, Observatory registers, and in the Polytechnic Department, the exhibitions for which are half-yearly, for drawings, turnery, fretwork, &c., &c. Photography, electrotyping, taxidermy, the preparation of skeletons, and various other pursuits, have occasionally been added to those mentioned above.  
(See Reports sent herewith.)

#### Tests of Progress

**Question 23** How often is the work tested?—The ordinary school work is registered, and places in class revised by these registers about every six weeks. A written examination, embracing, of course, the scientific as well as the other instruction given in the school, takes place each year before the Midsummer vacation.

A few of the older boys have for the last year or two sat at the South Kensington local examinations in mathematics (elementary), chemistry, and physics; their doing so was not compulsory, but those who had taken an interest in these subjects were encouraged to try the examination this year, three took the mathematics, all of whom passed; eight or nine the physics, six of whom passed; and about 12 the chemistry, of whom three, I believe, failed.

**Question 24.** In what way? e.g. by examination of note books merely, or by oral or written questions?—The class work, of which registers are taken (see 23) is conducted both by oral and written questions.

**Question 25.** By whom? by the teachers of the subjects, or by an independent examiner?—The class work as above is conducted mainly by the Science teacher, but in the lower classes the ordinary class teacher takes some part of this duty.

The yearly examination questions are proposed by the Superintendent, on the basis of questions prepared and submitted to him by the Science Teacher (and to some extent by the other teachers also). The answers are examined, in the upper classes by the Science teacher, in the lower by the ordinary teacher of the class.

#### Teachers

**Question 26** Is there any difficulty in procuring competent Science Masters?—Not for our purpose; if we wanted more distinctly technical instruction, the case might be different.

**Question 27** Where are the best obtained? Have they been specially trained for the work, and if so, in what does such training consist?—Our late Science Teacher, T. H. Waller, was a B. A. and B. Sc. of the University of London; but I think it is not too much to say that he was pretty much self-taught, beyond the fact that while a scholar with us he acquired a very fair groundwork of scientific knowledge.

His successor, our present Teacher of Science, was similarly trained, and though not equal in brilliancy of scientific ability to his predecessor, he is for our purpose very efficient.

**Question 28** What evidence of scientific qualification tendered by candidates is considered of most value?—Having only had to deal with young men trained up in the school as scholars and pupil teachers, we have judged of their qualification rather from our own observation than from any testimonials or diplomas. The London B. Sc. degree we should think amply sufficient as a test of attainment for our purpose; but a real love for scientific pursuits, and thorough ability as a teacher, would be even more important.

**Question 29** Can you state any results of Science-teaching in the school? such as—

(a) Success, professional or otherwise, of individual scholars

(b.) Influence upon the general studies and intellectual life of the school.

Many of our scholars have afterwards successfully prosecuted the study of various branches of Science, and are at this time carrying on Scientific and Natural History pursuits, mostly in addition to their ordinary avocations.

Several have gone from us to Owens College, and been complimented by the Professors on their knowledge of Science.

**Question 30** Are any special rewards or encouragements (e.g. exhibitions, scholarships, or prizes) open to successful students of Science in the school?—None beyond those referred to in answer 22, and those offered in connexion with the South Kensington Examinations.

**Question 31** What improvements, do you think, could be effected in the teaching of Science in your own school?—The limited time at our disposal for Science seems to me pretty effectively employed. Had we a much larger number of scholars, it might be an advantage to subdivide more minutely, and to take different branches with different classes, so as to provide a more continuous gradation of work, e.g., take chemistry one year, electricity, heat, and optics another, mechanics another, and move the boys on from class to class so as to secure a wider range; but with our numbers, and the limited time that many boys stay with us, this would not be practicable.

**Question 32** What are the principal obstacles to the teaching of Science in your own school?—Want of time; the pressure of other studies, deemed equally important.

**Question 33** How could the Universities best assist Science-teaching in schools?—Personally, I should be glad of an examination similar to that of the London Matricu-

lation in differently, but divided into two sections, so that a boy of good ability in Science and Mathematics might take up, say—

Euclid I-IV.  
Algebra to quadratics  
Physics and Chemistry as at present, or the Chemistry a little more advanced.  
French or German.

And another might take up—

Latin  
Greek  
English language } as at present.  
History  
French or German }

Many boys leaving school at 16, with no prospect of going to College, like to take the London Matriculation Examination as a test of good school work, but it is so broad in its range as to be beyond the reach of a good many who would find an examination such as I suggest a very useful stimulus. I must particularly guard myself against wishing this *instead* of the present Matriculation Examination, which I hope may not be in any way curtailed for its actual purpose, as a preliminary to studying for a degree; but for many who use it now as the best available test of good schoolwork, without any idea of a College course afterwards, it would be more useful *divided*, a clever boy could still pass in *both* sections, just as at present.

Question 34. Can you suggest any way in which Government could assist Science-teaching in Schools, as, for example, by inspection?

Question 35. Have you any other information to give, or suggestion to make, likely to be helpful to the Commissioners?

FIELDEN THORP, Superintendent  
JOHN F. FRYER, Head Master  
Nov 6, 1873.

TAUNTON COLLEGE SCHOOL.  
(SUPPLEMENTARY REPORT)

The College School, Taunton,

Sir, October 18, 1873.  
In answering your letter of the 14th inst., I must explain that our science teaching has been so greatly developed during the past year that my former report is obsolete, and has to be almost entirely rewritten. In case the Commissioners may wish to retain my former statements, as illustrative of what can be done towards teaching science in a young school and with imperfect appliances, I leave the old report untouched, and send a fresh statement arranged in accordance with the plan of their Appendix. I should mention that we have recently built a laboratory, added considerably to our apparatus, and engaged a Special Science master of very high reputation.

§ 1 ON THE GENERAL ARRANGEMENT OF SCHOOLS

The school consists of seven Forms. The sixth and fifth Forms are divided, one side being classical, the other scientific. The scientific side works in the laboratory, the classical side merely attends some of the scientific lectures. The "Remove" has no practical science work, but attends all the lectures, the fourth Form does practical work in the laboratory, and also attends lectures, the third Form receives elementary instruction in Physics.

§ 2 SUMMARY OF THE NUMBER AND AVERAGE AGE OF BOYS LEARNING EACH OF THE VARIOUS SUBJECTS IN THE NATURAL SCIENCE CLASSES

	Chemistry	Botany.	Physics.	Physical Geography
Number	64	38	18	70
Average age	14-18	15-18	14-16	14-18

§ 3. HOURS PER WEEK GIVEN TO SCIENCE IN THE SEVERAL COLLEGES AND SCHOOLS

There are two lectures per week in General and Theoretical Chemistry, attended by the four higher Forms. There is one lecture a week on Physical Geography, attended by the same Forms. The "Science side" of

Forms VI. and V. works four hours per week in the laboratory. The fourth Form works two hours per week in the laboratory. Each of these classes attends a separate lecture once a week in *and vice versa* work, and problems in Chemistry and Heat. The VI and V. Forms attend two lectures a week in Botany.

§ 4 SUBJECTS TAUGHT TO SENIOR AND JUNIOR STUDENTS

At the present moment the main subjects are Chemistry and Botany. Practical Chemistry occupies a prominent position, being the basis of the laboratory work. In Botany also high value is assigned to practical work, the boys being taught to dissect and classify plants. There is an elementary class in Physics, conducted by experimental teaching; and a more advanced class in Physical Geography. The list of subjects taught has lately been under revision, and the present arrangements are only tentative, and preliminary to a more complete scheme. Thus Physics will ultimately rank as co-ordinate in value with the other leading subjects, Physiology, in which two courses have been conducted, may probably be revived; the Surveying class, which has in past years done much practical work with the theodolite, will be continued; and Meteorology, of which the senior boys have a good working knowledge, derived from daily registration, will be taught to them scientifically. It should be remarked that we possess a complete collection of meteorological instruments, a fairly typical museum of biological preparations, zoological, geological, mineralogical, and botanical specimens, and a botanic garden containing from 700 to 800 selected species.

§ 5 TEXT BOOKS

In Practical Chemistry no text book is used. A scheme of laboratory practice is dictated, and carefully written down by each boy. In Physical Geography, the master lectures from his own notes, which the boys are expected to reproduce in brief. In aid of the Chemistry lectures, we recommend Roscoe, in Botany, Oliver, and Lindley's *Descriptive Botany*; in Physics, at present confined to the younger boys, Balfour Stewart's *Primer*.

§ 7 METHODS OF TEACHING, AS REGARDS ORAL DEMONSTRATION, BOOK WORK, AND PRACTICAL WORK

In the laboratory each boy learns the reactions of the metallic and non-metallic bodies. Mixtures are then given of progressive difficulty, the composition of which the pupil detects by his own judgment. Much supervision is employed, in order to cultivate habits of neatness, and skill in manipulation. The course of lectures on Theoretical Chemistry is illustrated by experiments, and there are additional classes in which problems previously given to be worked out of school are verified on the black board. In the same lectures previously assigned portions of the text book are discussed, and questions put on past lectures. High value is attached to the working out of problems, which appear to be a good test of scientific ability. Upon the senior boys is urged the importance of reading scientific books, so that they may acquire mental independence, and not remain a mere shadow of their teacher. Special opportunity is given to all the boys out of school for discussing any difficulties they may encounter. The Botany lectures include dissection and schedule writing, with practice in classification and description.

§ 8 TESTS OF PROGRESS

Oral questioning in class, and examination of note books after each lecture. Written examinations twice in each term.

§ 9. MOST EFFECTIVE FORM OF LESSON

Our Science Master is of opinion that the advantages derived from practical and theoretical work are different in kind and cannot easily be compared. But, while assigning equal effectiveness to lectures illustrated by experiment, to practical work, and to discussion of book work, he lays much stress on the necessity of working out problems, as enabling a boy not only to give a verbal enunciation of a law in Chemistry or Physics, but to understand and exhibit its applications.

W TUCKWELL,  
Head Master of Taunton College School.

APPENDIX IV.

HONOURS GAINED AT THE UNIVERSITIES BY SCIENCE STUDENTS FROM THE VARIOUS COLLEGES AND SCHOOLS.

200

Year	Rton College	Rugby School.	Harrow School	Olton College	Marlborough College	
1851	None.	1st class, Nat. Sc. Tripos, Cambridge			A Science Master has been added to the staff too short a time at present to have rendered it possible for boys to win Science Scholarships. A laboratory will probably be built very soon; but the large majority of the boys are distinctly destined by their parents for a classical education. FREDERICK W. FARRAR	
1852						
1853		1st class, Nat. Sc. Tripos, Cambridge				
1854		1st class, Nat. Sc., Oxford.				
1855		1st Honours in Expl. Sc., Trin. Coll., Dublin		Aldrichian Professor of Chemistry, Oxford		
1856						
1857				Clinical Professor of Medicine, Oxford. Regius Professor of Medicine, Oxford. 1st class in Nat. Sc., Oxford.		
1858						
1859				Lee's Reader in Chemistry, Oxford. 1st class in Nat. Sc., Oxford		
1860						
1861				1st class in Nat. Sc., Oxford.		
1862				1st class in Nat. Sc., Oxford Lee's Reader in Anatomy, Oxford.		
1863			1st class, Nat. Sc., Oxford.			
1864			1st class, Nat. Sc., Oxford. Nat. Sc. Studentship, Ch. Ch., Oxford	1st class in Nat. Sc., Oxford.		
1865				Waynflete Professor of Chemistry, Oxford. 1st class in Nat. Sc., Oxford.		
1866				Johnson Prize for Astronomy, Oxford.		
1867			Nat. Sc. Studentship, Ch. Ch., Oxford	Radcliffe Travelling Fellowship, Oxford		
1868			Burdett-Coutts' Geological Scholarship, Oxford. Nat. Sc. Scholarship, New Coll., Oxford Nat. Sc. Postmastership, Merton Coll., Oxford.			
1869						
1870			Nat. Sc. Studentship, Ch. Ch., Oxford. Whitworth Exhibition, Oxford. 1st class, Nat. Sc., Oxford 1st class, Nat. Sc. Tripos, Cambridge. 1st class, Nat. Sc., Oxford	Foundation Scholarship at Trin. Coll., Cambridge.		Scholarship at Sidney Sussex Coll., Cambridge.
1871		Nat. Sc. Studentship, Ch. Ch., Oxford. Burdett-Coutts' Geological Scholarship, Oxford. Nat. Sc. Exhibition, St. John's Coll., Cambridge. 1st class, Nat. Sc., Oxford.	Proxime accessit for Johnson Prize for Astronomy, Oxford	Scholarship at Queen's Coll., Oxford. Scholarship at Pembroke Coll., Cambridge.		
1872		Minor Exhibition in Nat. Sc., Ball. Coll., Oxford. 1st class, Nat. Sc., Oxford. 1st class, Nat. Sc., Oxford. 1st class, Nat. Sc., Oxford. 1st class, Nat. Sc., Oxford. Nat. Sc. Exhibition, St. John's Coll., Cambridge.		Junior Studentship at Ch. Ch. Coll., Oxford. Scholarship at St. Peter's Coll., Cambridge. Scholarship at St. Peter's Coll., Cambridge. Demyship at Magdalen Coll., Oxford. 2nd class, Sc. School, Oxford. The Brackenbury Scholarship at Balliol Coll., Oxford.		
1873		Burdett-Coutts' Geological Scholarship, Oxford. 1st class, Nat. Sc., Oxford. 1st class, Nat. Sc., Oxford.	1st class in Nat. Sc., Oxford. 1st class in Nat. Sc., Oxford. 1st class in Nat. Sc. Tripos, Cambridge.	Scholarship at Clare Coll., Cambridge Scholarship at St. Peter's Coll., Cambridge. Demyship at Magdalen Coll., Oxford.		

ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION, ETC.:



(continued)

Year.	Winchester College.	St. Peter's College, Westminster	Wellington College.	Cheltenham College.*	Rossall School.	Charterhouse School.	Christ's Hospital School.
1851							
1852							
1853							
1854					1st Sc Honours, Dublin.		
1855							
1856		1st class, Nat. Sc., Oxford.					
1857							
1858		2nd class, Nat. Sc., Oxford					
1859		Radcliffe Travelling Fellowship			1st class, Nat. Sc. and Geol. Scholarship, Oxford.		
1860		2nd class, Nat. Sc., Oxford					
1861							
1862							
1863					Nat Sc Scholarship, Magdalen Coll., Oxford.		
1864	1st class, Nat. Sc., Oxford.					A Scholarship for Nat. Sc. and Math, King's Coll., Cambridge.	
1865							
1866			None.	1st class, Nat. Sc., Oxford.			
1867					1st class, Nat. Sc., Oxford		
1868		2nd class, Nat. Sc., Oxford.					
1869	A Demysnip at Mag Coll, Oxford Two 1st class, Nat Sc, Oxford. One 2nd class, Nat. Sc., Oxford.						Whitworth Scholarship, St John's Coll., Cambridge.
1870	1st class, Nat. Sc., Oxford	Burdett-Coutts Scholarship, Oxford.		Exhibition at Balliol Coll., Oxford.		A Scholarship for Nat Sc., Clare College, Cambridge	Senior in Nat Sc Tripos, Queen's Coll., Cambridge. 1st class, Nat. Sc., Jesus' Coll., Cambridge
1871		1st class, Nat. Sc., Oxford.			Nat. Sc Scholarship, St John's, Cambridge		2nd class, Nat Sc Tripos, Downing Coll., Cambridge Radcliffe Travelling Fellowship
1872	1st class, Nat Sc, Oxford Radcliffe Fellowship, Oxford	3rd class, Nat. Sc., Cambridge					Exhibition, Magdalen Coll., Oxford (elected at the same time to a Postmastership at Merton, but selected Magdalen)
1873							

See:

\* N B - It is not at the Universities but at the examinations for the Indian Civil Service for Cooper's Hill, and for Woolwich, that students of Natural Science from both Departments of Cheltenham College usually present themselves.  
T W JENKINS.

(continued)

Year	City of London School *	Dulwich College	Taunton College School	King's College School	University College School	Manchester Grammar School
1851						
1852						
1853						
1854						
1855						
1856						
1857						
1858						
1859						
1860						
1861						
1862						
1863	Open Nat Sc Exhibition, Magdalen Coll, Oxford.					
1864						
1865						
1866	1st class Honours in Chemistry and Nat Philosophy, London Univ					
1867	Degree of M B, London, with 1st place. Degree of B Sc. with 1st class Honours in Zoology, London			1st class, Nat. Sc., Oxford.		
1868	Whitworth Exhibition for Mechanical Sc., Univ. of London.					
1869	Open Scholarship for Nat. Sc., St John's Coll., Cambridge. Two Exhibitions, Univ of London Degree of M B. and B S., Lond, with 1st class Honours in Medicine, and first in 1st class Honours (and gold medal) in Surgery, with an University Science Scholarship, also an Exhibition, and first in 1st class in Botany and Zoology	None		Honours in Botany, Prel. Sc., Univ of London	(See separate returns)	Exhibition, Balliol Coll, Oxford. Studentship, Ch. Ch, Oxford.
1870	Nat. Sc Scholarship, St John's Coll, Cambridge.			Honours in Zoology, Prel Sc, Univ. of London.		Studentship, Ch. Ch, Oxford.
1871	1st class, Nat. Sc., Cambridge. Degree of B Sc., in Honours, London			Nat. Sc. Scholarship, Christ's, Cambridge Honours in Chemistry, Prel. Sc., Univ. of London		Exhibition, Wadham Coll, Oxford. Scholarship, Merton Coll, Oxford. Exhibition, Merton Coll, Oxford. Studentship, Ch. Ch., Oxford. Second Class Sc School, Oxford. Scholarship, Caius Coll, Cambridge.
1872	Degree of D Sc., London, placed first in 1st class in Geology and Palaeontology Degree of B.Sc., London, in 1st class. Degree of M D, M Ch., L.M., in Honours, Queen's Univ., Ireland, with 1st prize in Anatomy and Medicine. Third in 1st class in Nat Sc. Tripos, Cambridge			Honours in Zoology, Prel. Sc., London. Gold Medal for Nat. Phil.; 1st B. Sc. Examination, London. 1st class, Nat. Sc., Cambridge Radcliffe Sc. Studentship, Oxford.		Demyship, Magdalen Coll, Oxford. Brackenbury Exhibition, Balliol College, Oxford. Studentship, Ch. Ch., Oxford.
1873						Studentship, Ch. Ch., Oxford. Second Class Sc School, Oxford. Scholarship, Pembroke Coll, Cambridge Brackenbury Exhibition, Balliol Coll, Oxford.

The improved arrangements for Science teaching and the engagement of a special Master date only from May 1873, no boys have, therefore been as yet sent up for University distinctions W. TUCKWELL.

\* [See also, the list of Honours given in the Return from this School in pp. 99-103.]

## NATURAL SCIENCE. HONOURS OBTAINED BY FORMER PUPILS OF UNIVERSITY COLLEGE SCHOOL.

N.B.—The list includes,—

(1) *Honours in Mathematics* in cases where the examinations in Natural Philosophy are not distinct from those in Pure Mathematics, and,(2) *Fellowships, Scholarships and Prizes given without specification of subject* when the presumable ground of award was distinction in Mathematics and Natural Philosophy

March 1874

1838.

University of London.—Matriculation Honours: Two mentions in Mathematics and Natural Philosophy

1839

University of London.—Matriculation Honours Mention in Mathematics and Natural Philosophy

1841.

University of Cambridge.—B A. Honours. Mathematics and Natural Philosophy: Senior optime (with first class in Classics)

University of London.—1st M B Honours. Gold medal and mention in Anatomy and Physiology, mention in *Materia Medica* and Pharmaceutical Chemistry

Matriculation Honours. Exhibition in Mathematics and Natural Philosophy.

1842.

University of Cambridge.—Pembroke College. Scholarship, prize

1843

University of Cambridge.—B A Honours: Mathematics and Natural Philosophy. Senior optime

University of London.—First M B Honours. Exhibition and gold medal in Chemistry, mention in Anatomy and Physiology, exhibition and gold medal in *Materia Medica* and Pharmaceutical Chemistry.

Matriculation Honours. Mention in Mathematics and Natural Philosophy.

1844

University of London.—B A Honours. Prize in Chemistry

Matriculation Honours. Mention in Mathematics and Natural Philosophy

1845.

University of London.—B A Honours: Scholarship in Mathematics and Natural Philosophy

Matriculation Honours. Exhibition and mention in Mathematics and Natural Philosophy

1846.

University of London.—First M B Honours. Gold medal in *Materia Medica* and Pharmaceutical Chemistry.

1847.

University of Cambridge.—St John's College. Prize.

University of London.—B A Honours. Scholarship in Mathematics and Natural Philosophy

Matriculation Honours. Exhibition and mention in Mathematics and Natural Philosophy.

1848

University of Cambridge.—St. John's College. Prize

Trinity College. Two prizes

University of London.—B A Honours. Scholarship in Mathematics and Natural Philosophy

Matriculation Honours: Mention in Mathematics and Natural Philosophy.

1849

University of Cambridge.—St. John's College. Scholarship, prize.

Trinity College. Scholarship, prize.

University of London.—B A. Honours: Scholarship in Mathematics and Natural Philosophy, three mentions in Animal Physiology.

1850

University of Cambridge.—B A Honours. Mathematics and Natural Philosophy. Fourth wranglership; senior optime

Trinity College. Prize

Emmanuel College. Scholarship, prize

University of London.—B A Honours. Scholarship in Mathematics and Natural Philosophy.

Matriculation Honours. Mention in Mathematics and Natural Philosophy.

1851

University of Cambridge.—B A Honours. Mathematics and Natural Philosophy. Third wranglership and second Smith's prize

St Peter's College. Scholarship, prize in Mathematics.

Trinity College. Prize for Mathematics

Emmanuel College. Scholarship; prize

University of London.—B A Honours. Mention in Animal Physiology, mention in Botany

Matriculation Honours. Mention in Chemistry

1852

University of Cambridge.—B A. Honours. Natural Sciences. First class.

St Peter's College. Prize in Mathematics.

St. John's College. Fellowship

Trinity College. Two prizes

Emmanuel College. Prize

University of London.—M A Examination. Gold medal in Mathematics and Natural Philosophy

B A Honours. Mention in Animal Physiology

First M B Honours. Gold medal in Chemistry, mention in Anatomy and Physiology, mention in Botany

Matriculation Honours. Two mentions in Mathematics and Natural Philosophy; two mentions in Chemistry; prize in Botany

1853.

University of Oxford.—Moderations. First class in Mathematics (together with first class in Classics)

University of Cambridge.—B A. Honours. Mathematics and Natural Philosophy. Second wranglership; second Smith's prize

St. Peter's College. Prize in Mathematics.

Caus College. Scholarship

Trinity College. Fellowship; scholarship; prize.

Emmanuel College. Fellowship

University of London.—M A Examination. Gold medal in Mathematics and Natural Philosophy

B A Honours. Mention in Chemistry

Matriculation Honours. Mention in Mathematics and Natural Philosophy

1854

University of Cambridge.—B A Honours. Mathematics and Natural Philosophy. Senior wranglership, equal first Smith's prize

Caus College. Prize in Mathematics

Trinity Hall. Two scholarships; prize.

Trinity College. Prize.

University of London.—M B Honours. Gold medal in Physiology and Comparative Anatomy

B A. Honours. Mention in Mathematics and Natural Philosophy, mention in Animal Physiology

Matriculation Honours: Two mentions in Mathematics and Natural Philosophy, mention in Zoology

1855.

University of Oxford.—B A Honours. Third class in Mathematics and Physics (with third class in Classics)

University of Cambridge.—B A. Honours. Mathematics and Natural Philosophy. Fourth wranglership.

St. Peter's College. Fellowship

Trinity Hall. Prize in Mathematics.

Trinity College. Prize for Mathematics

University of London.—B A. Honours. Mention in Mathematics and Natural Philosophy; mention in Animal Physiology.

Matriculation Honours: Three mentions in Mathematics and Natural Philosophy.

1856.

University of Cambridge.—B A. Honours: Mathematics and Natural Philosophy. Senior optime, senior optime (with first class in Classics).

Trinity College Fellowship, two prizes  
 University of London.—B.A. Honours: Mention in Mathematics and Natural Philosophy  
 First M.B. Honours: Gold medal in Botany; mention in *Materia Medica*.  
 Matriculation Honours: Exhibition and mention in Mathematics and Natural Philosophy.

1857

University of Cambridge.—B.A. Honours, Mathematics and Natural Philosophy; Ninth wranglership; senior optime.

Trinity Hall. Fellowship.  
 Trinity College. Scholarship; prize.  
 University of London.—B.A. Honours; Mention in Mathematics and Natural Philosophy; mention in *Animal Physiology*.

1858.

University of Cambridge.—Trinity College. Prize  
 University of London.—B.A. Honours: Scholarship and mention in Mathematics and Natural Philosophy; mention in *Animal Physiology*, mention in Botany  
 Matriculation Honours: Mention in Mathematics and Natural Philosophy; two mentions in Chemistry.

1859.

University of Cambridge.—B.A. Honours: Mathematics and Natural Philosophy; Sixteenth wranglership  
 University of London.—M.A. Examination: Two degrees in Mathematics and Natural Philosophy  
 M.B. Honours: Gold medal in Physiology and Comparative Anatomy  
 Matriculation Honours: Three mentions in Mathematics and Natural Philosophy; mention in Chemistry.

1860

University of Cambridge.—B.A. Honours: Mathematics and Natural Philosophy: Junior optime  
 University of London.—M.A. Examination: Gold medal in Mathematics and Natural Philosophy.  
 B.A. Honours: Mention in Mathematics and Natural Philosophy; prize in *Animal Physiology*  
 First B.A. Honours: Two mentions in Mathematics and Mechanical Philosophy  
 Matriculation Honours: Three mentions in Mathematics and Natural Philosophy.

1861.

University of Cambridge.—Trinity College. Fellowship, minor scholarship.  
 University of London.—B.A. Honours: Mention in Mathematics and Natural Philosophy.  
 First B.A. Honours: Three mentions in Mathematics and Mechanical Philosophy.  
 Prel. Sci. (M.B.) Honours: Exhibition in Chemistry and Natural Philosophy.  
 Matriculation Honours: Three mentions in Mathematics and Natural Philosophy, two mentions in Chemistry

1862.

University of Oxford.—B.A. Honours: Mathematics and Physics: Fourth class (with first class in Classics)  
 University of Cambridge.—Trinity College: Two prizes.  
 University of London.—B.Sc. Honours: Mention in Mathematics and Natural Philosophy.  
 B.A. Honours: Mention in Mathematics and Natural Philosophy.  
 First M.B. Honours: Exhibition and gold medal in Organic Chemistry; mention in Physiology, Histology and Comparative Anatomy.  
 First B.Sc. Honours: First place in Chemistry; mention in Biology  
 Prel. Sci. (M.B.) Honours: Mention in Chemistry and Natural Philosophy.  
 Matriculation Honours: Two mentions in Mathematics and Natural Philosophy; mention in Zoology.

1863.

University of Cambridge.—Trinity College. Scholarship.  
 University of London.—M.A. Examination: Two degrees (one with gold medal) in Mathematics and Natural Philosophy

B.Sc. Honours: First class with scholarship in Chemistry; second class and third class in Biology; second class in Geology

B.A. Honours: First class with prize, and two second classes in *Animal Physiology*  
 First B.A. Honours: Second class in Mathematics and Mechanical Philosophy  
 Prel. Sci. (M.B.) Honours: First class with exhibition in Biology.

Matriculation Honours: Two mentions in Chemistry.

1864.

University of Cambridge.—Trinity College. Prizes.  
 University of London.—B.Sc. Honours: First class in Logic and Moral Philosophy.

B.A. Honours: First class with scholarship in Mathematics and Natural Philosophy; first class with prize in *Animal Physiology*  
 First M.B. Honours: First class with exhibition and medal in Physiology, Histology and Comparative Anatomy; first class in Organic Chemistry  
 Matriculation\* General Honours: Two prizes and two mentions.

1865

University of Cambridge.—B.A. Honours: Mathematics and Natural Philosophy: Eighth wranglership; senior optime

Trinity College: Minor scholarship.  
 Sidney Sussex College: Entrance scholarship.  
 University of London.—B.A. Honours: Second class in *Animal Physiology*.  
 Prel. Sci. (M.B.) Honours: First class in Chemistry and Natural Philosophy  
 Matriculation General Honours: Exhibition and three mentions.

1866.

University of Cambridge.—Trinity College. Two prizes.  
 Sidney Sussex College: Prize in Mathematics; prize in Natural Science  
 University of London.—Prel. Sci. (M.B.) Honours: Second class in Biology.  
 Matriculation General Honours: First place with exhibition and two mentions.

1867.

University of Oxford.—Moderations: Third class in Mathematics.  
 University of Cambridge.—Trinity College. Scholarship; prize  
 Sidney Sussex College: Prize in Mathematics.  
 Downing College: Minor scholarship.  
 University of London.—First B.A. Honours: Second class in Mathematics and Mechanical Philosophy.  
 Matriculation General Honours: First Place with exhibition and two mentions.

1868.

University of Cambridge.—B.A. Honours: Mathematics and Natural Philosophy: Senior optime.  
 St Peter's College: Entrance Science scholarship.  
 Trinity College: Prize.  
 Downing College: Prize in Mathematics  
 University of London.—B.A. Honours: Second class in *Animal Physiology*  
 First M.B. Honours: First class with gold medal in Organic Chemistry.  
 First B.Sc. Honours: Second class and two third classes in Chemistry and Natural Philosophy, third class in Botany; First class in Zoology  
 First B.A. Honours: Second class in Mathematics and Mechanical Philosophy.  
 Prel. Sci. (M.B.) Honours: Second class and third class in Chemistry and Natural Philosophy; first class in Zoology; third class in Botany.  
 Matriculation General Honours: Exhibition and two mentions

\* The examinations for special subjects, including Mathematics and Natural Philosophy, Chemistry, Botany, Zoology, were discontinued in 1864. Honours have since been awarded for general merit displayed in the subjects of the Pass examination. The examination embraces Mathematics, Natural Philosophy, and Chemistry, but not Botany or Zoology.

1869

University of Oxford.—B A Honours. Mathematics and Physics. Third class  
 University of Cambridge.—B A Honours. Mathematics and Natural Philosophy. Senior wranglership, second Smith's prize.  
 St. John's College. Natural Science Exhibition  
 Trinity College. Minor Scholarship, prize for Mathematics.  
 Sidney Sussex College. First entrance scholarship in Mathematics  
 Downing College. Scholarship, prize in Mathematics  
 University of London.—B Sc Honours. First class in Chemistry; first class in Zoology, first class in Logic and Moral Philosophy  
 Prel. Sci. (M B.) Honours. Third class in Botany  
 Matriculation General Honours. Exhibition, four prizes, and four mentions.

1870.

University of Oxford.—B A Honours. Natural Science: Second class.  
 Moderations. Mathematics. Second class  
 University of Cambridge.—St. John's College. Scholarship in Natural Science, prize in Natural Science  
 Sidney Sussex College. Scholarship, prize in Mathematics  
 Downing College. Prize in Mathematics  
 University of London.—First B Sc Honours. Second class in Chemistry  
 Prel. Sci. (M B.) Honours: Second class in Chemistry  
 Matriculation General Honours. Second place with exhibition in January Examination, second place with exhibition in June Examination; three prizes and four mentions

1871.

Royal Society.—Fellowship.  
 University of Oxford.—B A Honours. Mathematics and Physics. Third class  
 University of Cambridge.—Hon. M.A. for distinction in Natural Science  
 B A Honours. Mathematics and Natural Philosophy. Senior optime  
 St. John's College. Prize in Natural Science  
 Trinity College. Fellowship for Natural Science, scholarship, open scholarship in Natural Science; prize  
 Sidney Sussex College. Prize in Mathematics.  
 University of Dublin.—First senior moderators in Natural Science  
 University of London.—First B. Sc. Honours: Second class in Experimental Physics, second class in Chemistry.  
 Prel. Sci. (M B.) Honours. Second class in Chemistry  
 Matriculation General Honours: First place with exhibition.

1872

Royal Society.—Four fellowships  
 University of Cambridge.—B A Honours. Natural Sciences. First place in first class.  
 Trinity College. Prize  
 Sidney Sussex College. Scholarship  
 University of London.—D Sc., Degree in Electricity  
 B. Sc. Honours. First class with scholarship in Chemistry  
 Matriculation General Honours. First place with exhibition; third place with exhibition, two mentions  
 University of Glasgow.—Prize in Mechanics, two prizes in Natural Philosophy

1873

University of Cambridge.—B A Honours. Mathematics and Natural Philosophy, senior optime; Natural Sciences, second class.  
 Trinity Hall. Entrance scholarship in Mathematics  
 St. John's College. Fellowship for distinction in Natural Science; prize.  
 Trinity College. Entrance exhibition, prize.  
 University of London.—M A. Examination. Gold medal in Mathematics and Natural Philosophy.  
 First B Sc. Honours. First class in Chemistry; third class in Experimental Physics  
 Prel. Sci. (M B.) Honours. Second class in Experimental Physics.  
 Matriculation General Honours. Two exhibitions; prize; mention.

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1874.

University of Cambridge.—B A. Honours. Mathematics and Natural Philosophy, second wranglership and first Smith's prize.  
 University of London.—Matriculation General Honours. Two mentions

## LIST OF FORMER PUPILS OF UNIVERSITY COLLEGE SCHOOL, DISTINGUISHED IN SCIENCE

(I) *Natural Science.*

- Abraham, P S*, B Sc. London, B A Dublin  
 B Sc. London (1869) First Class Honours; B A. Dublin (1871) First Senior Moderator in Natural Science  
*Atkinson, R. W.*, B Sc. London:  
 B Sc. (1872) Scholar in Chemistry; Demonstrator of Birkbeck Laboratory, University College, London.  
*Ayrton, W E*  
 Professor of Natural Philosophy, Yeddo, Japan; late Assistant Electrical Superintendent of Indian Government Telegraphs, and recently in charge at Mitcham as representative of the Great Western Telegraph Company's engineers.  
*Bennett, F J*  
 Assistant Geologist, Geological Survey of the United Kingdom.  
*Carpenter, W L*, B A and B Sc. London; B A (1860), B. Sc. (1862).  
*Dillon, Ed.*, B A. London  
 B A (1869), Associate of the Royal School of Mines in Metallurgy and Mining (1871-72), Chief Assayer, Imperial Mint, Osaka, Japan  
*Fleming, J A*, B Sc. London  
 B Sc. (1870); Assistant Demonstrator in the Advanced Laboratory, Royal College of Chemistry, late Science Master at Rossall School  
*Foster, Michael*, B A and M.D. London, M A. Cambridge, F.R.S.  
 B A. (1854) Scholar in Classics, Hon. M A. Cambridge (1871); Fellow of University College, London, and of Trinity College, Cambridge, Praelector in Physiology, Trinity College, Cambridge; late Professor of Physiology, Royal Institution, and Professor of Practical Physiology, University College, London.  
*Garrod, A. H.*, B A. Cambridge  
 B A. (1872) Head of Natural Sciences Tripos, Fellow of St. John's College, Cambridge; Prosector to the Zoological Society  
*Graham, J C B*, B Sc. London  
 B. Sc. (1871)  
*Guthrie, Fred*, B A London, F.R.S.:  
 B A (1852) Professor of Physics, Royal School of Mines  
*Harding, P J*, B A Cambridge  
 Late Scholar of Sidney Sussex College, Cambridge; late Lecturer in Applied Mathematics, University College, London; Assistant Examiner in Experimental Physics, University of London  
*Jevons, W. S.*, M A. London, F.R.S.:  
 M A. (1862) Gold Medal in Logic and Moral Philosophy; Professor of Political Economy and of Mental Philosophy, Owens College, Manchester, formerly Assayer, Royal Mint, Sydney, N S W.  
*Knox, G W*, B Sc. London.  
 B. Sc. (1863) Scholar in Chemistry; Mining Engineer.  
*Magnus, Rev P*, B A. and B Sc. London.  
 B A (1863) First Class Honours; B Sc. (1864) First Class Honours.  
*Murhead, Alex.*, D Sc. London:  
 B Sc. (1869) First Class Honours; D Sc. (1872) in Electricity; Member of Council of Society of Telegraph Engineers.  
*Orme, T A*:  
 Teacher of Chemistry and Chemical Physics, University College School; Author of "An Introduction to the Science of Heat."

(II) *Mathematical Science.*

- Adler, M N*, M A. London:  
 M A. (1859) in Mathematics and Natural Philosophy; Fellow of University College, London, Actuary.

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- Lall, W. W. R.*, M.A. London, B.A. Cambridge.  
M.A. London (1873) Gold Medal in Mathematics and Natural Philosophy, B.A. Cambridge (1874) Second Wrangler, First Smith's Prize; Scholar of Trinity College, Cambridge.
- Batty, Rev. R. B.*, M.A. London and Cambridge (the late)  
M.A. London (1852) Gold Medal in Mathematics and Natural Philosophy; B.A. Cambridge (1853) Second Wrangler, Second Smith's Prize; Fellow of Emmanuel College, Cambridge.
- Crompton, Chas.*, M.A. Cambridge:  
B.A. (1855) Fourth Wrangler; late Fellow of Trinity College, Cambridge; Barrister-at-law.
- De Morgan, G. C.*, M.A. London (the late).  
M.A. (1863) Gold Medal in Mathematics and Natural Philosophy
- Guthrie, Francis*, B.A. and LL.B. London  
B.A. (1850) Scholar in Mathematics and Natural Philosophy, LL.B. (1852) Scholar, Fellow of University College, London, Barrister-at-law.
- Hartog, N. E.*, B.A. London and Cambridge (the late):  
B.A. London (1864) Scholar in Mathematics, Scholar in Classics, Prize in Animal Physiology, B.A. Cambridge (1869) Senior Wrangler, Second Smith's Prize; Fellow of University College, London, and Scholar of Trinity College, Cambridge.
- Haycock, R. B.*, B.A. London; M.A. Cambridge.  
B.A. London (1847) Scholar in Mathematics and Natural Philosophy; B.A. Cambridge (1850) Fourth Wrangler; Fellow of University College, London, and late Fellow of St. John's College, Cambridge; Mathematical Master at Harrow School
- Hutton, R. H.*, M.A. London  
B.A. (1845) Scholar in Mathematics and Natural Philosophy, M.A. London (1849) Gold Medal in Logic and Moral Philosophy, Fellow of University College, London, and Member of the Senate of the University of London
- Kisch, B.*, B.Sc. and M.A. London.  
M.A. (1863) in Mathematics and Natural Philosophy
- Nesbitt, H. A.*, M.A. London.  
M.A. (1859) in Mathematics and Natural Philosophy
- Routh, E. J.*, M.A. London and Cambridge, F.R.S.  
M.A. London (1853) Gold Medal in Mathematics and Natural Philosophy; B.A. Cambridge (1854) Senior Wrangler and Equal First Smith's Prize; late Fellow of St. Peter's College, Cambridge.
- Smith, Lumley*, M.A. Cambridge.  
B.A. (1857) Ninth Wrangler; Fellow of Trinity Hall, Cambridge; Barrister-at-law.
- Solomon, J. M.*, M.A. London:  
M.A. (1860) Gold Medal in Mathematics and Natural Philosophy; Student of the Inns of Court, 1863, Fellow of University College, London, Barrister-at-law
- Taylor, Sedley*, M.A. Cambridge  
B.A. (1859) Sixteenth Wrangler; Fellow of Trinity College, Cambridge.
- Watson, Rev. H. C.*, M.A. Cambridge.  
B.A. (1865) Eighth Wrangler, late Scholar of Trinity College, Cambridge; Assistant Master at Clifton College.
- Yool, G. V.*, M.A. Cambridge.  
B.A. (1851) Third Wrangler and Second Smith's Prize First Class, Natural Sciences Tripos (1852); late Fellow of Trinity College, Cambridge, Barrister-at-law.
- (III) *Medical Science*
- Arnott, Hy.*, F.R.C.S.  
F.R.C.S. (1868) Joint Lecturer on Morbid Anatomy, St. Thomas's Hospital, late Joint Lecturer on Pathology, Middlesex Hospital.
- Atkinson, W.*, B.A. London.  
B.A. (1857) Staff Surgeon, Army Medical Service.
- Aveling, C. T.*, M.S. and M.D., London.  
M.S. (1872) M.D. (1873), late House Surgeon, St. Thomas's Hospital
- Bruce, Alex.*, B.Sc., M.B. and M.S., London: (the late).  
B.Sc.—M.S. (1863-66), (two exhibitions and gold medal); Scholar of University College, London, and Assistant Curator of the Museum of Anatomy and Pathology (1866-68) University College.
- Buckanan, Albt.*, B.A. and M.B. London.  
B.A. (1854) in Honours; M.B. (1861).
- Buchanan, George*, B.A. and M.D. London.  
B.A. (1851) in Honours; First M.B. Gold Medal; M.B. (1854) Gold Medal in Physiology, Scholar and Medal in Surgery, Scholar and Medal in Medicine; M.D. (1855); Fellow of University College, London; Inspector, Medical Department of the Privy Council.
- Burton, Jos.*  
First M.B. (1846) Gold Medal
- Coigate, Hy.*, M.B. and B.S. London.  
M.B. (1873) Scholar and Gold Medal; B.S. (1873) Gold Medal
- Cumberbatch, A. E.*, M.B. London.  
Scholar of St. Bartholomew's (1868); M.B. (1871); Demonstrator of Anatomy, St. Bartholomew's Hospital.
- Filster, Wm.*, M.B. London, M.D. (the late):  
M.B. (1850)
- Ganges, Arthur*, M.D., Edinburgh; F.R.S. L and E.  
M.D. (1862) Thems Gold Medal; Professor of Practical Physiology and Histology, Owens College, Manchester, Examiner in Forensic Medicine, University of London; late Lecturer on Physiology, Surgeons' Hall, Edinburgh
- Gaquet, J. R.*, M.B. London.  
M.B. (1852), Gold Medal.
- Hake, Jas.*, F.R.C.S.:  
First M.B. London (1843) Exhibition and Medal in Chemistry; Exhibition and Medal in Materia Medica; Honorary Surgeon, Liverpool Royal Infirmary
- Harding, A. W.*, B.A. and M.B. London.  
B.A. (1867) First Class Honours; M.B. (1871) late Radcliffe Student, Oxford; House Surgeon, Infirmary for Children, Liverpool.
- Hill, Berkeley*, M.B. London.  
M.B. (1859) Gold Medal; Surgeon and Teacher of Practical Surgery, University College Hospital
- Howse, H. G.*, M.B. and M.S. London:  
M.B. (1866) Gold Medal and "Deserving of Scholarship," B.S. (1867) Scholar and Gold Medal; M.S. (1868) "Worthy of Medal;" Senior Assistant Surgeon and Lecturer on Anatomy, and Demonstrator of Morbid Histology, Guy's Hospital.
- Matthew, T. P.*  
First M.B. London (1841) Gold Medal
- Nunneley, F. B.*, B.S. and M.D. London  
B.S. (1866) Scholar and Gold Medal, M.D. (1867) "Deserving of Medal," and "Distinguished by Special Proficiency;" Fellow of University College, London; late Assistant Physician, and Lecturer on Experimental Physiology and Histology, St. Mary's Hospital.
- Powell, W.*, M.B. London  
M.B. (1862) in Honours, House Surgeon, Torbay Infirmary, late Resident Medical Officer, London Hospital
- Power, W. H. T.*, B.A. London.  
B.A. (1857); Surgeon Major, Indian Army Medical Service (appointment by open competition).
- Schlesinger, B. M.*  
Scholar in Pathology and Assistant Curator (1873); late Scholar and Assistant Demonstrator in Anatomy, St. Mary's Hospital.
- Sibley, S. W.*, F.R.C.S.:  
F.R.C.S. (1857) late Lecturer on Pathological Anatomy, Middlesex Hospital.
- Smith, H. Alder*, F.R.C.S.:  
First M.B. London (1868) Gold Medal; late Scholar, House Surgeon, and House Physician, St. Bartholomew's Hospital.
- Smith, W. J.*  
First M.B. London (1856) Gold Medal.
- Tapson, A. J.*, M.B. London:  
M.B. (1843) in Honours.
- Thompson, J. A.*  
Prize Essay, Guy's Hospital (1868); late Resident Accoucheur, Middlesex Hospital.
- Turle, Jas.*, M.D. Edinburgh:  
M.D. (1867) Thems Gold Medal.
- Waller, A.*, B.A. and B.Sc. London:  
B.A. (1865) in Honours; B.Sc. (1866); late House Surgeon, St. Thomas's Hospital.
- Winterbottom, L.*  
M.R.C.S. (1856) Consulting Surgeon, Cheltenham General Hospital.

APPENDIX V.

RETURNS FROM THE HEAD MASTERS OF CERTAIN ENDOWED SCHOOLS IN ENGLAND AND WALES FOR SECONDARY EDUCATION HAVING (AS STATED IN THE REPORT OF THE SCHOOLS INQUIRY COMMISSION) ANNUAL ENDOWMENTS OF 200L AND UPWARDS

A.

[The following letter and form were sent to the Head Masters of two hundred and five Endowed Schools in England and Wales, on the 30th June 1871.]

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, S.W., 30th June 1871

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to beg that you will be so good as to aid the Commissioners in the Inquiries which have been entrusted to them by filling up the enclosed form, and returning it, together with any additional information respecting the Teaching of Science in your School which you may be good enough to afford, with the least possible delay.

I have the honour to be, &c  
J. NORMAN LOCKYER, Secretary.

County \_\_\_\_\_  
Endowed School at \_\_\_\_\_

Net annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters	What Weight assigned to Natural Science in Examination for Exhibitions	Whether any Laboratory or other Aids for Practical Teaching in Science	AMOUNT EXPENDED IN TEACHING		
					Classics	Mathematics.	Natural Science
					s s. d.	£ s. d.	s s. d.

Remarks.—

[The following returns have been received in answer to the foregoing letter.]

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>ANGLESEY.</b> <b>Beaumaris.</b>	—	—	—	—
<b>BEDFORD.</b> <b>Bedford.</b> * 4,199l - † 640l	‡None	—	—	None
<b>Bedford (Commercial School).</b> Income derived from the estates of the Harpur Charity about 1,800l per annum. Two Exhibitions of 50l each for four years	None	—	—	No laboratory; no aids whatever
<b>BERRS.</b> <b>Abingdon.</b> Income about 350l Scholarships 250l	A few boys have in- struction in Botany	—	—	—
<b>BRECKNOCK.</b> <b>Brecon (Christ's College).</b> Income - - - £800 Exhibition, 40l a year (assigned triennially)	—	32	—	—
<b>CAMBRIDGE.</b> <b>Cambridge.</b> About 600l (no Exhibi- tions).	None	30	No Exhibitions.	None.
<b>CHESTER.</b> <b>Chester Cathedral Grammar School.</b> 200l. per annum paid to two Masters by the Dean and Chapter †	About 20	General Instruction, 30 hours per week; Scientific, perhaps two hours per week.		A small quantity of apparatus, but the want of class-rooms prevents it being frequently used.



AMOUNT EXPENDED IN TEACHING			REMARKS
Classics	Mathematics	Natural Science.	
£ s d.	£ s d.	£ s d.	
—	—	—	There is no organised system of instruction in Natural Science, but lessons in the elements of some branch of it are given twice a week to such boys as appear likely to profit by it, usually about 10 in number, by the Mathematical Master. W BEDELL STANFORD, M.A., Head Master
1,000 841 250 150 150 200 80 50 <hr/> 2,721	280 125 80 80 20 30 <hr/> 615	—	* This is the sum which appears in the published accounts of the Harpur Charity as expended on the Grammar School from Midsummer 1868 to Midsummer 1869 It includes sundry expenses for gas, &c The sum must be somewhat larger in the present year It includes Drawing and Modern Languages † s.e., eight Exhibitions, 80l each (two fall vacant every year, they are tenable for four years) ‡ Occasionally an individual boy receives part of his preparation for Matriculation at London University from the Mathematical Master § It is almost impossible to specify the sum actually spent on "Classics" and "Mathematics" respectively
s e Salaries of various Masters whose main subject is Classics, Divinity, with History, &c s e Salaries of Masters in Mathematics, Arithmetic, and Elementary English N B—The new scheme prepared by the Endowed Schools' Commissioners contemplates instruction in Natural Science No steps have as yet been taken by the Trustees for establishing this branch It is much wanted for many boys Exhibitions may be given (and sometimes are) for mathematical excellence, provided that the Classics are up to a "pass" standard July 11, 1871			F FANSHAWE, Head Master
Classics, French, German, and English exhaust the whole income	Mathematics	—	The introduction of the study of Natural Science has been long thought about, but the changes impending the government of this Charity have hitherto stood in the way of this and other improvements An effort, however, will be made after the Midsummer recess to introduce some branch of the subject into the school. July 11th, 1871 W FINLINSON, Head Master
—	—	—	The school buildings have been lately rebuilt, and the school is now making a fresh start under a new Head Master, who is desirous of encouraging certain branches for the cultivation of which the neighbourhood to Oxford offers advantages    These are not in the gift of the school, Pembroke College, Oxford, elects E. SUMMERS, M.A., Head Master
—	—	—	The College labours under a debt of 2,500l for its buildings, payable by instalments of 125l (with interest at four per cent, 100l), during the next 20 years 800l, 225l, 575l net If there has been no supply of Natural Science, there has been hitherto no demand. The amount "expended on teaching Classics and Mathematics" [French, German if necessary, Drawing, and English] differs from the total income only by what is wanted for repairs (more properly by even less, for the income is ill sufficient) by the 40l exhibition, and a 21l pension to a late Head Master, before the Act of 1853 and Scheme of 1845 The three Masters have endowments, together = 415l, and portions of the fees A fourth is engaged by and at the cost of the Head Master On his part there is no obstacle offered to Natural Science except in his incapacity to make much of it personally J. D. WILLIAMS, M.A., Trinity College, Cambridge
600l. for both, with English.		Nothing	The Head Master has for some time been anxious to begin a system of teaching in Natural Science, but there are considerable difficulties There are 100 Free Boys, for whom there are only three Masters These Free Boys may stay until they are 18 years old, many do stay, and require considerable teaching in Classics and Mathematics. The endowment is very small, so that there is no surplus fund either to pay a Natural Science Master, or to build Again, the decree forbids any charge to be made to the Free Boys, so that no extra subjects can be introduced, at least as part of the general system These remarks have been limited to Free Boys, as the great number of them checks every possible improvement They pay 1l per annum This 100l pays the Third Master, whose special duty is to teach English subjects. It would be possible to start a Voluntary Class in Science out of school hours, but the Head Master does not think such a method of teaching any subject an advisable course The above remarks apply with equal force to French and German The Head Master is hopeful that the Endowed Schools' Commissioners will do him great service in the matter
—	—	—	¶ The Cathedral statutes provide for four valuable Exhibitions to Oxford and Cambridge, but they have not been awarded for several generations The Dean and Chapter cannot be persuaded to revive them Perhaps the Endowed Schools' Commissioners may prevail upon the Ecclesiastical Commissioners to restore them The sum assigned by the Statutes for each Exhibition is one fourth of the statutabie stipend of a Canon The present income of a Canon is about 550l per annum I enclose some papers, which may possibly assist you in your inquiries July 10, 1871 JAMES HARRIS, M.A., Cantab, Head Master

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>CHESTER—cont.</b> <b>Macclesfield.</b> Income, 1,200 <i>l.</i> ; Exhibitions, 150 <i>l.</i>	Those who do not learn Greek, say 6	About 2	None as yet.	No.
<b>Macclesfield (the Modern School).</b> 1,250 <i>l.</i>	40.	—	None.	Chemical laboratory.
<b>Worthwich.</b> —	6	2	—	—
<b>Sandbach.</b> School receives 215 <i>l.</i> from Charity estates No Exhibitions	About 24.	6 to 7 hours.	—	Laboratory.
<b>Stockport.</b> Endowment - - £300 Rest of income variable, derived from school fees	—	28	None	No
<b>DERBY.</b> <b>Repton.</b> Income - - £1,200 Out of this 460 <i>l.</i> for Scholarships at the School, and Exhibitions to the University.	100 regularly.	2	None. Exhibitions given for the most part by private patronage.	No.
<b>Risley.</b> —	—	—	—	—

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics	Natural Science	
£ s. d.	£ s. d.	£ s. d.	
—	—	—	<p>1 The annual school income of 1,200<i>l</i>. maintains what is called a "Modern" School as well. In that, Natural Science is, I fancy, more extensively cultivated.</p> <p>2 It is difficult to discriminate and say what amount of money is expended on the teaching of the several branches, e.g., my own official salary of 300<i>l</i>. may be said to be expended exclusively in the teaching of Classics, and its kindred subjects, History and Geography, &amp;c. The Second Master, whose salary is about 190<i>l</i>., divides his time between Classics and Mathematics. An Assistant Master, with a salary of about 130<i>l</i>., teaches Arithmetic, Physical Science, so far as it can be said to be taught, and assists in French.</p> <p>Torcross, Kingsbridge, July 10, 1871 T. B. CORNISH.</p>
—	—	—	<p>The Modern School, in which alone Science is taught, is distinct from the Classical School, and receives 500<i>l</i>. per annum from the endowment. No separate charge to pupils is made on account of instruction in Science, and no payment from the endowment, except about 2<i>l</i>. per annum to renew chemicals, &amp;c. The only Exhibitions are held from the Classical School.</p>
60 0 0	50 0 0	10 0 0	—
<p>The 215<i>l</i>. is spent in giving salaries to two Masters head, 140<i>l</i>., second, 60<i>l</i>.; prizes, 15<i>l</i>. Natural Science is taught by an extra Master.</p>			<p>The laboratory has not been used in my time (two years past), nor, I believe, for some years previously. The teaching has been very elementary, and has been under the charge of an additional Master, appointed by the Trustees, and practically independent of me. He is paid by a tax of 5<i>l</i>. each on boarders, but as he undertakes other school work, the Natural Science teaching, although it has improved lately, is at a very low ebb and not efficient. I have resigned the School, and, I believe, now a single Head Master is to have the control of all departments, which I hope may result in Natural Science being properly taught.</p> <p>(Signed) JOHN CHAMBERS, M A., Head Master (St John's Coll., Camb.)</p>
—	—	—	<p>It is impossible to state separately the amounts expended in teaching Classics and Mathematics, because both subjects are taught by the same Masters. The whole amount expended in teaching Classics and Mathematics averages about 550<i>l</i>.</p> <p>CHARLES G. HAMILTON, Head Master</p>
<p>Impossible to distinguish All Masters teach in all classes according to their attainments in each.</p>			<p>I am hoping, as soon as I am enabled, by a new scheme, to form a School of Natural Science, with a laboratory and proper apparatus. Meantime regular instruction is given to a selected portion of the school by the Form Masters, from good text books, in certain branches of Natural Science; and these subjects form part of the examination for removes.</p> <p>J A PEARS, Head Master.</p>
—	—	—	<p>To the SECRETARY of the ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION and the ADVANCEMENT OF SCIENCE</p> <p>SIR, On attempting to fill up the printed form of inquiry which you were good enough to send me, I found it impossible to adjust any reply regarding the circumstances of this school to the classification of subjects laid down in that form.</p> <p>I must, therefore, beg to communicate with you through an ordinary letter. This foundation consists of three independent schools —</p> <p>i The Latin School, over which alone I have any authority (34 boys at present).</p> <p>ii The English School (48 boys)</p> <p>iii The Girls' School (24 girls)</p> <p>The last two are Elementary Schools; the first is an English Grammar School, intended to supply a "liberal education."</p> <p>The total endowment is not far short of 400<i>l</i>. a year. The Mistress receives 30<i>l</i>. a year and has a residence provided. The English Master has 90<i>l</i>. a year and a house; no boarders. The Head Master (<i>est mox</i>) has 140<i>l</i>. a year, a house, and liberty to take 20 boarders, with room for 13. I have now 11.</p> <p>In addition to the endowment, the Trustees at present receive capitation fees from my boarders, four Latin day scholars, and two English day scholars, to the amount of 64<i>l</i>. a year.</p> <p>I am allowed 20<i>l</i>. a year towards assistance; the English Master 5<i>l</i>. (!); and a sum of 5<i>l</i>. (!) a year has been allotted to us "towards" the fuel and cleaning of all three schools.</p> <p>A portion of the endowment is absorbed in repairs, &amp;c., on the estates of the schools, and in the expiation of old sins by the payment of costs incurred by former litigation.</p> <p>Still, you will learn with surprise that absolutely no scientific educational apparatus is provided in these schools by the Trustees; not so much as a map or a globe, nor pens, ink, nor black-board, much less (to use a slight hyperbole) diagrams or models. The English Master and the Mistress have asked for maps, without avail. The meagre supply in the English School, and the better apparatus of the Latin School, are the property of the Masters.</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>DERBY—cont.</b> <b>Risley—cont.</b> —	—	—	—	—
<b>Tideswell.</b> 320 <i>l</i> .	None	No time given to Science teaching, but school hours number 27½ per week.	—	None.
<b>DEVON.</b> <b>Exeter (Free Grammar School of St. John's Hospital).</b> a School income about 90 <i>l</i> b School Exhibitions, about 500 <i>l</i> , to Oxford and Cambridge	Varies from 7 to 12	About 3 hours	None hitherto	None
<b>Exeter (Kele's).</b> Endowment - £300 Payments of scholars - 319 Two Exhibitions of 50 <i>l</i> . in prospect	About 60 learning Physical Geography	One hour and a half by the Masters	As yet, no Exhibitions have been awarded	* No.
<b>DORSET.</b> <b>Sherborne.</b> About 1,100 <i>l</i> †	94	2½	In the <i>highest</i> Forms Classics - - 6 History and Divinity - - 2 Modern Languages - - 2 Mathematics and Natural Science 4	There is no laboratory, but plans are ready, as soon as the Governing Body is reorganised under scheme.
<b>DURHAM.</b> <b>Durham (City), attached to the Cathedral Body.</b> 18 King's Scholarships of nearly 40 <i>l</i> each.	None at present learning practically, about 20 in the Modern Form learning from books	—	None at present.	None at present.
<b>Darlington.</b> 200 <i>l</i> . No Exhibitions	20, in all about 40	30	No Exhibition. Monthly examinations in elementary subjects, Natural Science, and Mathematics.	None, except two globes.

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics.	Natural Science.	
—	—	—	<p>Being insufficiently assisted, and having many outgoings, the English Master and myself have too many ages, capacities, and standards of attainment to deal with, for us to attempt much in new studies</p> <p>In the English School some rudiments of Physical Science may appear in the reading books</p> <p>In the Latin School, the English classes, numbering 15 boys out of the total of 34, read Tyndall's <i>Elementary Lessons in Natural Philosophy</i> for two hours a week generally, but, owing to the variety of subjects of study, even this has to "go to the wall" when a "spurt" is needed in the Euclid, so you may put down my Natural Philosophy lessons at two hours a week for about 27 weeks in the year</p> <p>No Exhibitions of any kind have ever been paid down here, and none exist on the original foundation, or on that of Dame Elizabeth Gray</p> <p>It is not for want of will or of appreciation of the importance of Physical Science, nor yet for entire lack of information on my part, that I do so little in this way</p> <p>For further information allow me to refer you to— Mr John Stevens, Draycott, Derby,</p> <p>in whose hands, as Clerk of the Trust, the policy of conducting it chiefly lies.</p> <p>I am, Sir, your obedient servant, GEORGE F GRUNDY, M A (Brasenose Coll., Oxford).</p> <p>July 3, 1871.</p> <p>P.S.—In determining a prize for my class, I add up the marks for Tyndall with those for the Euclid</p>
			<p>No division of income. Only one Foundation Master, who receives three fourths of gross income, or 240l. Remainder given to poor in doles JOHN CARILLON, Master and Senior Member of the Corporation.</p>
			<p>I cannot apportion the amounts; an extra fee of 2 guineas a year is charged for any branch of Natural Science, and is entirely optional.</p> <p>Our new scheme from the Endowed Schools' Commissioners will, it is hoped, place Natural Science teaching in a more favoured position (Signed) H. NEWPORT, M A., Head Master. School House, 12th July 1871.</p>
†	†	†	<p>* 1. The pupils who wish it can avail themselves of instruction at the Science Classes, conducted at the Museum, which is near the school † 2. The total expense for instruction of 177 boys in all subjects is 428l. per annum, which I am unable to divide for the above subjects. July 8th, 1871. CHARLES LONG, A.C.P., Head Master.</p>
§	§	§	<p>† Gross rental returned in 1865 at 1,300l. 5s. 2d. § It is impossible to divide the amounts spent in teaching, as the Natural Science is taught by the regular Mathematical Masters, all three of whom have taken high degrees as Wranglers, and two are Fellows of St John's, Cambridge Moreover, one of the <i>Classical</i> Masters (who was a Wrangler as well as Chancellor's Medalist) is much interested in Natural Science, and takes a class therein We shall probably have a "Demonstrator" attached to our laboratory as soon as we can get one built, but propose to keep our teaching as at present Sherborne, July 1, 1871. H D HARPER, Head Master.</p>
—	—	—	<p>The Dean and Chapter of Durham propose to add a School of Natural Science next year, as soon as the requisite buildings are erected. HENRY HOLDEN, D D, Head Master</p>
			<p>No teachers but the two Masters I shall be most happy to furnish any required information in my power Eastbourn, Darlington, JOHN MARSHALL, 3rd July 1871. Head Master.</p>
			<p>Pupils procure their own books and im- plements.</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<p><b>ESSEX.</b></p> <p><b>Brentwood.</b> 1,434<i>l.</i> for School and Almshouses. School enjoys about 550<i>l.</i> Exhibition of 40<i>l.</i></p>	14	4	—	No.
<p><b>Chigwell.</b> Income about 427<i>l.</i> from Charity, 720<i>l.</i> from fees.</p>	134, <i>all.</i>	12	There are no Exhibitions	There is a laboratory, a small herbarium, and good apparatus.
<p><b>Dedham.</b> Income, 330<i>l.</i> 15<i>s.</i> 3<i>d.</i>, Exhibitions, 79<i>l.</i> 0<i>s.</i> 1<i>d.</i></p>	14	From 6 to 5	None.	Large and well-fitted laboratory.
<p><b>Earl's Colne.</b> About 240<i>l.</i></p>	5	30		No.
<p><b>Newport.</b> Head Master's stipend, 130<i>l.</i> Second Master's stipend, 75<i>l.</i></p>	None.			—
<p><b>GLOUCESTER.</b></p> <p><b>Bristol Grammar School</b> Income - - - - - 21,100 Exhibitions - - - - - 120 Scholarships at St. John's College, Oxford - - - - - 200</p>	78	10	None.	There is a laboratory in which about 10 of the most advanced pupils work with the Master.

AMOUNT EXPENDED IN TEACHING:			REMARKS.
Classical.	Mathematics.	Natural Science.	
£ s. d.	£ s. d.	£ s. d.	
—	—	—	<p>School House, Brentwood, July 7th, 1871</p> <p>SIR, I ENCLOSE the form but imperfectly filled up I regret I cannot answer its questions more precisely The facts are, as follow —1 The Exhibition referred to has only just been founded; no award has yet been made. and no conditions are attached to it in future awards except that in the Founder's will, that it is to be held at Oxford or Cambridge. I presume that if a scholar showed marked proficiency in Science he would be allowed an equal chance with a boy otherwise distinguished Till the present year no teaching in Science has taken place here It seems, however, to be the wish of the Endowed Schools' Commissioners that in future at least one branch shall be taught With a view to meet their wish, I introduced some lessons in Elementary Chemistry and Physiology to the upper boys The Commissioners are now engaged in preparing our scheme It is impossible to assign the amount paid for teaching the various subjects I have four Masters associated with me, we all, except the foreign language Master, take both classical and mathematical work, including arithmetic in that latter term. One takes also the lessons in Science referred to.</p> <p>Believe me, &amp;c WILLIAM QUENNELL, Head Master</p>
300 0 0	230 0 0	120 0 0	<p>The amounts expended in teaching are all approximate, as I teach some subjects We take Physiography or Advanced Object Lessons with the first and second Forms, Botany (Henslow's System), Physiology with Marshall's diagrams, and Chemistry with laboratory practice (four hours per week). The Science is taught by a London graduate, an Oxford first class in Science, and myself. It is a compulsory subject, and we are now yearly sending boys up to the Government examinations H. M. ROBINSON, M. A., F. R. G. S., M. C. P., July 1st, 1871 Head Master</p>
200 0 0	100 0 0	50 0 0	<p>The above particulars are given with as much accuracy as, under the circumstances, is possible. The 14 scholars learning Natural Science are members of a practical class, in which the Classics are not taught, so that more time is afforded for the study of Modern Languages, Chemistry, Physics, and other practical subjects. In addition to the regular instruction in Science enjoyed by the above 14 scholars, occasional lectures on the subject are given by the Head Master, and by other competent teachers, to the whole school GERALD T. LERMIT, LL.D., Head Master.</p>
—	—	—	
—	—	—	<p>The boys at the above school are at present receiving almost elementary instruction, as they are for the most part young and generally very backward. JAMES BROWN.</p>
<p>It is impossible to fill up these columns, because there are no definite sums set apart for each subject, and certain masters teach both classics and mathematics. The arrangements for teaching Natural Science are described below</p>			<p>Natural Science has no recognised place in the teaching of the school Six years ago the Head Master recommended to the Trustees a scheme for its introduction, but the Trustees found themselves unable to provide the necessary funds A private arrangement has since been made with a Teacher of Natural Science, under which certain rooms are put at his disposal, and he receives and teaches pupils of the school for a fee of 5s a quarter These fees are paid by the parents of the pupils to the teacher, and neither the Masters nor the Trustees have anything to do with them, the provisions of the "scheme" under which the school is governed forbidding extra fees to be charged for any part of the teaching of the school Practically Natural Science is an alternative for Latin and Greek Verse Composition, the Head Master excusing such boys as attend the Natural Science Classes from the verse composition of their respective classes. The working of the system is not altogether satisfactory, because the attendance of the pupils at the Science Classes is voluntary, and any exercise of discipline is apt to be followed by the withdrawal of the pupil from the class. At the same time, many of the pupils have gained great advantage from the teaching, and more than half the boys, who would otherwise have been spending their time in acquiring a smattering of Latin and Greek versification, have learned the principles of Chemistry and Physics; and some have made very considerable progress in the knowledge of these subjects Prizes to the value of 7l have been provided by private gifts, and the Trustees pay an examiner to examine the classes in order to determine these prizes The Trustees have drawn up a new Scheme for the School, which will enable them to put Natural Science into its proper place as a part of the regular teaching of the school. But it is not certain that the Endowed Schools' Commissioners will accept this scheme. JOHN W CALDICOTT, M.A., Head Master.</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<p><b>GLOUCESTER—cont</b> <b>Cheltenham.</b></p> <p>Available from endowment for purposes of education and kindred subsidiary objects : 75<i>l</i> 9<i>s</i> Exhibition at Pembroke College See Government Blue Book for Gloucestershire, Vol ( ).</p>	<p>Routine subjects for half year ending June 1871 : Chemistry - 38 Heat - - 15 Botany and Zoology - 1</p>	<p>6 The masters, however, work very many additional hours at irregular periods, as circumstances may require.</p>	<p>At the last examination held at Pembroke(1869), the candidates were offered the choice of adding certain specified Physical subjects, of which Chemistry was one.</p>	<p>A laboratory, and occasional grants of money for apparatus from the patrons.</p>
<b>Gloucester (the King's or Cathedral School).</b>				
None	About 50.	<p>There is one lesson every Saturday morning for about an hour.</p>	—	None.
<b>Northleach.</b> 568 <i>l</i> .	15	4 hours	None.	None.
<p><b>HEREFORD.</b> Hereford (attached to the Cathedral). Endowment, 30<i>l</i> (Separate) Scholarships and Exhibitions, 1,000<i>l</i></p>	—	—	None.	None.





Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>HEREFORD—cont.</b>				
<b>Kington.</b> Endowment, 304l 10s Charge for writing, &c., about 45l. No Exhibitions.	None.	30	—	—
<b>Leaton.</b> Out of income, 300l. per annum to Exhibitions, if sufficient candidates	None	38, exclusive of ex- ercise times.	None.	No.
<b>HESTS.</b>				
<b>Aldenham.</b> (See Report of Endowed Schools' Commission.)	None.	—	None.	None.
<b>Berkhamstead.</b> Income 1,500l. 4 Exhibitions of 60l. each, 240l	40 boys learning Chemistry.	One hour per week, but there is some work given to the boys to be done out of school.	None, but some marks will probably be given for Che- mistry are long.	No laboratory.
<b>KENT.</b>				
<b>Canterbury.</b> No income separate from the Dean and Chapter funds Gross sum paid to King's scholars and exhibi- tioners, 753l. 6s. 8d.	92	8	None	A small laboratory fitted up at our (the Science Master's) expense, and an air pump provided by the Dean and Chapter.
<b>Canterbury (Clergy Orphan School).</b> —	None	—	None	None.
<b>Faversham.</b> Income, 360l., less 80l. Two Exhibitions, 60l. each.	—	—	—	—

AMOUNT EXPENDED IN TEACHING			REMARKS
Classics.	Mathematics.	Natural Science.	
—	—	—	There are no pupils sufficiently advanced to be instructed in Natural Science. The Rev Mr Bebb, the Second Master, once formed a class in Chemistry, but was obliged to discontinue teaching it. There is no separate sum appropriated to Classics, Mathematics, or Natural Science, the only fees received for many years is 10s 6d per quarter paid to the Second Master for Writing and Arithmetic, and there is a separate charge of 15s. per quarter for a few who learn French. J. N. WALSH, M.A., Oxon, Head Master
—	—	—	The Head Master regrets that, owing to the constitution of the school, he cannot fill up the schedule in a way which would be satisfactory, either to the Royal Commission or to himself. No attention has been given to Natural Science (unless Geography be considered a branch of it), nor could there have been as the school is at present constituted
—	—	None	I am utterly opposed to the introduction of what must be, having regard to the number of subjects taught, a mere smattering of Natural Science, whatever is intended by that loose word ALFRED LEEHAN, M.A., Head Master
—	—	The Chemistry class does not pay its expenses, in fact it entails a loss of, perhaps, 15l. a year or more on the Head Master, but it has been established, (a) as being very useful, (b) as an attraction to the school.	The Chemistry class seems much appreciated, is a decided advantage to the school, and does not injure the other subjects. But the amount taught is not very much, though boys with a taste for the subject attain more knowledge than might be supposed. E. BARTRUM.
No separate fees charged or paid for the different subjects taught.			We have no separate Science Master, the Second Master (Head Mathematical Teacher) and myself (I took first-class honours in Science at Oxford) undertake the entire work. We have a regular scheme of teaching throughout the school. In the Lower School, the two Upper (Arithmetic) Classes go through an elementary year's course of Botany and Physiology (Anatomy) with me. The Fourth Form, through a course of elementary Inorganic Chemistry with the Second Master in the laboratory. The Fifth Form, also with him, go through a course of Physics. He also has a more advanced class of Fifth and Sixth Form boys in Chemistry. In the Sixth Form the boys make their election between German and Science. Those who choose the latter go through a year's course of Geology or more advanced Physiology with me in alternate years
P.S.—The marks in Science, with those in Classics, Mathematics, &c., determine a boy's school rank.			(Signed) JOHN MITCHINSON, D.C.L., Head Master
430l on both subjects, but every Master teaches both subjects.	—	—	
—	—	—	SIR, Faversham, 8th July 1871 I WRITE in reply to your communication of the 30th ulto, which I return with this. I beg to say that my father, the Rev. Sampson Kingsford, Head Master of the Faversham Grammar School, is incapacitated, through extreme age, from attending to business. My father retired from the active duties of the school about four years ago. He then appointed a Deputy Head Master, who should undertake the sole conduct of the school, his proceedings, however, being subject to my father's approval. The present Deputy Head Master is the Rev. J. Hunt, but he has recently received his dismissal for next quarter day. The endowment of the school is derived from a farm in the neighbouring parish. The farm is at present let for 360l a year, which sum is paid to the Trustees of the school. Out of this sum the Trustees retain 80l to meet the cost of improvements on the farm and other expenses; and they hand over to my father 280l a year. From the 280l, aforesaid my father pays the Deputy Head Master 100l a year, and 5l a year to the portress of the school. About 30 years ago a gentleman named Henry Wreight died at Faversham, leaving about 100,000l for the benefit of the town. Some years ago the Trustees of this bequest agreed, under certain conditions, to award two Exhibitions of 60l each for three years at Oxford or Cambridge, to boys trained on the foundation of the Faversham Grammar School qualified to enter the University. The only Exhibition of this kind that has been hitherto awarded, was given last year to Mr. Benjamin Snell, of Trinity College, Cambridge. In the past half year the number of scholars in the school was between 30 and 40. The Deputy Head Master has been assisted by one or two other masters, according to the requirements of the school. The masters give instruction to the pupils for six hours a day on four days of the week, and for four hours a day on two days of the week, being the half holidays. The instruction given is that of the usual kind in Classics, Mathematics, Foreign Languages, &c. Natural Science is taught amongst other things, but no particular stress is laid upon it, and there is no laboratory or other agency of that kind. From these particulars you will, I trust, be able to fill up your paper with more certainty than I can. I beg to say that I have nothing to do with the school, and merely write on behalf of my father. I have, &c. To J. Norman Lockyer, Esq. PHILIP KINGSFORD, Clergyman.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>LEWISHAM—cont.</b>				
— <b>Lewisham, for hundred of Blackheath.</b>	—	There are two lessons a week in text books of Science, and it forms part of the regular school work.		
<b>Rochester (Cathedral School).</b> None.	None in the school.	None given by masters except in Mechanics and Dynamics, &c., as portions of mixed Mathematics.	No examination for exhibitions of any kind.	None at all.
<b>Rochester.</b> 548 <i>l</i> as returned to Schools' Inquiry Commission	—	—	—	—
<b>Tonbridge.</b> Income about 2,643 <i>l</i> (net). Four exhibitions annually of 100 <i>l</i> . each.	None.	None	None.	None.
<b>LANCASTER.</b>				
<b>Blackrod (B'rod Free G. School).</b> —	9	32½	—	None.
<b>Bolton-le-Moors (Grammar School).</b> —	—	—	—	—
<b>Burley.</b> There are none of any kind.	About 40.	2 hours.	Due weight would be assigned if there were Exhibitions.	Strictly speaking there is no laboratory, but there are numerous chemicals and instruments belonging to the school.
<b>Cithreoe, in Parish of Whalley.</b> Income of school from endowment, about 300 <i>l</i> . Two Exhibitions, each 40 <i>l</i> . per annum.	All the Senior Forms, about 20 in number	No regular stated hours, but a lesson per week.	The Exhibitions are awarded to the boy of highest standing, not by special subjects.	None attaching to the school. All such property belongs to the Head Master, who has good philosophic apparatus, and uses it to illustrate the school lessons.

AMOUNT EXPENDED IN TEACHING			REMARKS.
Classics.	Mathematics	Natural Science.	
100 <i>l.</i> is assigned by the Chancery Scheme as Master's salary.			Instruction scheme, Art 22, comprises—Religion, Greek, Latin, French, English, Mathematics, Arithmetic, History, Geography, and such other branches as may to the Governors seem expedient, but the funds are too small to allow any Scientific Teaching worth the name, though I should much wish it, and I think here specially it would be valued. THOMAS BRAMLEY, M.A., Oxon, Head Master.
£150 100 60 30 £340		None in the school.	Five pupils of the school were learning Chemistry last half-year (ending July 20, 1871), but privately and from a teacher in the town: Classics and Mathematics are taught by the same masters. The Dean and Chapter, who are governors of the school, do not recognise competitive examination for any scholarship or exhibition in their gift. ROBERT WHISTON, M.A., Head Master.
—	—	—	Natural Science is not taught in this school, and the amount expended in teaching cannot be arranged under heads as "Classics" and "Mathematics." The Second Master teaches the lower portion of the school all that the boys learn; the Head Master all that the elder boys are taught. The boys enter the school at seven years of age, "reading" being the sole qualification for admission. If they reach the Head Master's school before 12, they then begin Latin. The boys leave at 15, having then gone through one or two books of Cæsar, in some cases six books of Euclid and Todhunter's <i>Algebra</i> for beginners; Colenso's <i>Arithmetic</i> , Geography (General), English History; Cornwell's English Grammar; Merlet's <i>French Accidence</i> , and a work of some French author.
Cannot be separated.		None.	We are waiting for the New Scheme before we commence Natural Science. At present we could not enforce attendance upon the Classes for Natural Science if we had them, nor make any charge in the way of payment.
—	—	—	This being a mining and manufacturing district, the children generally are taken from school at an early age to be employed in coal mines, cotton mills, bleach works, &c. Master's salary, 90 <i>l.</i> per annum. July 15, 1871. RO. SMITHSON, Master.
—	—	—	This is for the most part a free school, and there is no special instruction in Science, nor is it required, as such instruction may be obtained at the evening classes, both at the Church Institute and the Mechanics' Institution, for a very small payment. DISTRON S. HODGSON, M.A., Bolton, July 5, 1871. Head Master.
All the subjects mentioned in the Middle Class Schools Commissioners' Report are taught for 1 <i>l.</i> 1 <i>s.</i> per quarter.		Each boy pays 1 <i>d.</i> per lecture to the Science Master.	The Head Master has the honour to inform the Commissioners that for many years past every encouragement has been given by all the three Masters of this Institution to induce the boys to try and excel in Science. For several years past the more advanced pupils have presented themselves as candidates for distinction at the Annual Examinations held here by representatives of the Science and Art Department, South Kensington. The Second Master, an F.R.A.S., has used great exertions, and has always successfully taught a class in Geology. (Signed) JAMES BUTLER, D.C.L., Oxon, Head Master.
There being no separate accounts on these heads, the questions do not admit of answer.			Text book in <i>Natural Science</i> , Harding's <i>Lardner</i> , but we view Natural Science chiefly as a branch of Mathematical Science, and Todhunter's <i>Mechanics</i> , Tait's <i>Practical Mechanics</i> , form a part of the Senior Form course of study. EDW. BODEN, M.A. (Cambridge). Head Master.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<p><b>LANCASTER—cont.</b> <b>Great Crosby.</b></p> <p>We have no Exhibitions Income, 950<i>l</i> (mixed endowment), of which 400<i>l</i>, nearly is applied to the school.</p> <p><i>Station in the Parish of Penwortham.</i> Nil</p>	<p>30 boys learn Physical Geography, Four have lately begun Mechanics.</p>	<p>About two hours to Geography, and one hour to Mechanics.</p>		<p>None.</p>
<p><b>Manchester.</b></p> <p>Endowment, 22,500 Exhibitions and Scholarships given at the school— 1 Rickards' Scholarship, value 250 3 Brackenbury " 160 4 Shakespeare " 54 9 " " 284</p> <p>These Exhibitions have all been founded, the first by a Trustee, C. H. Rickards, Esq., and the remaining three by Miss Brackenbury, within the last year and a half. In addition to the money thus given, 23,000<i>l</i>, has been subscribed by the public for the erection of new buildings, E. R. Langworthy, Esq., heading the subscription list by a sum of 10,000<i>l</i>. There are close Scholarships and Exhibitions attached to the school, 10 at Brasenose College, Oxford, and four at St. John's College, Cambridge. The following are the particulars respecting the Scholarships, Exhibitions, Prizes, &amp;c.</p> <p><b>Somerset Scholarships</b>—Two or more scholarships at Brasenose College, Oxford, tenable for five years, and varying in annual value from 50<i>l</i>. to 60<i>l</i>., fall vacant every year. They may be held along with open scholarships of the College. No boy is eligible who has been less than two years at the school.</p> <p><b>Somerset Exhibitions</b>—One Exhibition at St. John's College, Cambridge, tenable for three years, and of the annual value of 50<i>l</i>., falls vacant every year, with an additional one every third year. They may be held with sizarships, or open exhibitions, or scholarships of the College. No boy is eligible who has been less than two years at school.</p> <p><b>Rickards' Scholarship</b>—In 1869 a sum of money was subscribed by the inhabitants of Manchester, in recognition of the public services of Charles H. Rickards, Esq., formerly a Scholar and now a Trustee of the school. With the funds thus raised Mr. Rickards has established a scholarship of 50<i>l</i>., which was awarded for the first time at the Michaelmas examination.</p> <p><b>Brackenbury Scholarships</b>—Miss Brackenbury has presented 4,000<i>l</i> to be appropriated to the foundation of three exhibitions or scholarships at the University of Oxford, to be held for three years by the best scholar of the year in Classics, Mathematics, or Physical Science. The Mathematical Exhibition was awarded for the first time at the Michaelmas examination.</p> <p><b>Shakespeare Scholarships</b>—These scholarships were founded to encourage the study of the English language and literature. They are tenable for two years, and are four in number—two of 20<i>l</i>., and two of 7<i>l</i>. a year. The competition is open to all boys under 17 who have been a full year at the school, and have passed a preliminary examination in Elementary Classics and Mathematics.</p> <p><b>Owens College Exhibitions</b>—Three Exhibitions were founded in 1861 for the purpose of enabling the holders to continue their studies at Owens College after leaving the school. One Exhibition, tenable for three years, and worth about 14<i>l</i>. a year, is offered for competition annually.</p> <p><b>Lawson Medals</b>—Two medals, one gold, of the value of 18<i>l</i>., the other silver, in memory of Charles Lawson, M.A., formerly High Master, are awarded for the highest and second place respectively, in Classics, at the Midsummer examination.</p> <p><b>Thompson Prize</b>—A book prize, of the value of 4<i>l</i>., in memory of Richard Thompson, M.A., formerly Second Master, is awarded at Midsummer for proficiency in History. Any boy below the High Master's Form may compete.</p> <p><b>Royal Geographical Society's Medals</b>—These medals are offered for general competition among the boys of the principal schools in Great Britain, Manchester School being one of those selected.</p> <p><b>Early English Text Society's Prize</b>—This is an annual prize given for the encouragement of the study of early English. The competition is open to all boys in the school.</p>	<p>150</p> <p>120 of these make Physical Science and Mathematics, their main study, and I think with success. I give below a list of distinctions gained at the Universities and elsewhere during the years ending Midsummer 1870.</p> <p>50 hours (i.e.) the entire time of two Masters. An additional Master in Physical Science it is contemplated should be engaged at Christmas, when the new laboratory is completed.</p> <p>The close Scholarships and Exhibitions are, I believe, given without reference to Natural Science, but should a boy of distinct promise in Physical Science offer himself at Brasenose College, the authorities would, I have no doubt, elect him.</p>	<p>50 hours (i.e.) the entire time of two Masters. An additional Master in Physical Science it is contemplated should be engaged at Christmas, when the new laboratory is completed.</p> <p>The close Scholarships and Exhibitions are, I believe, given without reference to Natural Science, but should a boy of distinct promise in Physical Science offer himself at Brasenose College, the authorities would, I have no doubt, elect him.</p>	<p>One Brackenbury Exhibition, vacant once in three years, is awarded exclusively for Natural Science, and another for Mathematics, (i.e.) half the School exhibitions are given to Mathematics and Physical Science.</p> <p>The close Scholarships and Exhibitions are, I believe, given without reference to Natural Science, but should a boy of distinct promise in Physical Science offer himself at Brasenose College, the authorities would, I have no doubt, elect him.</p>	<p>There is at present a laboratory where 30 scholars can work at a time, which cost 400<i>l</i> to fit up, and which takes 100<i>l</i>. a year for working expenses. The Trustees have begun to fit up an additional laboratory at an estimated cost of 800<i>l</i>., where more advanced scholars can be instructed in volumetric and quantitative analysis. Two rooms are set apart for instruction in Physics, and 300<i>l</i>. has within the last two years and a half been spent in the purchase of physical apparatus.</p>

AMOUNT EXPENDED IN TEACHING			REMARKS
Classics.	Mathematics	Natural Science.	
—	—	—	<p>As our school consists of 73 boys of all ages, from 8 to 16, and as there are only two Masters (besides a French Master, who comes twice a week for two hours) to teach all the subjects, it is impossible to make any way in the direct subjects of Natural Science. We are, however, hopeful of prosecuting them more extensively when the Endowed Schools' Act shall have removed certain restrictions which at present clog the school.</p> <p>As we have no special Masters for subjects, it is not possible to answer as to the "amount expended in teaching."</p> <p style="text-align: right;">SAM. C. ARMOUR, B.A., Head Master.</p>
—	—	—	<p>The funds of this endowment are expended in the maintenance of a <i>Free Grammar School</i> at Hutton, in the centre of the parish, for the better accommodation of the whole parish, to the children of the inhabitants of which it is open, and who learn the <i>Classics</i> only if they desire it. And besides the <i>Grammar School</i> at Hutton, separate <i>Free Schools</i> (Elementary) for boys, and <i>Schools</i> are maintained in each of the following townships of the parish, viz. Penwortham, Farington, and Longton, and a mixed school for boys and girls in the township of Howick. There is also an elementary school for girls at Hutton.</p> <p style="text-align: right;">JOHN KETTON, M.A., Head Master.</p> <p>Hutton, Preston, July 3, 1871.</p>
<p>The gross aggregate of salaries amounts to - 4,600l. a year</p> <p>The salaries of the Mathematical Teachers - 860l. "</p> <p>The Science Teachers - 500l. "</p> <p>And the Drawing Master - 200l. "</p>			<p>It is impossible to separate the cost of the classical teaching, the using masters who teach classics teach English subjects, Writing, and a large part of the French; the salary of the High Master, who has the general superintendence of the school, is of course included in the aggregate salaries.</p> <p>Since the introduction of Natural Science into the school our balance sheet exhibits a constant deficit. I calculate the Science teaching entails an annual loss of 300l.</p> <p>Honours gained by scholars in Physical Science, Mathematics, and Drawing during the last two years have been, Midsummer 1869 to Midsummer 1870; Midsummer 1870 to Midsummer 1871</p> <p><i>Oxford and Cambridge</i> - 1 Mathematical Fellowship, 1 Wrangler, 1 Senior Optime, 3 Open Mathematical Scholarships, 2 Open Physical Science Scholarships, 2 Close Scholarships (chiefly for Mathematics), 1 First Class in Mathematics, 1 First Class in Natural Science, 1 (partly Mathematical) Fellowship, 2 Open Mathematical Scholarships; 4 Open Physical Science Scholarships</p> <p><i>University of London</i>.—7 Matriculations, 12 Matriculations, 1 Board School, London.</p> <p style="text-align: center;"><i>Department of Science and Art.</i></p> <p><i>Science</i>—37 Prizes, 256 passes, 85 prizes, 335 passes.</p> <p><i>Art</i>.—5 Higher Grade prizes, 34 Second Grade prizes, 152 Second Grade passes, 7 Higher Grade prizes, 38 Second Grade prizes; 171 Second Grade passes</p> <p style="text-align: right;">July 31st, 1871. FRED. W. WALKER, High Master.</p> <p>[See also an additional Report in reply to Secretary's Letter of 27th of September 1872.—Appendix III, p. 179.]</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>LANCASTER—cont.</b>				
<b>Rivington.</b> £500	—	25	—	—
<b>Warrington.</b> Gross endowment - £550 Capitation fees - 400 <hr/> £950 <hr/> Net amount available for Masters' stipends - £830 N.B. No Exhibitions.	40	2	—	No.
<b>Wigan.</b> Endowment, about 280l. Exhibitions, none.	5 boys learn Chemistry	1½ hours.	—	No.
<b>LEICESTER.</b>				
<b>Ashby-de-la-Zouch.</b> 1,037l.	None.	None.	None.	None.
<b>Loughborough.</b> —	—	—	—	—
<b>Market Bosworth.</b> 4 Exhibitions, 80l. a year each.	None.	26 in school, more (as required) out of school.	None.	No.
<b>LINCOLN.</b>				
<b>Afford "Royal Grammar" School.</b> Income, about 280l. There is one Fellowship, and there are two Scholarships at Magdalene College, Cambridge, but not made use of for five years.	Not any.	30 hours, by two Masters.	Natural Science and Modern Languages, especially French, deared	None.
<b>Caistor.</b> 305l.	—	—	—	—
<b>Donington.</b> 800l. or 900l., Exhibitions, 76l.	—	—	—	—
<b>Heighington.</b> 154l. 12s. 0d. to Head Master; 66l. to usher, no Exhibitions.	—	Each Master gives 30 hours.	—	No.



AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics.	Natural Science.	
£ s. d. 145 0 0	£ s. d. —	£ s. d. —	* These two subjects are both taught by the Head Master, together with other subjects, such as English Grammar, History, &c SEPTIMUS TEBBY, B A., Head Master.
350 0 0	90 0 0	10 0 0	The above is a very rough approximation, it being impossible to calculate with accuracy the exact amount of time devoted to each subject specified above by each Master. O. H. CARY, Head Master.
—	—	30 0 0	No Master receives a salary for teaching Classics alone, or Mathematics alone. Each Master has a variety of duties to perform. The teacher of Chemistry is paid by the Head Master out of his own income. The Governors contribute nothing
[Latin.] 320 0 0	[English.] 220 0 0	—	Several pupils attend Evening Science Classes in connexion with the Department of Science and Art, taught by the Head Master of our English Department
—	—	—	We have no Science taught in this school at all, not for want of will, but for want of means, and there will be none until the Endowed Schools' Commissioners have helped us out of our difficulties. J. WALLACE, M A., Head Master.
—	—	—	I have no accurate or formal knowledge of the income of the school, or of the sums expended yearly on instruction, &c This belongs wholly to the Patron, and Governors or Trustees, who have the sole charge and management of the property and income.
<p>The school consists of an Upper or Latin School for Boys going either to Oxford or Cambridge, but chiefly they will go to Cambridge, as the school is connected with Emmanuel College The English School is for the instruction of the boys of Bosworth and its "chapelries," the sons of tradesmen, farmers, labourers, and the like. "Natural Science" forms no part of the education of boys of either class</p> <p style="text-align: right;">GEORGE JOHN DAVIE, M A., Clerk in Holy Orders, Head Master.</p> <p>July 4, 1871.</p>			
270	Amount expended in Classics, Mathematics, and English subjects of education, and partly in French.	—	The Head Master has been but recently appointed; he has delayed sending this report, as he wished to hold inquiries in the neighbourhood. There seems to be every desire in this neighbourhood to have Natural Science and French (and German if possible) introduced. Thus I have recommended in my report to the School Commissioners H. SEYMOUR ROBERTS, LL D, Of the University of Cambridge, Royal Grammar School, Alford, Lincolnshire, 20 July 1871.
—	—	—	Up to the present time Natural Science has not been taught in the Caistor Grammar School. The teaching has been confined to Classics, Mathematics, and the ordinary subjects of a commercial education ANTHONY BOWER, Head Master.
—	—	—	The annual income here applied to education is from 800l. to 900l. a year; 75l. expended in Exhibitions. This endowment supports four schools, viz., Grammar, Lower Boys', Girls', and Infants' schools. In the Grammar School (40 boys) the lessons on Mechanics are illustrated by Willis's apparatus and models. A microscope, a magic lantern with lime light and a microscope adapted to it, a geological cabinet, some chemical apparatus, an air-pump, electrical apparatus, diagrams, &c, are used from time to time as we need them; but it would be difficult to give statistics as to hours, &c., because we have no "Natural Science Master," but introduce apparatus to illustrate lessons as occasion may require. W. J. R. CONSTABLE, LL.D., Head Master
—	—	—	By the most recent scheme of the Trustees it is ordered, "That the instruction given in the school include all the branches of a good English education, viz., the Holy Scriptures and the Prayer Book, Grammar, Analysis, Geography, English History, Arithmetic; and that Latin be taught to any boy whose parents express their desire to that effect in writing." The boys are all of the labouring class, and there are at the present time no Latin scholars.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>LINCOLN—cont.</b>				
<b>Numberstone.</b>				
—				
—				
—				
<b>Lincoln.</b>				
From all sources and fees, 339l Exhibitions: two given at present by the Governors, of 50l for three years	Varies from 10 to 30	2	None.	A small collection of chemical and mechanical apparatus and diagrams.
<b>Leath.</b>				
—				
—				
<b>Stamford (Radcliffe's Free Grammar School).</b>				
—				
—				
<b>MIDDLESEX.</b>				
<b>Milk Street, Chesham, E.C. (City of London School.)</b>				
Income from fees, about 46,000 Scholarships and Exhibitions, about 1,800 <u>47,800</u>	All the boys in the School. Average number for last 10 years, 642.	Six divisions. Each division one lecture per week of 1 hour and 12 hours	Proportion:— Classes:— Mathematics - 1 Natural Science 4 There are 26 Scholarships and Exhibitions, in competing for 21 of which the candidate is examined in Natural Science, the seven others having been founded for specific objects.	Laboratory very inconvenient. One of the class rooms is used by the Practical Class, which assembles two hours per week, and consists of 27 boys, the best three boys from each of the first nine classes, the total classes being 12 For Science Lectures, the 12 classes are arranged into six divisions.
<b>City of London, St. Lawrence, Jewry (Foundation of Mrs. Elizabeth Smith).</b>				
Annual value, about 380l	None.	None.	None.	None.
<b>Edmonton (Latimer's School).</b>				
About 500l	20	1 hour.	—	No laboratory. The necessary apparatus and reagents for an elementary knowledge of Chemistry.

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics.	Natural Science.	
—	—	£ s d.	<p>Great Grimsby, 5 July 1871.</p> <p>SIR, Matthew Humberstone's Charity</p> <p>THE Head Master of the Humberstone School has handed me your letter to him of the 30th ulto. The scholars who attend the school are compelled to leave as they attain the age of 14 years. No Natural Science (as such) is taught in the school.</p> <p>I have the honour to be, &amp;c.,</p> <p>ROBERT STEPHENSON, Clerk to the Trustees.</p>
?	?	Don't know; it is mixed up with other teaching.	<p>It is not very possible to answer the above questions categorically in regard to a school like this</p> <p>We have taught Science here for 12 years or so. It has been Chemistry chiefly, but of late chiefly Mechanics.</p> <p>J F.</p>
—	—	—	<p>SIR, The Lodge, Louth, 15th August 1871.</p> <p>ON my return from the continent, I have found your circular dated 30th June, in reply to which I have the honour to acquaint you that Natural Science is not at present taught in Louth Grammar School, and beg to remain, Sir,</p> <p>Your obedient servant, GEO. C. HODGKINSON, Head Master.</p>
—	—	—	<p>The work done in this school comprises the usual course of Classics and Mathematics, preparatory to entrance at the Universities, it further involves instruction in the Scriptures, History, Geography, Writing, and Arithmetic</p> <p>(Signed) F E GREYTON Head Master</p> <p>July 1st, 1871.</p>
Senior Department Mathematics, Classics, and English, 2,980 <i>l</i> (nearly).	Junior Department Arithmetic and English, 1,170 <i>l</i> (nearly)	215 0 0	<p>[See also additional Reports in Replies to Secretary's Letters of 22nd of July 1870, and 27th of September 1872.—Appendix III., pp 98-103, and pp. 138-140 ]</p>
—	—	—	<p>There is no school—no Master Under a scheme sanctioned by the Court of Chancery, the whole income is expended in giving Exhibitions to the sons of the ratepayers, elected by the Vestry, who must go either to University College School, the City of London School, or King's College School. The Treasurer pays the school bills of each boy so elected up to 20<i>l</i>. In 1869-70, there were seven boys at University College School, and 10 at the City of London School. I have no returns yet for 1870-71 The answers to this inquiry will, therefore, be included in returns from the two schools last mentioned</p> <p>Gresham College, 28, Gresham Street, July 2, 1871</p> <p>B. M. COWIE, Vicar of St Lawrence, Jewry, and Rector of St. Mary Magdalen, Milk Street.</p>
—	—	—	<p>This school is worked by a scheme established by the Court of Chancery in 1869 By quoting article 29 of this scheme, the Science Commission will perceive that general provision is made for instruction in Science at the discretion of the Trustees.</p> <p>Article 29, page 17 —“The secular instruction in the First Branch of the School shall comprise, besides Reading, Writing, Spelling, Grammar, Arithmetic, and General History and Geography, also Algebra and Mathematics, the Latin and French languages, and Drawing and Designing, and such subjects of Physical Science and Useful Knowledge as shall from time to time be directed or authorized by the Trustees.”</p> <p>CHARLES VINCENT DOLBÉ, M.A., LL.B., (Clerk in Holy Orders), Head Master.</p> <p>16 August 1871.</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>MIDDLESEX—cont.</b> <b>Enfield.</b> 209 <i>l.</i> 11 <i>s</i> 4 <i>d.</i>	About 40 of a very elementary character.	26	None.	Nothing.
<b>Hammersmith.</b> 700 <i>l.</i> income; 15 <i>l.</i> Exhibition.	—	30	—	—
<b>Highgate, W.</b> This varies, and is in the hands of the Governing Body. There is always one, and sometimes there are two exhibitions, given for proficiency in <i>Classes</i> and <i>Mathematics</i>	None daily; but some occasionally, by a course of lectures.	Occasional lectures to those who wish it in <i>Chemistry</i> .	None at present, except as to <i>Mathematics</i> generally.	None whatever
<b>Westminster (St. Peter's College).</b> Corporate income, 3,700 <i>l.</i> Tuition fees, about 4,300 <i>l.</i> School Exhibitions, 200 <i>l.</i>	47 (out of 185)	1½ hours	Hardly any at all.	Models of mechanical powers, celestial globe, telescope.
<b>Whitechapel, Leman St., E.</b> * Income: see below under "Remarks." No Exhibitions.	40	3 hours.	Prizes are given at the <i>Midsummer</i> examinations Science teaching has every encouragement No Exhibitions.	Yes.
<b>BRISTOL.</b> <b>Brommouthe.</b> Gross income about 2,800 <i>l.</i> Income of total number of Masters from "Income of Foundation," 1,310 <i>l.</i> Exhibitions, three of 50 <i>l.</i> , one of 60 <i>l.</i> One of these confined to pupil distinguishing himself in <i>Physical Science</i> .	40	30 For Natural Philosophy, 2½.	One Exhibition of 50 <i>l.</i> , confined to pupil distinguished in <i>Physical Science</i> .	No laboratory, one contemplated. Some amount of apparatus about to be obtained immediately.

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics.	Natural Science.	
No division is made of the salary for any special subject.			This is a free school governed by an old useless scheme, so long as this incumbrance remains nothing can be done. The income is from land, and capable of augmentation. Under a new scheme, with capitation fees, the school would do useful work. Twenty-three years' experience has convinced me that the <i>free</i> instruction is not valued by the parents, and is a positive block to any improved course.  CHAS. CHAMBERS.
Cannot be stated separately.		Nil.	
400 <i>l.</i> per annum is all paid for teaching.			The Head Master has endeavoured to make Chemistry a part of the regular school teaching for all boys whose friends wished them to learn. These have been very few, only those looking to Matriculation at the University of London for a medical career. There is no endowment for a teacher, and he has always had to pay more to a lecturer than he received, add to this, the lecturer has always felt the want of a laboratory. Under these circumstances, the Head Master generally suggests that students of this class should go to London for lectures out of school hours, where the best lecturers and appliances are to be obtained. He generally finds those succeed best who finish their school course <i>first</i> . J. B. DYNE, D.D., Head Master. 5 July 1871.
Divinity, Classics, History, Geography, Modern Languages with English, 3,400 <i>l.</i>	900 <i>l.</i>		An extract from the regulations sent for approval to the Special Commissioners of the Public Schools included in the Act of 1868 is enclosed, which will show what is intended. [Given below.] At present there is no space for extension. There are 40 Foundation Scholarships, which are not called Exhibitions, but perhaps would be intended to be included under that head in the column above. The Mathematical Masters teach Practical Mechanics and Astronomy, which are the only branches of Natural Science at present attempted. The Classical Masters teach a multitude of other things, as noted above, so that it is not possible to fill up the three columns as printed; and 1,260 <i>l.</i> of the tuition fees (col. 1) is paid from the corporate income. I request, therefore, that the figures above given may not be included in a table as representing what they do not in fact represent.
REGULATIONS FOR WESTMINSTER SCHOOL, FRAMED BY THE GOVERNORS			
<i>" School Instruction.</i>			
<p>" 1. The instruction given in the school shall include Religious teaching, Classics, Mathematics, <i>Natural Science</i> (so far as practicable at present), French, or German for boys well advanced in French, English, History, Geography, and likewise either Drawing or Music, at the option of the parents, the Head Master having the power of exempting any boy, with the consent of his parent, from learning Drawing or Music, if he think it desirable so to do in the special case.</p> <p>" 2. Further arrangements shall be made for teaching <i>Natural Science</i> when additional space may become available</p> <p>" 3. The representation of a Latin Play by the Scholars of the Foundation at Christmas shall continue as heretofore.</p>			
<i>" Number, Position, and Payment of Masters</i>			
<p>" 1. The number of Masters shall be so regulated that there may be not less than one Classical or General Form Master for every 30 boys, and one Mathematical or <i>Natural Science</i> Master for every 75 boys. All such Assistant Masters shall be on the regular staff of the school, and shall devote (if required) their whole time to its service.</p> <p>" Masters shall also be appointed for Drawing and Music, and for Modern Languages, so far as may be required for efficient instruction in such subjects, beyond what the aforesaid Assistant Masters are competent to undertake."</p> <p>[See also additional Reports in Replies to Secretary's Letters of 22nd July 1870, and the 27th September 1872.—Appendix III, pp. 94, and 130, 131.]</p> <p style="text-align: right;">CHAS B SCOTT, Head Master.</p>			
			* This school is endowed in the following manner.—A certain proportion of the salaries of the Masters, as well as the keeping up of the establishment, is paid out of the surplus income of the Whitechapel parish estates.
Arrangements are now made to give instruction in all the classes of the Upper School. We have a good supply of instruments for Chemistry, Electricity, Magnetism, Light, and Heat. The Trustees are exceedingly liberal in this way; I have only to state what I want, as far as funds go I am supplied. To encourage further study in <i>Natural Science</i> , the Trustees have allowed the old scholars to found a Library and Scientific Institution. I enclose you a copy of the rules. The lectures, all by old pupils, are solid and good. <i>Science</i> in the classes stands on the same footing as Latin, Mathematics, and Modern Languages, <i>s.e.</i> , an equal number of marks are given to each. See enclosed papers.		CHARLES JUDD, Head Master.	
Great difficulty to obtain a Master who knows anything about teaching <i>Science</i> . A good practical man would be very expensive when employed at a single establishment.			The Head Master teaches both Mathematics and Classics, and receives 200 <i>l.</i> per annum from school endowment. The Assistant Master for Classics receives 180 <i>l.</i> ditto. The Assistant Master for Mathematics teaches also Junior Classics and <i>Natural Philosophy</i> , and receives 150 <i>l.</i> ditto. C M ROBERTS, B.D., Head Master, July 5th, 1871. Late scholar of St. John's Coll., Cambridge.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>WORFOLK.</b> <b>North Walsham.</b> About 290 <i>l</i> .	None.	—	—	—
<b>Thetford.</b> No Exhibitions. This is a mixed charity; about 230 <i>l</i> is spent on the school.	None.	—	—	None.
<b>Yarmouth.</b> About 260 <i>l</i> ; no Exhibitions.	None.	None.	—	None, and none obtainable in the town.
<b>NORTHAMPTON.</b> <b>Northampton.</b> 360 <i>l</i> .	36	One.	No Exhibitions.	None.
<b>Oundle.</b> Grocers' Company, *105 <i>l</i> 10 <i>s</i> . 0 <i>d</i> Parents' entrance and school fees, 210 <i>l</i> 13 <i>s</i> 0 <i>d</i> . Exhibitions, 75 <i>l</i> .	None Postponed till it be seen what the Commissioners will do.	†31.	None.	†None.
<b>NORTHUMBERLAND.</b> <b>Haydon Bridge, in the Parish of Warden.</b> About 900 <i>l</i> . (No Exhibitions.)	None.	About 30 in other subjects, but none in Natural Science.	There are no Exhibitions.	None.
<b>NOTTINGHAM.</b> <b>East Retford.</b> Value of income about 500 <i>l</i> ; Exhibitions, none.	None.	29	—	None.
<b>OXFORD.</b> <b>Magdalen College, Oxford.</b> Silver medal, value 1 <i>l</i> . 10 <i>s</i> .*	13	Masters give 14 hours, boys have each 5.†	Our stimulus is given by University Scholarships.	A chemical laboratory, and mechanical room.
<b>ESSEX.</b> <b>Oakham.</b> —	—	—	—	—

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics	Mathematics.	Natural Science.	
£ s. d. 140/	£ s. d. —	£ s. d. —	By the deed of endowment provision is made for the free instruction of 40 boys in Religion and Classics by a Master and usher. No usher has been appointed for many years by the Trustees, and the Master has been allowed to receive a capitation fee of 8/ in the case of each boy learning Mathematics, Arithmetic, Writing, History, and Geography. The Master's annual stipend from the income is 140/. The surplus has been allowed to accumulate for many years. THOS DRY, Master
—	—	—	The income is expended in teaching English and the Classics when required. There is no separate amount spent on each. Two masters:— ALFRED FOWLER SMITH, M.A., Cantab, Head Master, 130/. John Henry Gates, M.C.P., Usher, 100/
From fees and endowment about 1,130/.		Nil.	It is impossible to make a separate return for Classical and Mathematical teaching. I consider the absence of instruction in Natural Science a great defect in our system, but I trust that when we are settled in our permanent buildings we shall supply this want. There is no encouragement for boys to learn Chemistry, as there is no laboratory. Our site provides ample room for building one. Difficulties must be expected on account of the obstructive spirit of one or two of the older Trustees, and the dilatoriness and circumlocution of the Charity Commissioners. School House, Great Yarmouth, 1 July 1871. JOHN JAMES RAVEN, B.D., Head Master.
No separate Masters.		—	I am very anxious to introduce the teaching of Natural Science more largely into the school; but there are no funds for apparatus, or for a special master. W. H. KEELING, M.A., Head Master.
575/.	410/	—	* Besides the above sum, the Company paid in 1870 for repairs of school house and master's residence, retaining the bills and receipts, I cannot, therefore, mention the amount. They also paid 115/ 5s 6d. for rates and taxes, school fuel, cricket club and athletic sports, do examiners' fees and book prizes. Except the original 41l. 4s. 0d. and the 210/ 13s. 0d. paid by parents for instruction in Greek and Latin, Mathematics, French, German, and the usual English course, viz., Geography, History, Religious Knowledge, &c., all other payments, I am informed, are voluntary gifts on the part of the Company, and may be withdrawn by them at any time. † Including rather more than one hour on Sunday mornings for scriptural teaching, being optional with day boys. ‡ Estimates and a plan were forwarded to Grocers' Hall, April 1870, for pulling down old buildings attached to the master's residence, and erecting Science class-rooms, a laboratory, museum, &c., but were laid aside till it should be seen how the Commissioners propose to deal with the endowments. There can be no doubt as to their urgent need and importance. J. F. STANSBURY, D.D., Head Master.
275 0 0	Nothing expended under this name. About 350/ is paid for teaching in the English Schools, Arithmetic being one of the subjects taught.	—	The foundation is twofold — I. A "Grammar School" with (at present) one foundationer and the Head Master's boarders; and II. An "English School" numerously attended, and nothing differing from an ordinary National or Elementary School, the children leaving at an early age (some even at 10 years old) to go to work. W. L. PENDEEB
Head Master's stipend - £150 Second do. - 100 French and German 100		—	It would be very desirable that Natural Science be taught in this school. The present Head Master (only recently appointed) is very anxious to form a class for this subject, and hopes that attention may be drawn to it when the Commissioners reorganise the school; and the sooner this is done the better for the interests of all parties. F. R. PENTREATH, M.A., Head Master.
1,000 0 0	250 0 0	113 0 0	* The only endowment, practically, is in buildings, which are excellent. † Boys often attend University lectures; these are <i>sometimes</i> paid for. ‡ If the boarding profit be given, please at least double the Classical. There is given to Applied Mathematics, not here accounted for, and Drawing is taught to about 14. July 5, 1871. (Signed) R. H. HILL, D.C.L., Head Master.
—	—	—	There is no regular instruction in Natural Science. Lectures are occasionally given, and the boys are encouraged in any efforts they may make voluntarily; but as the school is small and there is no laboratory to fritter away time on what would be only learning Science by rote. No separate sums are devoted to teaching distinct subjects. Classics, Mathematics, English, &c., being all included in the regular school routine. Wm. S. Wood, D.D., Head Master.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>RUTLAND—cont.</b>				
<b>Uppingham.</b>				
Sums spent by the Trust.	Six pupils in Chemistry.	From three to six hours.	None.	A small museum set up by me.
Head Master's salary - £150 0				
Usher's do. - 120 0				
Exhibitions - 420 0				
Library - 5 0				
Prizes - 7 10				
<u>£702 10</u>				
Repairs, a small sum Between 700 <i>l</i> and 800 <i>l</i> spent on the foundation				
<b>SALOP.</b>				
<b>Ludlow.</b>				
Three Exhibitions of 50 <i>l</i> . each.	—	—	—	—
<b>Newport.</b>				
—	14	2	None.	None.
<b>Oswestry.</b>				
One Exhibition	—	—	—	—
<b>Wem.</b>				
Gross income, 240 <i>l</i> Two Exhibitions to Christ Church, Oxford, of 50 <i>l</i> each	—	—	—	—
<b>Whitchurch.</b>				
Gross income, 507 <i>l</i> No Exhibitions	None.	—	—	—
<b>SOMERSET.</b>				
<b>Burton.</b>				
420 <i>l</i> Two Exhibitions at 30 <i>l</i> , tenable for three years.	14	33	Exhibitions given for general or special merit.	Small apparatus.
<b>Ilminster.</b>				
About 860 <i>l</i> .	50	1½	None.	Small.



AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics	Natural Science.	
£ s. d.	£ s. d.	£ s. d.	
—	—	—	<p>Classics and Mathematics are taught as regular school work throughout the schools, there is no separate fee for tuition yet, and if there were, it would not fairly represent the matter, for reasons too long to be stated here. The terms for everything are 70s per annum, this covers the boarding fees and tuition in Classics and Mathematics. Besides this, about 500l per annum is received as payment for extra mathematical teaching, and about 50l. for the Chemistry lessons.</p> <p>The Foundation gives towards the educational expenses for the school 282l 10s per annum, and one house. The whole of the school system is carried on on a basis established by me since the year 1853, at my own risk originally, and is, as far as it goes, self-supporting. The Foundation, practically, does nothing for it. Some years ago I made great efforts to set on foot voluntary classes in Natural Science on the same footing as our other supplementary subjects, but utterly without success, no boys would learn. There are 320 boarders in the school now.</p> <p style="text-align: right;">EDWARD THING.</p>
—	—	—	<p>We have no data from which to furnish replies to these questions, but are happy to furnish such information as we have applicable to the matter. The income of the school has varied with its requirements, being part of a general income available to many charities, of which the school is one. The Exhibitions are three in number, tenable for three years, of 50l annual value. The holders may matriculate at Oxford, Cambridge, or Durham. There are no facilities for teaching Natural Science, in the way of laboratory or apparatus. It has never been contemplated in previous schemes for the school, and could only now be taught by the suppression of something already prescribed. We cannot tell in what proportions the income would be divisible under the last three heads, as every pupil goes through the same course of Classics, Mathematics, and English, all of which are taught, and a fee paid which includes these subjects. This annual fee is 3l., paid half-yearly.</p> <p style="text-align: right;">WILL C. SPARROW, LL D., Head Master.</p>
—	—	—	<p>I have only recently been appointed Head Master of Newport Grammar School. It is a school of large endowment, some 1,500l a year. At present there are about 90 scholars. No Science was taught when I went there in January last. At present the first class, 14 boys, do Natural Philosophy. Next half year I hope to have 30 doing it. There is no laboratory, and all the teaching has to be done solely by book.</p> <p style="text-align: right;">J. COLLINS, Head Master.</p>
—	—	—	<p>There is no instruction in Natural Science at this school, and only one Exhibition (lately established), for Classics and Mathematics. The boys are mostly young.</p> <p style="text-align: right;">AMBROSE SHORT, M.A., Head Master.</p>
—	—	—	<p>Natural Science not taught. There are two divisions of the school, Upper and Lower, in the first, Classics chiefly taught, but five boys learn Euclid. In the second, an English education only given, and that of a very meagre description, so that boys very seldom pass from the Lower to the Upper School. I am unable to state the net annual income; the gross is about 240l. The school shares in the Carewwell Charity, and has two Exhibitions from that source to Christ Church, Oxford. Value, 60l. per annum each.</p> <p style="text-align: right;">WM. BOULTON, Head Master.</p>
—	—	—	<p>There is no instruction in Natural Science at present in the Whitchurch School, occasionally, in past years, instruction has been given in Botany. As all the Masters, except the French Master, take a part in the general teaching of the school, I cannot say how much is expended in teaching Classics, Mathematics, &amp;c, separately.</p> <p style="text-align: right;">J. R. PEAKE, M.A., Head Master of the Whitchurch Grammar School.</p>
190 0 0	80 0 0	80 0 0	<p>It is impossible to answer the questions directly. Our staff consists of three graduates (Oxford and Cambridge), an A.R.A. for Drawing, and a Music Master. Chemistry is taught by the Second Master, who also teaches Mathematics, he being a Wrangler and First Class in Chemistry at Oxford Locals.</p> <p>Does the question "Hours of Instruction" allude only to Natural Science? If so, the answer should be three hours.</p> <p style="text-align: right;">A. D. GILL, M.A. (Head Master).</p>
<p>As the Masters, including myself, teach different branches of instruction, it is impossible to specify the amount expended on each subject.</p> <p style="text-align: right;">G. T. GOWRING, M.A., Head Master.</p>			

Net Annual Value of Income and Exhibitions	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science
<b>SOUTHAMPTON.</b> Fortsmonth. —	None.	—	—	—
<b>STAFFORD,</b> Eugeley. No Exhibitions. 225l Head Master, 70l. +50l Second Master from Head Master.	12	4	—	No.
<b>Walsall.</b> Gross, about 1,100l	None.	30 hours.	—	—
<b>SUFFOLK.</b> Bury St. Edmund's (Grammar School) About 590l,* of which Exhibitions take 220l.	22	Half an hour.	Counts to a trifling extent along with Mathematics.	None.
<b>Ipswich.</b> 109l, which is absorbed in payment of rent of school buildings. Exhibitions, 147l.	15	2	Nil.	At present none, but there is a prospect of some additional buildings being erected.
<b>Woodbridge.</b> About 400l	18	2	No Exhibitions yet.	No.
<b>SURREY.</b> Croydon. —	None.	—	—	—
<b>Southwark (St. Saviour's Parochial School).</b> —	—	—	—	—
<b>SUSSEX.</b> Hastings (Parker's). —	—	—	—	—
<b>Horsham.</b> —	—	—	None.	No.

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics.	Mathematics	Natural Science	
£ s. d.	£ s. d.	£ s. d.	
			The school is at present in a transition state, pending its reconstruction. A. RUSSWURM, Head Master.
225	70	50	As yet Natural Science is represented by elementary works on Astronomy and Chemistry. For the last year, and for the succeeding one (perhaps certainly), 50l out of the Head Master's salary has been, and will be, paid to a Third Master, who teaches Classics and Mathematics. (REV) EDWARD ROGERS PITMAN, M.A., 1946, Christ's Coll., Cambridge, Editor of "Iphigenia in Tauris," 1857.
660l. for both subjects.		—	Some years ago there was a Chemistry class, for a time it flourished, but as the subject was optional the numbers fell off, and the class was discontinued. The boys then paid 10s each a year for tuition in Chemistry, and the Governors of the school allowed an additional salary to the teacher of 2l. Under the new scheme, it is proposed to make one of the Natural Sciences not optional but compulsory. Walsal, July 3, 1871. A. C. IRVINE, Head Master.
275 0 0		Nil	* From Report of Commissioners, p. 146. Half an hour per week is devoted to the fourth and fifth Forms by the Head Master in teaching the general principles of Natural Philosophy, and explaining the mechanical powers and ordinary instruments and machines. Different Masters take upper and lower work in different subjects, so that it is utterly impossible to classify the amount expended in different branches of teaching. There is no possibility of apportioning the sums paid by the endowment for Classics, Mathematics, and English separately. A. H. WRATISLAW, M.A., Head Master.
		—	A scheme will be shortly submitted by the Trustees to the Charity Commissioners for appropriating a considerable sum to the uses of the school, and it is probable that some portion will be devoted, provided the application be successful, to the promotion of Natural Science teaching. The funds of the school at present are insufficient to provide adequate salaries for the existing Masters. H. HOLDEN, LL.D., Head Master.
		—	The same Masters are employed in teaching both these subjects, so that there is no possibility of instituting a comparison under this head. The Head Mathematical Master teaches the little amount of Natural Science which is undertaken. It is difficult to answer these questions, as we have no special Master for the teaching of Natural Science. WILLIAM TATE, M.A., LL.D., Head Master.
—	—	—	The Whitgift Middle-class School was opened on the 4th of May 1871, and at present Science is not taught in it. It is hoped that in the course of the next year instruction in some branches of Natural Science may be given. July 3rd, 1871 ROBERT BRODIE, M.A., Oxon, Head Master.
—	—	—	The instruction given in this school is purely elementary, and no time is devoted to the study of the Sciences. RICHD. HUNT.
—	—	—	Natural Science is not taught in the above school. JOHN BANKS, Master.
Nil.	Nil.	Nil.	The Head Mastership of this school is at present vacant. The Trustees of the school are the Mercers' Company of London. I do not know the net annual income. It was founded for 60 poor children, and the Trustees added 20 in 1857; the total 80 are chosen by the local Governors from the poor, and receive their education entirely free of any charge. There are no Exhibitions attached to the charity. The present scholars are of that class of life found in the upper classes of national schools. July 3rd, 1871. RD. CRAIG (Usher), Acting Master.

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<p><b>WARWICK.</b>  <b>Atherstone.</b>            About 220l.            About 40l. a year privately subscribed for Exhibitions tenable at school</p>	13	About 6.	It balances Greek for older boys, and counts equally with it.	Maps at present. Formation of a small museum in progress
<p><b>Coventry (Sablake).</b>            Not known officially.</p>	—	—	—	—
<p><b>Stratford-on-Avon.</b>            310l.</p>	—	31	None.	None.
<p><b>Burton Coldfield.</b>            About 330l.            No Exhibitions</p>	31	From 2 to 4 hours per week.	There are no Exhibitions.	There are all the necessary apparatus and chemicals, &c., for experiments.
<p><b>Warwick.</b>            Salaries for four Masters, 400l.            Capitation fees, about 140l.            Three Exhibitions, 195l, 65l. each</p>	No instruction in Natural Science.	—	—	—
<p><b>WESTMORELAND.</b>  <b>Appleby.</b>            230l.</p>	No Natural Science taught	—	—	—
<p><b>WILTS.</b>  <b>Mariborough.</b>            Net annual income of school about 190l.            No Exhibitions held in the school.</p>	42	About three hours to Botany or Natural Science.	No Exhibitions.	None.
<p><b>The Close, Salisbury.</b>            712l net, including clothing and boarding of boys and premiums.</p>	None at present.	—	—	—
<p><b>WORCHESTER.</b>  <b>Dudley.</b>            Two Exhibitions of 30l. each.</p>	—	A lecture of one hour's duration.	—	—

AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics	Mathematics.	Natural Science.	
* —	—	—	<p>A fortnightly course of lectures, by lecturers invited by Head Master, delivered last autumn.</p> <p>* It is impossible to give even an approximate estimate, as at present the Head Master alone takes the Natural Science, and receives no special payment for it. The Trustees, as far as they have the power, expend a small sum on necessary apparatus at the suggestion of the Head Master. As the school had been at a low ebb before and at the appointment of the present Head Master, and is only just recovering its number, the teaching of Science is necessarily only in embryo, but it is intended to extend it by degrees as opportunity offers.</p> <p>(Signed) SMITH W. CHURCHILL, M.A., Head Master.</p>
—	—	—	<p>I have myself taught the elements of Geology and Phynology, but these subjects do not form part of the school routine.</p> <p>F. W. HUMBERSTONE, A.K.C., Head Master.</p>
—	—	—	<p>The only Masters provided by the Foundation are a Head and Second Master, who are responsible for the Classical, Mathematical, and English work of the school. The present Head Master has obtained also the assistance of French and English Masters. The Head Master is sensible of the value of Natural Science, and has made several efforts to introduce the study of it into the school. As, however, the only persons qualified to teach it are himself and the Second Master, and they cannot multiply themselves at pleasure, but little time can be devoted to the study. It requires considerable time and a competent staff to maintain Classes, Mathematics, and English in an efficient state.</p> <p>H. GRIFFITH EVANS, M.A., Head Master.</p>
* —	—	40 0 0	<p>*It is impossible to determine the amount spent separately on teaching Classics or Mathematics, because all the Masters teach both branches of education.</p> <p>ALBERT SMITH, M.A., Head Master.</p>
—	—	—	<p>C. THREEFIELD, M.A., Head Master.</p>
—	—	—	<p>Cannot be stated under specific heads. Salaries of assistants about 350<i>l</i>, besides board and lodging.</p> <p>For several years classes have been instructed and prizes given for advance in Natural Science, and the formation of botanical collections, &amp;c, has been encouraged as much as possible. Owing, however, to the class from which the majority of the pupils come being unwilling to incur additional expense, and other reasons, we have not made much progress in our little museum. The great drawback under which we are now suffering is the utter uncertainty as to the future of the school. We can incur no expense while we are in ignorance of what the school is to be, classical or modern, first or second grade.</p> <p>F. H. BOND, M.A., Master.</p>
—	—	—	<p>It is probable that ere long an alteration in the teaching staff will be made, which will allow of the introduction of elementary Natural Science.</p> <p>EDMUND DOWLAND, M.A., Master.</p> <p>July 6th, 1871</p>
—	—	—	<p>We have no laboratory. For one hour per week a lecture is given on Natural Science to two classes, consisting of about 24 boys between them. This takes place on each Thursday from 10.15 to 11.15 a.m. We attach equal weight to Natural Science as to Classics or Mathematics. We have two Exhibitions of 30<i>l</i> per annum each for scholars going to Oxford or Cambridge; but only one has yet been held, so there has been no competition for them.</p> <p>ROBT HARPER, M.A., Head Master.</p>

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>WORCESTER—cont.</b>				
<b>Stanley Castle</b> 247 <i>l.</i>	About 15 last term.	3½	No Exhibitions.	None as yet.
<b>Kidderminster.</b>				
---				
<b>Stourbridge.</b>				
One of 50 <i>l.</i> , one of 8 <i>l.</i>	15	3 hours.	None.	Suitable chemicals and apparatus are provided.
<b>Worcester (Royal Free Grammar School).</b>				
---				
From 20 to 30.				
About 1.				
<b>Worcester (Worcester Cathedral School).</b>				
There is no separate endowment. Three of the Masters are paid by the Dean and Chapter. 200 <i>l.</i> , 150 <i>l.</i> , and 100 <i>l.</i> respectively	All the classes above the lowest learn Natural Science; about 80 boys on an average.	One hour a week to each class.	---	No laboratory Text books and diagrams
There are 40 King's Scholars, who receive a free education for four years, and 2 <i>l.</i> 13 <i>s.</i> 4 <i>d.</i> each yearly. There is no extra charge for teaching, except an optional one of 2 <i>l.</i> for Modern Languages and Drawing				
<b>Wolverley (Kidderminster).</b>				
---				
<b>YORK.</b>				
<b>Wharfedale</b>				
Income, including Woollers, 450 <i>l.</i> (net)			No Exhibitions	None
<b>Giggleswick</b>				
About 1,100 <i>l.</i> [See Appendix, p. 244.]			---	No.
<b>Halifax.</b>				
---				
<b>Hemsworth</b>				
700 <i>l.</i> No Exhibitions.			No Exhibitions.	None.

AMOUNT EXPENDED IN TEACHING			REMARKS.
Classics	Mathematics.	Natural Science.	
<i>£ s. d.</i>	<i>£ s. d.</i>	<i>£ s. d.</i>	
Cost of tuition from endowment for all branches, 170l.			This school was in a deplorable state at the visit of the Inspector on behalf of the Royal Commission. Consequently the Head Master was removed, a new scheme obtained, and there are now 60 pupils, besides the Elementary Department. On account of building large schools, funds have until now been wanting. In the future any surplus will be appropriated for providing laboratory, &c, at least as soon as the school is in a state to warrant the outlay. Our new scheme provides for instruction in elementary branches of Science. W. WALKER (M.A., &c), Head Master
—	—	—	Till the present year, no instruction has been given in this school in Natural Science. This present year we have begun short weekly lectures in Chemistry, but without laboratory or other aids. The School is in a state of transition, there being no Head Master, and a fresh scheme being made. LIONEL B. PENLEY, Master pro tem P.S.—I am not able to fill up the form. I am at present the sole Master, and there are under 20 boys.
—	—	—	I cannot fill up the last column, because the teaching of the Masters is not confined exclusively to one branch. W. J. J. WELCH, M.A., Head Master.
Cannot be separated. No special payment at present for teaching Science.			Two courses of Geology in the year, each lasting a month or five weeks, and including four night lessons per week and corresponding lectures in school. From four to six excursions each year to teach Geology in the field, accompanied by field lectures given by the Master or other competent persons. The Head Master is anxious to obtain assistance in teaching other branches of Natural Science but has not as yet been able to procure competent teaching for the small sum at his disposal. MAURICE DAY, M.A., Head Master.
The amount expended in teaching these subjects cannot be exactly given, as most of the Masters take classes in each of them.			
—	—	—	I am the only Master, W. SHUTT.
†	—	—	* No Science Master, or special hours devoted to same; taught in Class Book of Modern Science twice a week by Head Master. † Income not distributed over separate subjects. (Signed) THOMAS DIXON, B.D., July 19th, 1871. Head Master.
—	—	—	It is impossible to send any useful information with reference to this school. A scheme of work recently adopted by the Board of Governors directs that instruction in Science should be given. But we are waiting for the action of the Endowed Schools' Commission, who have been engaged for some time on a new scheme for the school. Every one will gladly help forward Science teaching when the new scheme comes forward. G. STYLLS, Head Master. July 1871.
—	—	—	There is no provision for any scientific teaching at this school, there being no funds either from endowment or from fees available for the payment of a Master. The Head Master, too, has no time, as he has to teach to the upper boys Latin, Greek, Divinity, English Literature, and Mathematics; and, to do these well, a division of labour would be a good thing. July 4, 1871. THOMAS COX, Master.
90 0 0	90 0 0	—	Clause 29 of the Scheme provides that "the principles of Chemistry and Physical Science generally" should be taught if in the judgment of the Trustees they be necessary to render the "foundation of the most general use and benefit."

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<b>YORK—cont.</b> <b>Kirkby Ravensworth, near Richmond.</b> 245l. 16s. 8d.	10	From March 1 to November 1, 32½ hours From November 1 to February 28, 30 hours.	There are no Exhibitions.	None
<b>Kirkcubbin.</b>	—	—	—	—
<b>Leeds.</b> Income, 1,421l. Exhibitions, 50l.	Systematically studying Science, average 8. Incidentally, average 60	12	None	A laboratory with all necessary appliances.
<b>Mirfield.</b> 208l.	21	1	No Exhibitions attached to this school	None.
<b>Pocklington.</b> Income somewhat in excess of 1,000l. Exhibitions, 160l.	6	26, besides 8 of evening preparation.	The examination is conducted at St. John's College, Cambridge, in Classics and Mathematics generally. Very considerable weight would be assigned to proficiency in the latter, including Natural Science	None.
<b>Ripon.</b> Net income, about 700l. No Exhibitions	About an average of 12	—	—	Yes.
<b>Rishworth.</b> 3,300l. Exhibitions, 150l.	—	36	—	—



AMOUNT EXPENDED IN TEACHING.			REMARKS.
Classics	Mathematics	Natural Science.	
*—	†—	£ s d. ‡—	<p>As a general rule parents and guardians or friends do not allow pupils to remain at this school a sufficient length of time to enable such pupils to extend their education to the Natural Sciences further than to the bare elements, which I introduced in teaching the nature of, and the laws governing common things.</p> <p>I cannot so divide the Masters' stipends as to fill up columns marked by me (*), (†), and (‡).</p> <p style="text-align: right;">(Signed) JOSHUA WOOD, Clerk, M A, Head Master, &amp;c.</p>
—	—	—	<p>Sir William Turner, Knight, Alderman, and Lord Mayor of the city of London, Founder of the Alms' House at Kirkleatham in Cleveland, in the County of York, for the habitation of 10 old men, 10 old women, 10 boys, and 10 girls That the Master shall daily provide dinners for the 10 brethren, and shall attend to their general comfort, especially in times of sickness The Matron the same on the women. The Master to provide for the boys good, wholesome, and sufficient food, find them in washing, and see that their beds, lodging, and clothing be well and decently ordered and kept The Matron the same The boys to be instructed in Reading, Writing, and Arithmetic, English Grammar, Geography, and History The girls the same. J H CABR, Master</p>
Assistant Masters, 950l.	85 10 0		<p>The boys studying "systematically," who are the only real students of the subject, give at least three mornings and three evenings entirely to the study. Those who take it as an incidental or subordinate part of their work, give only two hours a week</p> <p>I would observe that there has been every anxiety on the part of the Trustees and the Master to encourage scientific studies in the school; that liberal prizes have been founded for their encouragement, that the present Scientific Master is, as was his predecessor, a gentleman of great ability; yet that these studies are not popular with parents, and that the scheme, so far as a special department for such study, can hardly be considered otherwise than unsuccessful, as its success should be measured by the number of pupils who study Science systematically Even in the case of boys where these subjects form a compulsory part of their work, objections have often been raised by parents. It is, in fact, the only branch of the ordinary course towards which disinclination is shown.</p> <p>No weight is assigned to Natural Science in examinations for Exhibitions, as the subjects of examination stand at present under the school statutes, bearing date June 7, 1855, but a new scheme for the school, including this matter of the Exhibitions, is at present under the consideration of the Endowed Schools' Commissioners.</p> <p>The sum given or paid to Assistant Masters unavoidably includes that for French and for English subjects. The amount at present paid for Scientific teaching is sufficient to meet the demand If there were more boys willing to follow the course, there would not be the least hesitation in providing additional instruction.</p> <p style="text-align: right;">W G HENDERSON, D C L., Master.</p>
—	—	—	<p>The total amount paid to the Head Master for all subjects is 120l. Out of school fees he has to provide all assistance. A new scheme is pending, which may give greater weight to Natural Science.</p> <p style="text-align: right;">(Signed) GEO. GREEN, Head Master.</p> <p>July 3rd, 1871</p>
<p>The same Masters teach all these branches. The Master and Usher of the school are entitled to the income from the estates No additional charge is made for any teaching in any of these branches of learning.</p>			<p>Returns of the income and expenditure are made annually to the Charity Commissioners. The course of instruction in Mathematics, &amp;c. embraces, Arithmetic, Euclid, Algebra, Trigonometry, Mechanics, Hydrostatics, Optics, Chemistry, Differential and Integral Calculus, Conic Sections, both Geometrical and Analytical, &amp;c &amp;c</p> <p>NB—The Head Master is at this moment away from his books, papers, &amp;c.</p>
<p>No separate sums are assigned to these subjects. The Head Master and Usher (whose united income is 370l per annum) teach Classics and Mathematics each to his own classes, and so much of Natural Science as is stated below</p>			<p>* No stated time per week can be put down as given to Natural Science So soon as the two senior classes have mastered the elements of Euclid and Algebra, they are taught the Mechanical Powers, the Law of Gravitation, Modes of determining the Specific Gravity of Solids, the Use of the Barometer, &amp;c, and are set to work examples in these subjects. About 10 days or a fortnight in each half year are given to this study as a general rule.</p> <p style="text-align: right;">July 6, 1871. J. F. MACMICHAEL, Head Master.</p>
Head Master	-	- 200 0 0	<p>There is no provision for teaching the Natural Sciences.</p>
Second ditto	-	- 100 0 0	
Preparatory ditto	-	- 80 0 0	
Usher	-	- 20 0 0	
Mistress	-	- 50 0 0	
		£450 0 0	
Drawing	-	- 40 0 0	
Singing	-	- 15 0 0	
Drilling	-	- 15 0 0	
French	-	- 30 0 0	
		£550 0 0	

Net Annual Value of Income and Exhibitions.	Number of Scholars learning Natural Science	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions.	Whether any Laboratory or other Aids for Practical Teaching in Science.
<p><b>YORK—cont</b> <b>Sedburgh.</b></p>	—	—	—	—
<p><b>Wakefield.</b> About 350l Exhibitions, 350l.</p>	None specially.	25	"Brewer's Guide to Science" is learnt, and questions set from it.	There is an apparatus, but no funds to find teachers
<p><b>York (Archbishop Holgate's School).</b> The endowment a little more than 400l. per annum We have no Exhibitions</p>	About 20 boys learn Agricultural Chemistry	—	—	No.
<p><b>Clifton (St. Peter's).</b> The exact amount is stated in Appendix to 1st Volume of Schools Commissioners' Reports. About 500l. There are no Exhibitions in the strict sense of the word. (a)</p>	80 (the VI., V., and IV. Forms, and the boys in the Modern Department).	The VI., V., and IV have one lesson a week of three quarters of an hour each, with work to prepare between lessons. The boys in the Modern Department have two lessons a week Do (b)	At present none but prizes are awarded.	The Master who teaches Zoology, &c., illustrates by specimens, and the Chemical Lecturer has abundance of materials for experiments supplied by himself.

AMOUNT EXPENDED IN TEACHING			REMARKS												
Classics	Mathematics	Natural Science													
—	—	—	There is no teaching in Natural Science at present, that not being a subject required by our charter <b>HENRY GEORGE DAY, Head Master.</b>												
120l., Head Master, with house. 100l., Second Master, without house, for Classics, Mathematics, and English generally			I append the school programme, as settled by a new statute 14 years ago.— The Rev J. Taylor, D D., begs to inform his friends and the public that by a recent statute the school routine embraces Religious Instruction in the principles of the Church of England, Old Testament and Gospel History, the Latin, Greek, and French Languages, Mathematics, Algebra, and Arithmetic, Writing, Drawing, Geography, with the use of the Globes, Ancient and Modern History, and English Literature While Classics and Mathematics are pushed as far as possible with pupils destined for the Universities, all the subjects of a thoroughly good English and Commercial education are carefully attended to Sound Religious Instruction is also given, based on the principles of the Church of England <b>J. TAYLOR, D D, Head Master</b>												
—	—	—	SIR, Parrox Hall, near Fleetwood, July 11, 187... YOUR communication of the 30th ult has reached me here, and I have given you what information I can on the subject of it. It is impossible to say what sum is expended in teaching Classics and Mathematics, &c, separately, as the Masters are paid for teaching all the subjects of a general education. I may add we give more attention to Mathematics and a general English Education, including Political Economy, than to Classics. A majority of the boys also learn French. <b>R. DANIEL, Head Master</b>												
(a.)	(c)	(c)	(a) One Exhibition to the Universities for three years of 50l. is annually awarded by the Dean and Chapter (the Trustees of the School); after examination in Divinity, Classics, and Mathematics. There are eight Foundation Scholarships (entitling to free board and education), tenable for four years, and eight Free Scholarships (entitling to free education), tenable for four years, open for competition to boys who have been in the school for one year, and are under 15 years of age. The subjects of examination are Divinity, Classics, and Mathematics (b) The boys in these forms have been during the past year specially studying Zoology. There is also a Voluntary Class, taught by Dr Procter, an eminent physicist in York, who teaches Chemistry, Electricity, Heat, Light, &c, taking these subjects in turn. He attends for one hour a week, and a charge of 1l 11s 6d, for each half year is made. He teaches by lectures and experiments, and gives two prizes at the examination. The papers in Zoology (for which four prizes were awarded at our recent examination, and for which the boys were ranked as in Classics and Mathematics, French, &c, separately), and in Chemistry (for which two prizes were awarded), are contained in the examination book, of which I send a copy. (c.) I do not know how to make a clear statement on this point in a few words. There are nine regular Masters attending the school daily, and one (teacher of French and German) who attends four days in the week, of these the following teach Classics, History, Geography, &c <table border="0" style="margin-left: 20px;"> <tr> <td>Head Master, with salary, of 250 a year.</td> <td>House for boarders</td> <td rowspan="5" style="font-size: 2em; vertical-align: middle;">}</td> <td rowspan="5" style="vertical-align: middle;">Paid by Trustees.</td> </tr> <tr> <td>Second do. " 300 "</td> <td>No house.</td> </tr> <tr> <td>Third do. " 200 "</td> <td>Do.</td> </tr> <tr> <td>Fourth do. " 160 "</td> <td>Do</td> </tr> <tr> <td>Fifth do. " 120 "</td> <td>Do</td> </tr> </table> <p style="text-align: center;">£1,030</p> <p style="text-align: center;">Sixth do. " 110 (paid by Head Master)</p>	Head Master, with salary, of 250 a year.	House for boarders	}	Paid by Trustees.	Second do. " 300 "	No house.	Third do. " 200 "	Do.	Fourth do. " 160 "	Do	Fifth do. " 120 "	Do
Head Master, with salary, of 250 a year.	House for boarders	}	Paid by Trustees.												
Second do. " 300 "	No house.														
Third do. " 200 "	Do.														
Fourth do. " 160 "	Do														
Fifth do. " 120 "	Do														
Of the three remaining Masters —															
1. In Head Mathematical and Natural Science Master, receiving a salary of 250l. a year (taking the VI, V, and Upper IV in Mathematics, and the VI, V., IV, and boys of Modern Department in Natural Science, Zoology, &c.) He rents a house for boarders. He teaches Mathematics and Natural Science exclusively															
2. In Head of the Modern Department, teaching Mathematics, History, Geography, Book-keeping, Navigation, and Natural Philosophy (when boys specially need it for some examination), and receiving a salary of 220l. a year.															
3. In Lower Mathematical Master, taking the Forms below the Upper Fourth in Mathematics exclusively, and receiving a salary of 100l. a year, renting a house for boarders															
The fees for all these Masters, as also for French and German, are included in the ordinary school fees of 13 guineas for the Upper School, 11 guineas for the Lower School															
I have tried to explain the present system of teaching Natural Science which I have introduced into our school as a beginning, and while waiting for the new scheme to be drawn up by the Endowed Schools' Commissioners, and I hope that my remarks may be intelligible, with the aid supplied by the examination book, which I send. As our Natural Science Master is also a Mathematical Master, I did not know how to fill up the columns relating to the amount expended in teaching, and thought it better to enter into details, as I have done in note (c), and I must apologise for any shortcomings or want of clearness in my statements															
I may, perhaps, be allowed to add that one of the former members of St Peter's School, A W Reinold, Esq., late Fellow of Merton College, Oxford, is now Lee's Reader in Physics at Christ Church College, Oxford, that another, the Rev Richard Albay, now Fellow of Wadham College, Oxford, was formerly Lecturer and Demonstrator in Experimental Philosophy at King's College, London, and has been succeeded by another of the members of our school, H Tomlinson, Esq., who also gained a Whitworth Exhibition in the University of Oxford.															
			<b>R ELWYN, Head Master of St. Peter's School</b>												

## APPENDIX

Net Annual Value of Income and Exhibitions	Number of Scholars learning Natural Science.	Hours of Instruction per Week given by Masters.	What Weight assigned to Natural Science in Examination for Exhibitions	Whether any Laboratory or other Aids for Practical Teaching in Science.
YORK—cont Giggleswick. 1,000 <i>l</i> .	70	Chemistry, 3 or 4 hours; Physics, 3 hours.	There are no exhibitions which are competed for by boys already at the school.	An excellent chemical laboratory. A fair amount of apparatus for teaching physics.

ANALYSIS of the foregoing RETURNS from SCHOOLS having ANNUAL ENDOWMENTS amounting to 200*l*. and upwards.

Number sent to.	Number of Returns.	Number in which Science is taught	Number having a Laboratory.	Number having limited Apparatus for Teaching Science
205	128	63	13	18

APPENDIX.

AMOUNT EXPENDED IN TEACHING			REMARKS.
Classics.	Mathematics	Natural Science.	
—	—	—	<p>According to the Scheme of the Endowed Schools' Commissioners, at least two branches of Natural Science must be taught in the School. Chemistry and the various branches of Physics are taught to all boys in the Upper School; and all (except those in the lowest class) receive instruction in Practical Chemistry and Analysis. The laboratory is well provided with apparatus and chemicals for the practical study of Chemical Science. To the erection of the laboratory and the provision of apparatus, the Governors have recently appropriated over 1,200l., and the building is shortly to be extended. Natural Science has the same weight in determining promotion in the school and prizes as the other main branches of instruction. The Senior Assistant Master devotes nearly the whole of his time to Chemistry and Physics. The School depends upon these subjects and Mathematics for distinction at the Universities and elsewhere. A museum is in process of organization, which will contain various typical collections.</p> <p style="text-align: right;">GEORGE STYLE, Head Master.</p>
31st March 1874.			

## B.

[The following letter and form were sent, on the 16th of November 1874, to the Head Masters of the one hundred and twenty-eight Endowed Schools contained in the preceding list.]

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, S.W., 16th November 1874.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to facilitate the labours of the Commission by filling in the form at the foot. You would confer an additional favour if you would place His Grace in possession of this information at the earliest possible moment.

I have the honour to be, &c.

J. NORMAN LOCKYER, Secretary.

Endowed School at \_\_\_\_\_

1. Number of boys in the School - - - - - \_\_\_\_\_
2. Number of boys learning Science - - - - - \_\_\_\_\_
3. Number of hours given per week by each boy learning Science to that subject in class time. (If some boys give more than others this should be stated.) - - - - - \_\_\_\_\_
4. Number of hours given per week by each boy learning Science to laboratory or practical work - - - - - \_\_\_\_\_

[The following returns have been received.]

Number of Boys in the School	Number of Boys learning Science.	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time.	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work	REMARKS.
<b>ANGLESBY.</b> Scammaria. 14	—	—	—	Those parents who wish their boys to learn Science can have them taught. There is no extra charge, and one of the masters is competent to teach Chemistry, &c. C. F. MILNER, B A., Camb., Head Master.
<b>BEDFORD.</b> Bedford. A little more than 270	A few occasionally, voluntarily, from a teacher, unconnected with the school, on the South Kensington plan.	—	—	By the New Scheme for the government of the school, Natural Science is required to be taught; but the Governors have not yet made the arrangements necessary for its being done. F. FANSHAWE, Nov. 17, 1874. Head Master.
<b>BERE.</b> Abingdon. 70	Nearly all at times have some instruction	Various—at times two hours.	No practical work, as there is no laboratory.	
<b>BRECKNOCK.</b> Breckon (Christ's College). 46	—	—	—	J. D. WILLIAMS, Head Master. Nov. 23, 1874.

Number of Boys in the School.	Number of Boys learning Science.	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work.	REMARKS.
<b>CAMBRIDGE.</b> Cambridge. 147 (nearly half forming a Junior, <i>s. c.</i> , practically a Second Grade School)	Botany, 8 } Chemistry, 7 } (2 boys do both subjects).	Four hours; two to each subject.	Two boys give six hours per week.	Science is made a voluntary subject. Any boy, on coming into the Vth Form, may choose between Classics, Mathematics, and Science. If any boy makes choice of any of the three, he is allowed to devote most of his time to it—reading only as much of the others as is necessary for the previous examination. As Science has only been introduced within the last year, it has not won its place compared with the other two.
<b>CHESTER.</b> Chester (Cathedral Grammar School).				I give a lecture on Botany in the School <i>occasionally</i> , but we have no fixed days or hours for this. JAMES HARRIS, Head Master.
<b>MACCLESFIELD (the Modern School).</b> 132	68	All the 68 boys give 2½ hours per week, and in addition to that 38 of them give 1½ hour to Laboratory Practice.		
<b>SANDBACH.</b> 57	20	Two hours - -	One hour - -	W. D MADDOCK, M.A., Head Master of Sandbach School, and late Fellow of St John's College, Oxford.
<b>DEBRY.</b> Kepton. 240	Science School in process of organisation; all boys to learn after Christmas.	Time not yet determined, probably two hours a week for ordinary classes		HENRY R HACKIN, Head Master.
<b>RISLEY.</b> 19	None.			S GOLDNEY, M.A., Head Master.
<b>DEVON.</b> Exeter (Hale's). 200	Physical Geography, 96.	One hour and a half.		CHARLES LONG, A.C.P., Head Master.
<b>DORSET.</b> Sherborne. 247	111	56 give 1½, 55 one hour per week	12 give 5 hours per week, in addition to lecture-time given under "3."	The Science School is not considered to be in proper working order yet H. D. HARPER
<b>DURHAM.</b> Darlington. 43	Natural Philosophy, Physical Geology, Mathematics, 10.			This school will be closed at Christmas by order of the Governors, pending arrangements for carrying out a new scheme, sanctioned by the late Commissioners. JNO. MARSHALL, B.A., Head Master.
<b>ESSEX.</b> Chigwell. 148	123	Two hours; three boys give few hours Chemistry and Physics taught.	Two - - -	Our great difficulty is want of funds to furnish a Laboratory, and a supply of trained Teachers. H. M. ROBINSON, Head Master.
<b>ESSEX.</b> Dedham. 96	26	Some two, others five or six.	Variable and uncertain.	G. T. LERMIT, L.L.D., Head Master.

Number of Boys in the School.	Number of Boys learning Science.	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work.	REMARKS.
<b>ESSEX—cont.</b> Hart's Colne. 45	16	Four hours.	—	
Newport. 13	None - - -	None - - -	None - - -	SAMUEL PEACOCK, Usber and Master in charge. Nov. 21st 1874.
<b>GLouceSTER.</b> Bristol (Grammar School). 294	64	Two hours - -	This work is not done by all the boys who learn Science. Those who do the work give about three hours per week to it (in other than class hours) in addition to the two hours given to Science, as by Question 3.	The Grammar School at Bristol is the First Grade Public School of the district. Its work is adapted to the needs of boys who are preparing for the Universities, for the Public Service, Civil or Military, and for the Professions. There are divisions of classes for other boys who desire an education better suited to business or commerce. Under the present scheme it has been found impossible to make Natural Science a part of the ordinary school work, and the teaching of the subject has been an "extra" which those boys
Cheltenham. 120	42	Div. — I (2) { Chemistry 3 Physics 3 II (7) Chemistry 2 III (20) Chemistry 2½ IV (13) Chemistry 2	Divisions I and II one hour, subtracted from the preceding hours.	have been allowed to take up who have preferred it to verse composition in Latin and Greek. The practical work is done in hours when the other boys are not in school. A Scheme of the late Endowed Schools' Commission (which is understood to be unopposed, having been accepted by the Governing Body of the School and the masters) is at present before the Privy Council, by which scheme Natural Science is made one of the subjects of instruction in the ordinary course of school work. Certain portions of the subject will then be taught to all boys in the school; a more extended course being allowed as an alternative for Greek and Latin verse composition. JOHN W. CALDICOTT, D.D., Nov. 17, 1874. Head Master.
<b>Gloucester (the King's or Cathedral School).</b> 70	Six - - -	Two - - -	One - - -	HENRY M. JEFFERY, M.A., Head Master of Pate's Grammar School.
Worthleach. 35	20	Two - - -	—	
<b>HEREFORD.</b> Hereford (attached to the Cathedral). 108	No regular science teaching in the school.			ERIC J. S. RUDD, M.A., Head Master.
<b>Kington.</b> None.	None - - -	None - - -	None - - -	The school is temporarily closed for extensive repairs, almost rebuilding; J. N. Walsh, M.A., late Master.
<b>HERTS.</b> Herkchamstead. 113	Between 40 and 50.	One hour (preparation not reckoned).	—	We have no Laboratory, thanks to the Endowed Schools' Commission, without which we could not and cannot move; our plans for one were prepared, and would have been carried out some years ago, had we not been under "Commission." E. BARTRUM, Head Master.



Number of Boys in the School.	Number of Boys learning Science	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work.	REMARKS.
<b>KENT.</b> Canterbury. 110	10	Two - - -	One.	-
Canterbury (Clergy Orphan School). 105	None - -	-	No Laboratory; no funds for its erection, or special teaching.	(Signed) C. MATHESON, Head Master.
Lewisham. 71	65	Half an hour, entirely elementary	No accommodation.	THOMAS BRAMLEY, M.A., Head Master.
Rochester. 90	None - -	They leave the school at 15 years of age.	-	-
Tonbridge. 230	None - -	None - - -	None - - -	We have more than once tried to get up Science Classes, but our efforts have failed, because (1) the boys were allowed by their parents to leave off learning when they pleased, (2) because we have no power to compel boys to learn. We are waiting for a new scheme. J. I. WELLDON, D.C.L., Head Master
<b>LANCASTER.</b> Blackrod Grammar School.	-	-	-	Highfields, Blackroad, Chorley, Lancashire, Dec 8th, 1874. Sir, In answer to your request, dated 16th November 1874, on behalf of the Royal Commission on Scientific Instruction, I write to inform you that this school, being at present in a state of transition, awaiting the decision of the Educational Commissioners relative to a proposed scheme for its amalgamation with that of a neighbouring township, I have not been able to form a Science Class, as my numbers are too small to allow of my doing so. I have, &c, H. FRANK MALTRY, Head Master
Molton-le-Moors (Grammar School). 58	Practical Science is not taught.	-	-	-
Burnley. 70	30	2	1	-
Ollthorpe. The two schools (Upper and Lower) have 62 boys.	Chemistry, Electricity, and Magnetism, 19 boys.* Mathematics and Theoretical Mechanics, 19 boys.*	Chemistry, &c, 2 hours. Mathematics, 6 hours. Mechanics, 1½ hours. This is exclusive of preparation, which is done out of class time, and practically adds several hours more	None yet sufficiently advanced.	-
Great Crosby. 84	27 learn Euclid, Algebra, and Trigonometry; 1 boy learns Mechanics	5 hours of class teaching, besides private work.	-	Edw. BODEN, M.A. (Cantab), 17th Nov. 1874 Head Master.

\* The identity of number in these classes is accidental, the classes comprising only partially the same members.



Number of Boys in the School.	Number of Boys learning Science.	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time.	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work	REMARKS
<b>LINCOLN—cont.</b> <b>Donington.</b> 48	10	Three - - -	None, except that they are called upon in class to manipulate the models of simple machines.	W. J. R. CONSTABLE, LL.D., Head Master.
<b>Heighington.</b> 57	None	—	—	FREDERICK DAY, Head Master
<b>Humberstone.</b> Limited to 100 generally kept on the list. Of course some are always absent out of the 100.	None, the boys leave when fourteen.	—	—	The average number of boys attending school varies, between 70 and 80. I shall be glad to answer any questions as correctly as I possibly can. CHARLES WILDBORE, Head Master 20th Nov. 1874
<b>Stamford.</b> 43	8	1	0	—
<b>MIDDLESEX.</b>				
<b>Milk Street, Chesham (City of London School).</b>				
677	All - - -	From 45 minutes to 75 minutes 27 boys in the Practical Chemistry Class devote two hours a week on Wednesday afternoons; likewise, two or three boys preparing for the Examinations in Natural Science, receive extra instruction in the Laboratory	None for the ordinary scholars, but those who take an extra interest in the subject attend the Practical Class and the after-lecture experiments	—
<b>St. Lawrence Jewry (Mrs. Elizabeth Smith's).</b>				
—	—	—	—	No School in connection with this Foundation, but the boys are elected to Exhibitions for the City School and King's College, and will, it is presumed, be included in the returns obtained from those schools JAS. HY. DAVIDSON, pp. Trustees, Vestry Clerk of St Lawrence Jewry, 70, Basinghall Street, E.C. 24th Nov. 1874.
<b>Edmonton (Latymer's).</b> 202	57	1 - -	No Laboratory	—
<b>Enfield.</b>	—	—	—	—
<b>Hammersmith.</b> 150 (N.B.—The average age of the three highest classes is 16, 15, 14)	29 (Chemistry and Elementary Geology.) (48 others Elementary Physical Geography.)	1½ hours (Also three boys learn Natural Philosophy for London University Matriculation, two hours additional.)	None (The Chemistry lessons are always illustrated by experiments)	—
<b>Highgate.</b> 172	About 110	33 boys 2½ hours, the rest 1 hour.	1½ hours - -	The subject has been only introduced within the last six months, and the time given to it will be increased next year.
<b>Westminster (St. Peter's College).</b>				
206	93	56 give two hours, 37 one hour.	None; no facilities	CHAS B SCOTT, Head Master.

Number of Boys in the School.	Number of Boys learning Science.	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time.	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work.	REMARKS.
<b>MIDDLESEX—cont.</b> Whitechapel (Leman St.) 211	130 (Upper School).	Lower classes two hours, Upper classes three hours.	Time divided between theoretical and practical work.	—
<b>WORFOLK.</b> Thetford.	—	—	—	This school is closed at present, a new scheme being under consideration. A. FOWLER SMITH, M.A., Head Master.
<b>Tarmouth.</b> 154.	None	None	None	J. J. RAVEN, D.D., Head Master. 17 Nov., 1874
<b>NORTHUMBRIA.</b> Haydon Bridge. 89 (not including infants).	5	$\frac{1}{2}$ (on an average)	—	W. L. PENDERED, Head Master.
<b>NOTTINGHAM.</b> East Retford. 45	14	$1\frac{1}{2}$ hours	None at present	ALFRED CHURCH, Head Master.
<b>OXFORD.</b> Magdalen College, Oxford (Disendowed). 115	About 12	From 9 to 15 or more	About six	No boy learns Science here who is not trying either for the Indian Civil Service, Cooper's Hill, Woolwich, or a College Scholarship (Signed) R. H. HILL, D.C.L., Head Master.
<b>SALOP.</b> Ludlow. 71	40 (Mathematical Science exclusively.)	About 25 boys give six hours per week in class time About 15 give four hours	There is no Laboratory work, as none of the science is experimental.	By Mathematical Science are intended Euclid, Algebra, Trigonometry, Mechanics, Mensuration, Practical Geometry, Use of Scales, and Plotting from Field-books, Practical Solid Geometry. A proposal has been made to commence a course of Chemistry for young farmers, but at present the authorities do not see their way. WILL. C. SPARROW, LL.D., Head Master.
<b>Oswestry.</b> 82	—	—	—	It is the intention of the Head Master to begin teaching Elementary Science in January. M. S. FORSTER, Head Master.
<b>Wom.</b> Average attendance for the year, 15.	None	—	—	Wm BOULTON, Head Master.
<b>Whitechurch.</b> 41	None	None	—	There were Chemistry Classes in the school within the last two years, but the boys are now almost all young, and the teaching they require is quite elementary.
<b>SOMERSET.</b> Ilminster. 26	11 for public examination, but the whole taught.	Four half hours, two to each subject.	None; subjects not requiring it.	W. J. WOODWARD, B.A., Head Master.
<b>SOUTHAMPTON.</b> F Portsmouth.	—	—	—	School closed.

Number of Boys in the School.	Number of Boys learning Science	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work.	REMARKS
<b>SUFFOLK.</b>				
<b>Sury St. Edmund's.</b> 59	20	Half an hour per week, i.e., one hour each fortnight.	None - - -	<b>A. H. WRATISLAW,</b> Head Master.
<b>Ipawich.</b> 90	75 attend lectures on Zoology, Geology, Physical Geography.	Two hours per week.	None.	<b>HUBERT A. HOLDEN, LL.D.,</b> Head Master.  The School House, Woodbridge Suff., Nov. 18, 1874. I lose no time in replying to your circular. To fill up the form sent to me reorganised within two months, and is now and will be for some time to come in a state of transition. Up to the time of my appointment no attempt had been made, I believe, to give any kind of Scientific Instruction. I have made some arrangements for that purpose, i.e., I have masters who teach different Scientific subjects, and hours fixed for instruction in those subjects. But at present very few boys seem disposed to avail themselves of the opportunities offered. This defect will I hope gradually be remedied. We have, besides, no apparatus whatever. I have no doubt that the Trustees will make some provision in response to an application which I shall make to them in a few days. It would be, therefore, hardly fair, or serve any purpose, to fill up the return. The great difficulty we have to contend with is the present general indifference of parents to anything beyond the most elementary instruction. The supply is or will be shortly ready, but there exists at present no demand. I am, &c, <b>JAS. R. WOOD,</b> Head Master
<b>SURREY.</b>				
<b>Croydon.</b> 288	145 are learning Physical Geography, Elementary Geology, or Physics.	From half an hour to two hours, ,,	—	
<b>SUSSEX.</b>				
<b>Horsham.</b> 80	None - - -	—	—	The boys in this school are of the class usually found in elementary schools, no charge being made. The Head Mastership is at present vacant <b>RD CRAGE,</b> Usher.
<b>WARWICK.</b>				
<b>Atherstone.</b> 70	34	5½	—	The class-room in which Science is taught not being quite suited for Laboratory work, the necessary experiments are performed before the class, one of the pupils being allowed to perform them occasionally
<b>Coventry (Bablake).</b> 70	25	None. The instruction is given out of school hours	None.	
<b>WESTMORELAND.</b>				
<b>Appleby.</b> 50	None regularly	None in class time	None as part of regular school work	<b>C. THREKELD,</b> Head Master.
<b>WILTS.</b>				
<b>Marlborough.</b> 63	Two, preparing for "Local" Examinations.	We have no Laboratory, and so, as part of the school course, attempt nothing in Science beyond a little Botany occasionally	—	<b>F. H. BOND, M.A.,</b> Master.
<b>The Close, Salisbury.</b> Being a school for the choristers of a Cathedral of the old foundation 14 choristers, and 7 day boys.	—	—	—	(Signed) <b>FRANCIS LEAR,</b> Canon Residentary, and Warden of the Choristers.
<b>WORCESTER.</b>				
<b>Kenley Castle.</b> 48 84734.	20 (elementary).	4	—	<b>K k</b>

Number of Boys in the School	Number of Boys learning Science	Number of Hours given per Week by each Boy learning Science to that Subject in Class Time.	Number of Hours given per Week by each Boy learning Science to Laboratory or Practical Work	REMARKS.
<b>WORCESTER—cont.</b>				
<b>Kidderminster.</b> 32	None (at present).	—	—	—
<b>Stourbridge.</b> 80	20	Three hours	Irregular	WM. J. J. WELCH, M.A., M.D., &c., Head Master
<b>YOKE.</b>				
<b>Giggleswick.</b> 115	57	The two highest classes, six hours. The two next, four hours.	Each boy in the two highest classes two hours, in other classes one hour But in special cases senior boys give much more time both to Science work generally, and to practical work in particular.	G. STYLE. THOMAS COX. Halifax, 18th Nov. 1874
<b>Halifax.</b> 65	None	—	—	THOMAS BLAND, Master.
<b>Kirkby Ravensworth.</b> 35	15	One hour	—	W G HENDERSON, D.C.L., Head Master. 17th Nov 1874.
<b>Kirkcathlam.</b> 27	Not specially taught.	Physical Geography, one lesson per week	None	THOMAS BLAND, Master.
<b>Leeds.</b> 218	130	96 boys 1 hour 23 boys 2 hours 11 boys 6 hours	Three, but only four boys do practical work.	W G HENDERSON, D.C.L., Head Master. 17th Nov 1874.
<b>Mirfield.</b> 36	12	130 Six, 1½ hours Six, 3 hours.	Nil.	—
<b>Pocklington.</b> 40	12	Four.	—	—
<b>Ripon.</b> 66	Chemistry, 66 Physical Geography, 54	2 hours by 40 boys 1½ " by 25 boys 6 " by 1 boy	One hour by six boys	—
<b>Sedburgh.</b> 21	—	—	—	HENRY GEORGE DAY, M.A., Head Master
<b>Wakefield.</b> 45	None specially.	—	—	—
<b>York (Archbishop Holgate's School).</b> 129	They all learn Mathematics more or less, but we have not found it compatible with the discharge of the regular School work, to give any attention to Chemistry or Science, in the sense in which I believe you mean it	—	—	R. DANIEL, B.D., Head Master York, Nov. 18th 1874.
<b>Clifton (St. Peter's).</b> 162	36	17 boys learn Geology twice a week, ½ of an hour each lesson, 12 once a week. There is also a voluntary Chemistry (practical) Class, twice a week, out of school hours. This averages about 12 to 14 boys, but about half of them will be members of the Geology classes. The Chemistry lessons are one hour each.	—	—

ANALYSIS OF THE RETURNS RECEIVED IN ANSWER TO THE SECRETARY'S LETTER OF THE 16<sup>TH</sup> OF NOVEMBER 1874.

Returns sent out.	Returns received back.	Number of Schools in which Science is Taught.	Aggregate Number of Boys in the Schools.	Number of Boys Learning Science.	Number of Hours given per Week to Science, as far as the Information received with regard to the Time given by the Boys to Science can be tabulated.
128	87	57	8,945	2,430	Half an hour per week in 3 schools 1 hour per week in 7 schools 1½ hour " 5 " 2 hours " 16 " 3 hours " 9 " 3½ hours " 2 " 4 hours " 10 " 5 hours " 4 " 6 hours " 2 " 10 hours " 2 "

LONDON

Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODS,  
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For Her Majesty's Stationery Office.



V124

SEVENTH REPORT

OF THE

ROYAL COMMISSION

5

ON

SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

---

Presented to both Houses of Parliament by Command of Her Majesty.

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LONDON:  
PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,  
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1875.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

---

*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named; to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

---

# SEVENTH REPORT:

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to Inquire what Aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such Aid could be rendered in a manner more effectual for the purpose, humbly beg leave to present to Your Majesty, in continuation of our former Reports, the following Report on the University of London; on the Universities of Scotland (Edinburgh, Glasgow, St. Andrew's, and Aberdeen); on the University of Dublin and Trinity College; and on the Queen's University in Ireland.

As in our Third Report we have dealt with The Universities of Oxford and Cambridge, and as in our Fifth Report we have referred to the Arrangements made by The University of Durham for the Promotion of Scientific Instruction at Newcastle-on-Tyne, the present Report will conclude that part of the Inquiry entrusted to us which relates to the Universities in Great Britain and Ireland and the Colleges thereof.

## I.—The University of London.

1. The University of London was founded by Royal Charter, on the 28th of November, 1836, for Objects which are best expressed in the words of its Original Charter:

"Deeming it to be the duty of our Royal Office, for the Advancement of Religion and Morality, and for the Promotion of Useful Knowledge, to hold forth to all classes and denominations of our faithful subjects, without any distinction whatsoever, an encouragement for pursuing a regular and liberal Course of Education; and considering that many persons do prosecute or complete their studies both in the Metropolis and in other parts of the United Kingdom, to whom it is expedient that there should be offered such facilities, and on whom it is just that there should be conferred such distinctions and rewards, as may incline them to persevere in these their laudable pursuits; further know that for the purpose of ascertaining, by means of Examination, the persons who have acquired proficiency in Literature, Science, and Art, by the pursuit of such course of education, as evidence of their respective attainments, and marks of honour proportioned thereunto, we do will, grant, declare, and constitute our right trusty and right well beloved cousin, William Cavendish Earl of Burlington [with 37 others], one Body Politic and Corporate, by the name of 'The University of London.'"

2. The Governing Bodies of the University are the Senate, and the Convocation. The Senate consists of the Chancellor, Vice-Chancellor, and Fellows. The Fellows (36 in number, exclusive of the Chancellor and Vice-Chancellor for the time being) are appointed partly by the Crown and partly by the Members of the Senate under the powers granted, by the Charter. The following Graduates of the University constitute the Convocation of the University, viz., all Doctors of Law, Doctors of Medicine, and Masters of Arts; all Bachelors of Law of two years' standing, all Bachelors of Medicine of two years' standing, all Bachelors of Arts of three years' standing, all Doctors of Science, all Bachelors of Science of three years' standing; and also all Graduates holding other Degrees recognised as qualifications for admission to Convocation by resolution of Convocation.

3. The whole of the annual expenses of the University are provided for in the Civil Service Estimates, the Estimates for the financial year 1874-75, being 9,861*l.* The fees received by the University are paid into the Exchequer: the sum thus paid in for the same year is given in the Appendix, together with the annual expenses for 1875-76.

The sum paid in was 4,202*l.* 10*s.* 10*d.*, see Appendix I., pp. 43, 44.

4. That the Government which founded the University desired specially to encourage the introduction of Scientific Study into General Education, may be inferred from the character of the original Body of Fellows; which included many names distinguished in Science, as well as many eminent members of the Medical Profession.

5. The Senate was not originally empowered to grant any other Degrees than those of Bachelor and Master of Arts, Bachelor and Doctor of Laws, and Bachelor and Doctor of Medicine.

6. Certificates of Studentship in some one or more of the affiliated Colleges or Medical Schools were required from all Candidates for Examination; and on the Report of the Senate to the Home Secretary, from time to time, the list of such affiliated Institutions might be varied, altered, or amended.

7. The Examinations have from the first been conducted by Examiners appointed by the Senate.

8. In proceeding to frame a Curriculum of Study for Degrees in Arts and Medicine (Degrees in Laws being conferred only upon such as had previously Graduated in Arts); the Senate determined to institute a Matriculation Examination, which should be the test of the candidate's qualification to enter upon a course of Academical Study for either of such Degrees. This Examination included, from the first, not merely Classics, Mathematics, and English, but also an Elementary Knowledge of either Natural Philosophy, Chemistry, or Natural History; and a further encouragement to the study of these Departments of Science was given by subsequent Honours Examinations.

9. The value attached to this Matriculation Examination, as a test of a good School Education, is increasingly shown by the large number of Candidates (now exceeding 1,000 annually) who present themselves at it, a considerable proportion of these having no intention of proceeding to any Degree.

10. No practical Examination was originally instituted at Matriculation, and no change in this respect has been hitherto made. It is evident that there would be considerable difficulty in organizing such an examination for five or six hundred candidates. But there can be no doubt that if this difficulty could be overcome, the enforcement of a practical test would accelerate the introduction of Practical Work into School Teaching, and would thus exert a very favourable influence on the progress of Scientific Education.

11. The Curriculum for the Degree of Bachelor of Arts included Animal Physiology, with Classics, Mathematics, and Mental Philosophy, as subjects of the Pass Examination; and Honours Examinations were instituted in Chemistry, Animal Physiology, and Vegetable Physiology with Structural Botany.

12. The First Examination for the Degree of Bachelor of Medicine included Chemistry and Botany, in both which subjects the examination was practical as well as written and oral. A subsequent Honours Examination was held in Chemistry, to which was attached an Exhibition of 30*l.* per annum for two years. And an Honours Examination was held in Botany.

13. In the Second Examination for the Degree of Bachelor of Medicine, Physiology (with Comparative Anatomy) took equal rank with Medicine, Surgery, and Midwifery; and was the subject of a subsequent Honours Examination, to which was attached a Scholarship of 50*l.* per annum for two years, with a gold medal and the style of University Medical Scholar.

14. No material change in these arrangements took place until the grant of a New Charter in the year 1858, by which the University was empowered to confer the several degrees of Bachelor, Master, and Doctor, in Arts, Laws, Science, Medicine, Music, and in such other Departments of Knowledge (except Theology) as the Senate might determine. And the same Charter provided that persons not educated in any of the affiliated Institutions, might be admitted to examination for any of the Degrees conferred by the University, other than Medical Degrees.

15. Before the terms of this Charter were finally settled, a Memorial had been presented to the Senate, signed by 20 of the most eminent Scientific Men in the Metropolis, urging the propriety of establishing Degrees in Science; and a Committee of the Senate, which included Dr. Arnott, Mr. Brande, and Mr. Faraday, with the subsequent addition of Mr. Hopkins, had been appointed for the consideration of the subject. In the following year (1859), the Degrees of Bachelor and Doctor in Science were instituted, under Regulations which, with some alterations in detail, remain in force at the present time.

16. The principle on which the Curriculum of Study for the Degree of Bachelor in Science was framed, was that of laying a broad foundation of Scientific Culture, upon which the student might advantageously base his acquirements in whatever department of Science he might choose as his special pursuit. The First (Pass) Examination for the

Degree of Bachelor of Science includes Pure Mathematics, Experimental Physics, Inorganic Chemistry, Zoology, and Botany. Subsequent Honours Examinations are held in these several branches of knowledge; an Exhibition of 40% per annum for two years being awarded to the highest proficient in each, provided that he is found deserving of it. The competition for the Exhibition in Mathematics is open also to Candidates who have passed the First Examination for the Degree of Bachelor of Arts; and the competition for the other Exhibitions is open also to Medical Candidates.

17. The First Examination for the Degree of Bachelor of Science, with the omission of Mathematics, under the style of the Preliminary Scientific Examination for the Degree of Bachelor of Medicine, is now imposed on all Candidates for degrees in Medicine, as a preliminary to the proper Medical Curriculum; the subjects of Inorganic Chemistry and Botany being omitted from the First Examination for the Bachelor's Degree, while Physiology is now transferred to it from the Second. All Medical Candidates are required to go through a Practical Examination in Chemistry; and it is the intention of the Senate to impose this test on Candidates for Degrees in Science also. The Examinations in Zoology and Botany have from the first been partly practical.

18. The Second (Pass) Examination for the Degree of Bachelor of Science includes Mechanical and Natural Philosophy, Organic Chemistry, Geology and Palæontology, Animal Physiology, and Logic and Moral Philosophy. Subsequent Honours Examinations are held in these several branches of knowledge; Scholarships of 50% per annum for three years (the competition for which is open also to candidates who have passed the Second Examination for the Degree of Bachelor of Arts) being awarded to the highest proficient in Mathematics and in Logic and Moral Philosophy respectively; and Scholarships of 50% per annum for two years being awarded to the highest proficient in Chemistry, Zoology (including Physiology), and Geology and Palæontology respectively.

19. The Programme of Subjects for the Degree of Doctor in Science, on the other hand, was framed with a view of encouraging the highest proficiency in some special Branch of Knowledge; the candidate being expected to be so fully conversant with the principal subject he may select, as to be able to go through any test (whether by theoretical or practical Examination) of his acquirements in it that can be fairly applied. Sixteen Primary Branches are specified; but several of these are again subdivided, and others may be treated in different ways, at the option of the Candidate.

20. The total number of Candidates who have obtained the Degree of Bachelor in Science up to the present time is 157; the number of those who have obtained the Degree of Doctor in Science is 21, of whom 11 presented themselves in one or other of the Departments of Chemistry.

21. In our Third Report we have suggested that a Doctorate in Science should be established in the Universities of Oxford and Cambridge, and we have expressed the opinion "that Candidates for this Degree should not merely show proficiency of knowledge as tested by Examination, but should also offer some Original Contribution to Science." This principle has already been adopted by the University of Edinburgh, and we think that the Senate of the University of London would do well to consider whether they should not also award the Degree of Doctor of Science only to those who have given proofs of the desire and the capacity to make some addition to Scientific Knowledge.

Third Report, p. xlii.

See para. 40



## II.—The Universities of Scotland.

### GENERAL REMARKS.

22. The four Scottish Universities were, as lately as 1863, the subject of an Inquiry, conducted, at considerable length and with great minuteness, by Commissioners appointed under the Universities (Scotland) Act of 1858. The powers given to the Commissioners included the Arrangement of the Financial Affairs of the several Universities and Colleges; the Foundation of new Professorships; the Regulation of the Course of Study and of Examinations for Degrees; and the Revision of Foundations. These powers were, however, conferred upon the Commissioners on the understanding that the additional sum to be provided by Parliament for the four Universities was not to exceed 10,000*l.* a year, and there can be no doubt that in making the Recommendations contained in their Report, they were influenced, not only by the ascertained wants of the Universities, but by the consciousness that their expenditure was to be confined within this limit.

See Letters  
in Appendix  
II., p. 44.

23. We have not thought it necessary to follow the Report of the Commissioners through its various details. It is, however, important that we should point out the position assigned by them to Science in the System of Education enjoined by their Ordinances.

24. The fourteenth Ordinance, which applies to the four Universities, prescribes for Graduation in Arts "a course extending over four winter sessions, and including "attendance on the Classes of Humanity, Greek, Mathematics, Logic, Moral Philosophy, and Natural Philosophy;" and, in addition to these, "attendance on a course "of English Literature," which previously had not been required in any Scottish University except that of Edinburgh.

General Report of the Commissioners under the Universities (Scotland) Act, 1858, p. xxvii.

25. The Commissioners "considered it necessary to take, as the basis of a System "applicable to the Universities of Scotland, the course of study which had been followed "in those Universities for a very long period;" they dwelt upon the variety of the subjects which that course already embraced, and upon the injurious effect of too large a variety in dissipating the attention of the Students; and they hesitated to recommend any steps which might tend to distract the attention of the Student still further.

Ibid, p. xxx.

26. They were, however, of opinion that "it was impossible to dispense with any of the branches of study already embraced in that course. "No one," they said, "who "is competent to form an opinion on such a question, could doubt the propriety "of making Classical Learning the Foundation of an University Course." Again, the historical distinction of the Scottish Universities as "Seminaries of Learning "for the cultivation of the various branches of Mental Philosophy," rendered the Commissioners unwilling to assign to it a position less considerable than that which it had hitherto occupied. So, too, the study of Mathematics, which, under the terms of Ordinance 14, includes Pure Mathematics and Natural Philosophy, appeared "to form an essential subject. Finally, "considering the importance which belongs "to the study of the English Language and Literature as part of a liberal education," and the success of the Literature Classes already in existence, although not compulsory, in the different Universities, the Commissioners "did not hesitate to prescribe, over "and above the three original subjects, attendance on the Language and Literature "Course to all Candidates for Degrees [without Honours] in Arts."

Ibid, p. xxxix.

Ibid, p. xxx.

Ibid, p. xxx.

Ibid, Appendix, p. 22.

27. These four subjects once admitted to the curriculum, the Commissioners were unwilling, unless the Universities themselves should think it expedient, to require attendance on a Natural Science Course (including in that term Geology, Zoology, Chemistry, and Botany) in addition to the subjects prescribed as essential by Ordinance 14.

28. Previously to this, however, attendance at Lectures on a branch of Natural Science, either Chemistry or Natural History, had been included in the course of study at the Universities of St. Andrew's and Aberdeen, and representations were addressed to the Commissioners by gentlemen connected with the latter University. In consequence of these representations a fresh Ordinance, No. 18, was issued, sec. 4 of which empowers the University Court of each University to require all Candidates for Graduation to give attendance on the Lectures of any one of the Professors of Natural History, Chemistry, or Botany, whose lectures are included in the Department of Honours in Natural Science. The University of Aberdeen is the only one which has taken action under this Ordinance.

Ibid, Appendix, p. 30.

29. For the purposes of Graduation with Honours, Ordinance 14 permits a student to select any one, or more, of the four following Departments:—

Ibid, Appendix, p. 23.

- (1.) Classical Literature.
- (2.) Mental Philosophy; including Logic, Metaphysics, and Moral Philosophy.

(3.) Mathematics; including Pure Mathematics and Natural Philosophy.

(4.) Natural Science; including Geology, Zoology, Chemistry, and Botany.

30. In each of the first three of these Departments two Grades of Honour are recognised. In the Department of Natural Science, however, one Class only was instituted by the Commissioners, in the anticipation that, for some time, fewer candidates would present themselves in this than in the other Departments.

31. The effect of this arrangement has been stated to us by Dr. Young, the Professor of Natural History in the University of Glasgow:—

“The understanding amongst the Professors, both in Glasgow and, I believe, also in Edinburgh, is, that the limitation to one class of Honours in Science means, practically, that the candidate shall pass simply. We require two classes of Honours in Arts, and a pass is all that is requisite, under the Ordinances, in Natural Science, so that hitherto there has been, one might almost say, no inducement to Students to attend the Classes in Natural Science.” Qu. 9578.

32. In order to prevent this discouragement of the study of Natural Science, we Recommend that for the future two Classes be recognised in the Natural Science Honours List.

33. We have already, in our Report on the Universities of Oxford and Cambridge, Third Report. expressed the opinion that, just as a knowledge of Language and Literature is indispensable to the Science Student, so also some acquaintance with Natural Science is essential to the completeness of that education of which a Degree in Arts given by one of the National Universities is accepted as a proof.

We observe with satisfaction that this principle has been adopted by the Scottish Universities, as the chief Departments of Experimental Physics are included under the head of Mathematics, which is one of the compulsory subjects for the Degree in Arts. We would suggest that the Student should be allowed to show the required proficiency, whether in Science or Literature, by passing an Examination at such a period in his University career as will enable him, in the latter part of his Academical Course, to devote his attention systematically to a particular group of subjects.

34. A large proportion of the Students at the Scottish Universities attend the Courses with the object of preparing themselves for a Profession. Their education is, not unfrequently, procured with difficulty, and at a sacrifice by which their resources are severely taxed. “It is undoubted,” say the Commissioners of 1858, “that a very large General Report of the Scottish Universities Commission, p. xxx. number of the Students in the Scotch Universities are in exceedingly poor circumstances. Many of them engage during the summer in teaching and other employments, in order to gain the means of supporting themselves at the University during the winter; and the Professors receive, in the last few weeks of the Winter Session, frequent applications from Students to dispense with their longer attendance, on account of their scanty funds being already exhausted.”

It follows from this that the payments which the Universities feel themselves justified in demanding from their Students are small, and the resources of the Universities themselves, in so far as they are derived from fees, are slender in proportion. Nor will their endowments bear comparison with those of the sister Universities in England. It was no doubt upon these grounds that Parliament, upon the occasion of the passing of the Universities (Scotland) Act, agreed to make, from public funds, a contribution in Aid of these Universities. An account of the application of these Grants, so far as they are available for Science Teaching, will be subsequently given. Qu. 9785.

35. In Universities accessible to, and widely used by, the middle classes, it is not surprising that, side by side with a system of education which has been successful in producing Literary and Scientific Culture of the highest order, there should exist a body of teaching more utilitarian in its character, and assigning a prominent position not only to Pure but to Applied Science.

Thus, in each of the Universities of Edinburgh, Glasgow, and Aberdeen, there is a complete Medical School, at which a large body of Students are engaged in qualifying themselves for the Medical Profession, by attendance on the Lectures of the Professors, and by Clinical Instruction in the Hospitals. In the University of St. Andrew's there is a Medical Faculty but no Medical School. Commissioners' Report, p. xxxiv. Qu. 9787-8. The St. Andrew's University Calendar for 1874-75, p. 45.

Again, both in Edinburgh and in Glasgow there are Chairs of Engineering, of which an account will be found in a subsequent part of this Report. These Chairs, as well as a Chair of Agriculture in the University of Edinburgh, the teaching of all of which has a decidedly technical character, are directly endowed by Government from Public Funds, while they share the advantages which have been secured to the Universities of Edinburgh and Glasgow by the expenditure of large sums of money voted by Parliament for the erection of University buildings.

EDINBURGH

The Scientific Curriculum.

36. The position assigned to Science in the University of Edinburgh has, in so far as it enters into the Examination for Graduation in Arts, been already described in the general account which we have given of Ordinance 14 of the Commissioners of 1858.

37. The Scientific Subjects taught in connexion with the Medical School may be divided into three groups:—

- A. The general Sciences, in which all Medical Students are instructed and examined in a manner to be presently described.
- B. The Sciences more especially appertaining to Medicine, such as Anatomy, Physiology, and Pathology.
- C. The Special Medical Subjects themselves, such as the Practice of Medicine, Surgery, and the Clinical Courses.

38. All Candidates for the Degrees of Bachelor and Doctor of Medicine are required to pass an Entrance Examination, including, among other subjects, Mechanics and Natural Philosophy. They then undergo a Preliminary Examination in Botany, Natural History, and Chemistry; and Candidates obtaining more than 75 per cent. of the marks are placed in the Honours List. This Examination is irrespective of those in the more strictly Medical Departments of Study included in the second and third of the above Groups. It is, however, proper to point out that doubts have been thrown by one of the Witnesses whom we have examined (the Professor of Natural Philosophy) upon the sufficiency of these Examinations for the purposes of his own Department. Mr. Tait states that "there is no provision in the University Regulations for attendance on Natural Philosophy by Medical Students. They are required to pass an exceedingly slight Entrance Examination in the merest elements of what is commonly called Mechanics, and there is also another Examination on what is called Natural Philosophy, but it would be absurd to say that the so-called elements of Natural Philosophy in which they are examined embrace the whole subject."

Qu. 9461.

39. The Examinations for Degrees in Science are described in the following extracts from a Statement furnished to us by a Committee of Senatus of the University.

Minutes of Evidence, Vol. II., App. V., p. 42.

"Candidates for the Degrees of Bachelor and Doctor of Science, in the Department of Physical and Natural Science, undergo a Preliminary Scientific Examination in Mathematics, Natural Philosophy, Chemistry, Zoology, and Botany. This examination is called the First Bachelor of Science Examination. The candidate may then select one of the following groups for the Second Examination, on passing which he attains the Degree of Bachelor of Science:—

- "(a.) The Mathematical Sciences - - - - - { Higher Mathematics.  
Natural Philosophy.
- "(b.) The Physical Experimental Sciences - - - - - { Experimental Physics.  
Chemistry.
- "(c.) The Natural Sciences - - - - - { Zoology, Botany.  
Physiology, Geology."

"For the Degree of Doctor of Science, the candidate must profess that Science which he intends to be the special object of his future study, and must further select a particular branch of it in which he believes himself to have attained a considerable knowledge."

Edinburgh University Cal. 1875-76, p. 128; and App. III., p. 47.

40. Since the foregoing information was received from the Authorities of the University of Edinburgh, a Regulation has been made that each Candidate for the Degree of Doctor of Science must submit a Thesis containing "Some Original Researches on the subject of his intended examination, and such Thesis must be approved before the candidate is allowed to proceed to examination."

41. In addition to the above General Degree in Science, there is also a Special Degree in the Department of Engineering, which is thus referred to in the same document:—

"Candidates for the Degrees of Bachelor and Doctor of Science in the Department of Engineering must undergo a Preliminary Examination in Mathematics, Natural Philosophy, and Chemistry. They may then proceed to the Second, Bachelor of Science Examination in the following subjects:—Mathematics applied to Mechanics, Engineering, and Mechanical Drawing. On passing this Examination they receive the Degree of Bachelor of Science in Engineering. The candidate for the Degree of Doctor of Science in Engineering must profess one, and not more than one, of the subdivisions in each of the two following groups of subjects:—

- "I.—Practical Engineering { (a.) The design of machinery, with complete drawings, specifications, and estimates.  
(b.) The preparation of designs, specifications, and estimates for Civil Engineering work.
- "II.—Applied Science { (a.) Applied Mathematics.  
(b.) Chemistry.  
(c.) Geology.  
(d.) One branch of Natural Philosophy.  
(e.) Telegraphy.

"The examinations in Group I. consist in requiring the actual execution of the specified work. The candidate is examined orally in connexion with the work submitted as his own."

42. To the Departments in which Degrees in Science may be obtained, has, we also App. III., learn, been recently added a Department of Public Health, an account of which will be p. 53, found in the Appendix to this Report.

#### *The System of Examinations*

43. We desire, before proceeding further, to refer to the Evidence which we have received with regard to the manner in which the Examinations for Graduation are conducted in this University. Its means have not admitted of payments to Special Examiners for the Science Degree, and the Examinations have consequently been hitherto conducted almost entirely by the Professors themselves, who receive no remuneration for their labour as Examiners.

44. The Examination for Degrees in the case of the Faculty of Medicine was, at the time when we received Evidence from this University, entrusted to all the Professors in the Medical Faculty, with three Non-Professorial Examiners, elected by the University Court, and paid by a Parliamentary Grant of 100*l.* a year each. Qu. 9329.

45. This arrangement was not one with which the University Authorities were content. "Many of my Colleagues," says the Professor of Anatomy, "and myself also are of opinion that our System of Examination would be improved if we had more than three Non-Professorial Examiners specially qualified. We are by no means indisposed to receive additional examiners *ab extra*, supposing that any arrangement could be made for properly remunerating them." With reference to this subject, the Professor of Chemistry stated to us that all his Colleagues "desired an increase in the number of Non-Professorial Examiners, because, as they are not appointed as Examiners in any one Department, it must frequently happen that no one of them is specially acquainted with the subject" in which he is called upon to examine. Qu. 9333. Qu. 9380.

46. Since this Evidence was given, the University Court has, in the case of the Medical Examinations, thoroughly recognised the principle of associating with the Professors additional Examiners, unconnected with the Professoriate, and has introduced a large number of additional Examiners. It would be very desirable that a similar improvement should be introduced into the other Scientific Examinations of the University. We learn that the question of appointing additional Examiners, not Professors, for the Degrees in Science, has been under the consideration of the University Court, but that this useful reform is still likely to be retarded, owing to want of funds. We should regard it as a fortunate result if, out of any assistance granted to the University, funds could be appropriated for this object. App. III., p. 51.

#### *Financial Statement.*

47. The capital of the University was stated, in 1872, to amount to 144,951*l.* Of this capital, the sum of 103,556*l.* is specially limited to certain uses. The income available for other than these special uses consists of— Qu. 9269.

1. Interest on the difference between the above sums;
2. Matriculation and Graduation Fees.
3. The Annual Grant from Government.
4. Sundry minor receipts.

From these various sources the University derives an income of 7,375*l.* of the distribution of which we received the following account:—

"The general administration of the University (*viz.*, the salary of the Secretary, the salary of the Clerk, the salary of the Factor, that is our man of business, the salary of the Dean of the Medical Faculty, of the Dean of the Faculty of Arts, and the Editing of the Calendar) costs 981*l.* a year: the Library absorbs 1,584*l.* annually; 217*l.* is allowed for the support of the Anatomical and Botanical Museums; the repair, cleaning, heating, and lighting of the buildings, the poor rate and water rate, and insurances, absorb 1,827*l.*; on the general service of the University, in the shape of door-keepers, warders, and so on, 595*l.* is spent; 1,465*l.* for Class Assistants and class expenses; 866*l.* for printing and advertisements; 207*l.* for prizes; 18*l.* for graduation expenses, and 41*l.* for sundries, making altogether 7,801*l.* The balance of unexpended income for the year 1871 was only 74*l.*" Qu. 9270.

48. Out of the income derived from the capital sum of 103,556*l.*, the interest of 24,056*l.* is applied under special bequests to the Endowment of five Chairs, including one of Natural History, while the interest of 54,720*l.* is set apart for Bursaries, Scholarships, and Fellowships, of which, however, one only is given in the Medical, and three only in the Natural Science School, the remainder being associated with the Faculties of Arts and Theology.

49. We have been supplied with the following Statement of the Funds Annually applied to Scientific Instruction, whether from Endowments or Parliamentary Grants or from the general University Fund.

## SEVENTH REPORT OF THE ROYAL COMMISSION

Minutes of Evidence, Vol. II., App. V., pp. 10, 11. See App. II., p. 45.

## FUNDS ANNUALLY APPLIED TO SCIENTIFIC INSTRUCTION, DERIVED FROM ENDOWMENTS OR PARLIAMENTARY GRANTS.

		£	s.	d.
<i>Natural Philosophy.</i>				
Endowment of Chair	{ Leith Harbour Annuity	-	-	22 4 4
	{ Parliamentary grant	-	-	180 0 0
Class Assistant—Parliamentary grant		-	-	100 0 0
<i>Practical Astronomy.</i>				
Endowment of Chair—Parliamentary grant		-	-	800 0 0
<i>Agriculture.</i>				
Endowment—Pulteney bequest, 50 <i>l.</i>				
Granted in 1868	{ Highland and Agricultural Society, 150 <i>l.</i>	-	-	850 0 0
	{ Parliamentary grant, 150 <i>l.</i>	-	-	
<i>Music.</i>				
Endowment of Chair from funds left for that purpose by General Reid	{ Salary of Professor	-	-	420 0 0
	{ Class Expenses:—			
	{ Assistants and instruments, &c.	-	-	300 0 0
	{ Annual Concert	-	-	800 0 0
<i>Engineering.</i>				
Endowment of Chair	{ Parliamentary grant	-	-	200 0 0
	{ Sir David Baxter's Foundation	-	-	200 0 0
Class Expenses—Sir David Baxter's Foundation		-	-	40 0 0
<i>Chemistry.</i>				
Endowment of Chair—Parliamentary grant		-	-	200 0 0
<i>Chemical Laboratory.</i>				
From the Hope Prize Fund, a Biennial Travelling Scholarship, tenable for one year, value 100 <i>l.</i>				50 <i>l.</i> per ann.
<i>Physiology.</i>				
Endowment of Chair—Parliamentary Grant		-	-	150 0 0
<i>Anatomy.</i>				
Neither endowment nor Parliamentary grant.				
<i>Natural History and Mineralogy.</i>				
Endowment of Chair	{ Parliamentary grant	-	-	160 0 0
	{ Thompsonian bequest	-	-	85 15 2
<i>Geology.</i>				
Endowment of Chair	{ Sir Roderick Murchison's Foundation	-	-	200 0 0
	{ Parliamentary grant	-	-	200 0 0
Class expenses—Sir Roderick Murchison's Foundation		-	-	40 0 0
<i>Botany.</i>				
Endowment of Chair	{ Parliamentary grant	-	-	160 0 0
	{ Leith Harbour Annuity	-	-	40 0 0

## FUNDS ANNUALLY ALLOCATED FROM THE GENERAL UNIVERSITY FUND TO SCIENTIFIC INSTRUCTION.†

		£	s.	d.
<i>Natural Philosophy.</i>				
By Ordinance of Commissioners—				
Class expenses		-	-	100 0 0
Annual vote of Senatus—				
Mechanical Assistant		-	-	100 0 0
<i>Practical Astronomy.</i>				
None.				
<i>Agriculture.</i>				
Annual vote of Senatus—				
For class expenses		-	-	5 0 0
<i>Music.</i>				
None.				
<i>Engineering.</i>				
Annual vote of Senatus for prizes		-	-	5 0 0
<i>Chemistry.</i>				
By Ordinance of Commissioners—				
Salaries of Assistants		-	-	200 0 0
Class expenses		-	-	100 0 0

\* This sum is independent of other emoluments which the Professor of Practical Astronomy receives as *Astronomes Royal* for Scotland; the two offices being, by his Commission, conjoined.

† Conditional on the state of the General University Fund, which is principally made up from Matriculation and Graduation fees, and depends, therefore, on the number of students attending at the University, and on the number graduating. There are many other unavoidable charges on this fund, such as the maintenance of the College buildings, salaries of librarians, clerk, servants, &c., &c., so the amount available for scientific purposes is very inadequate.

‡ The salaries of Assistants in the Chemical Department amount to 43*l.*, and the excess of this over the 20*l.* allowed is paid by the Professor.

		<i>Physiology.</i>				
By annual vote of Senatus—				£	s.	d.
Assistant	-	-	-	100	0	0
Class expenses	-	-	-	50	0	0
		<i>Anatomy.</i>				
By Ordinance of Commissioners—						
Class expenses and salary of Demonstrator of Anatomy	-	-	-	*200	0	0
		<i>Natural History and Mineralogy.</i>				
Annual vote of Senatus—						
Class Assistant	-	-	-	30	0	0
		<i>Geology.</i>				
		None.				
		<i>Botany.</i>				
Annual vote of Senatus for Assistant	-	-	-	25	0	0
" " for Herbarium (including class drawings)	-	-	-	50	0	0

50. A Statement of the total Emoluments of the Professors, inclusive of fees, will be found in the Appendix. It will be observed that there is a great disparity in the amounts received. App. III., pp. 54-58.

51. In the early part of the present century the University received from Government 129,000*l.* towards the erection of the present buildings, which had been commenced with a sum of 30,000*l.* only, raised by public subscription in Scotland. The result of this large expenditure has been to provide the University with buildings containing much excellent accommodation, though, as will be shown by the Evidence to which we shall subsequently refer, they are absolutely insufficient for its present needs.

*Number of Students.*

52. The number of Students who have Matriculated at the University each year, since 1867, indicates a steady and rapid increase, as will be seen from the following Statement:— Qu. 9287; and see App. III., pp. 62, 63.

1867-68	-	-	-	-	-	1,513
1868-69	-	-	-	-	-	1,564
1869-70	-	-	-	-	-	1,698
1870-71	-	-	-	-	-	1,768
1871-72	-	-	-	-	-	1,854
1872-73	-	-	-	-	-	1,906
1873-74	-	-	-	-	-	1,930

The number of Students in the Medical and Engineering Schools during the same period was as follows:—

	No of Medical Students	No. of Engineering Students.
1867-68	445	—
1868-69	516	29
1869-70	586	47
1870-71	678	55
1871-72	725	45
1872-73	782	52
1873-74	839	50

53. With regard to the numbers of Students newly joining the different Faculties of the University in the Summer Session, the following Statistics, relating to the last three years, have been placed before us:—

Summer Session.	Faculties of			Total.
	Medicine.	Arts.	Law.	
1872 - - -	89	8	9	106
1873 - - -	117	6	7	130
1874 - - -	128	8	8	144
Totals - - -	334	22	24	380
Average - - -	111	7	8	126

\* This sum falls much below the annual amount which the Professor is called upon to expend, in order to carry out, in an efficient manner, instruction in Practical Anatomy.

54. During the Winter Session of 1874-75, the number of Students attending the University Course in the different Faculties has been as follows:

Faculty of Arts	778
Faculty of Medicine	743
Faculty of Law	310
Faculty of Divinity	66

1,897

Taking the average attendance at the Summer Course, deduced from the foregoing Table, the number of Students attending the University of Edinburgh during the Academical Year 1874-75, may be set down as—

During the Winter Session (actual)	1,897
During the Summer Session (estimate)	126
	<u>2,023</u>

App. III,  
p. 68.

55. The fees paid for the various subjects will be found given at length in Appendix III, to this Report.

#### *Museums and Collections.*

56. The Museums and Collections available for Members of this University are as follows:—

1. An Anatomical Museum, the property of the University, maintained by a small grant from the general fund. This Museum is open to the Students and used by them and the Professors. It contains a valuable Collection (used for Teaching Purposes) illustrative of Comparative Anatomy.

2. A Museum of Materia Medica.

3. An Herbarium.

4. The Edinburgh Museum of Science and Art, open to the University under an arrangement made at the time when the Natural History Museum of the University was transferred to the Science and Art Department. Specimens are also collected by the Geological Survey, but there is at present no means of arranging them in such a manner as to render them available for the Purposes of Instruction.

Qu. 9483.

"The Geological Survey," Professor Geikie informs us, "has been prosecuted for about 16 years in Scotland, and every year during that time considerable Collections have been made to illustrate the Rocks, Fossils, and Minerals of the various districts which have been under examination by the Survey. These Collections have been to a very small extent exhibited in the Museum attached to the University; a large portion of them, all or nearly all the fossils, and a large mass of rock specimens and minerals, which would be of great value to the public if they were exhibited, to illustrate wide areas of the country, are at present stowed away in cellars for want of any space in which to exhibit them."

#### *Deficiencies in respect to Buildings, Assistants, and Apparatus.*

For Schedule  
of Lectures  
and Labora-  
tory Instruc-  
tion, see  
App III,  
pp. 58-62.

57. We have received much Evidence with regard to the Wants of the University, and to the Difficulties under which Scientific Teaching within it appears to labour. These Difficulties are occasioned principally by deficiencies in the accommodation afforded by the present University Buildings, and in the supply of Assistants and Apparatus.

#### *Buildings.*

Qu. 9284.

58. There is a complete concurrence of testimony as to the insufficiency of the present building for the work of the University. It is now provided with 18 Lecture Rooms, in which no less than 40 distinct Courses of Instruction have to be conducted. Some of the rooms are used for the Lectures of three different Professors, and it is not matter for surprise, therefore, that this should occasion great inconvenience. The Professor of Pathology has, we are told, "to lecture in a room which is used only one hour before he enters it by the Professor of Moral Philosophy, and one hour after he leaves it by the Professor of Geology."

59. The demand which has arisen in all the Departments of Scientific Education for Teaching of a more Practical Character than that with which the public was formerly satisfied, has given additional force to the plea unanimously put forward by the different Professors for accommodation more ample than that which the existing buildings afford. "Class rooms for practical instruction take up," we are reminded, "a large comparative amount of space, because you cannot pack up the Students as you do in a lecture room; they must have space to move about in." Qu. 9284.

60. The Professor of Chemistry represents to us that the accommodation at his disposal is not only inadequate, but most inconveniently arranged. "The room which is used for the laboratory "was never intended for the purpose. It is dark and ill-ventilated, and altogether unsuitable." The Students in the Practical Classes of this Department have increased from 72 in the Academical year 1861-62 to 140 in the Academical year 1870-71. The University Laboratory is able to accommodate about 12 students only at a time, and, owing to this limitation of the space available, it has been found necessary to preclude all but the more advanced Students from Laboratory work. Qu. 9356. Qu. 9363

61. The same want has been felt by the Professor of Natural Philosophy. He found it impossible to obtain space for a Laboratory till 1868, when he was provided with "a small class-room which had come to be disused, entirely unsuitable, or at least by no means very suitable for almost any class of experiments." The result of this is that when more than 8 or 10 students attend the Laboratory at once, some of them are obliged to work in the Class-room, and some among the Professor's Collection of apparatus. "The superintendence of groups of students scattered about, with stairs to ascend, and passages between them, is a matter of considerable difficulty, and adds materially to the labour of teaching." Qu. 9416.

62. We are informed by the Professor of Geology that his Lecture-Room is not adapted for the Purposes of a Natural History Lectureship. Diagrams and models cannot be properly displayed, and "the only table space for the exhibition of specimens is the desk which is used by the Professor of Moral Philosophy." For the storing of the specimens themselves there is no accommodation whatever in the lecture-room. A cellar in the S.E. part of the College Buildings has been used for this purpose, but it is inconvenient, owing to deficiency of light, distance from the lecture-room, and difficulty of access. The requirements for the effectual performance of the duties of this Chair are described by Professor Geikie in the following terms: Qu. 9467. Qu. 9468

"In order to the effectual performance of the duties of this Chair, I consider it essential, first of all, that the Professor should have a separate class room, with a suitable lecture table and wall space, as well as the other accommodation which is usual for illustration of lectures by means of diagrams, models, specimens, and apparatus. In the second place, there is required a retiring room attached to the class room, with sufficient space for cabinets of specimens, diagrams, &c, and with proper light to admit of the examination of the specimens, and also with adequate provision of microscopes, lathes, blowpipes, and other testing apparatus for thorough practical instruction in the subjects of the Chair; for I consider that the duties of this Chair should consist not merely in lecturing, which is all that they can consist of at present, but in practical instruction by examination of specimens, and in the mineralogical part of the Chair by a series of carefully directed lessons in mineralogical research, and especially in research with the blowpipe and with the microscope. At present no provision exists for that practical department." Qu. 9469.

63. The University Authorities have, however, by no means limited themselves to barren complaints of their present situation. A Committee was formed for the purpose of formulating the Requirements of the different Departments, and we have had before us a copy of their Report. It was proposed "to transplant the Medical School from the present University Buildings to a new site, so as to leave the present buildings for the other Departments of the University." The University was at this time in treaty "for the acquisition of a piece of ground excellently situated for the purpose, and hopes to acquire this ground without much delay." It was contemplated that in the New Buildings the Medical School would require about 60,000 superficial feet, made up as follows: Anatomy, 20,000 square feet; Chemistry, 12,000; Materia Medica, 5,616; Institutes of Medicine (that is, Physiology) 5,500; Pathology, 4,000; Medical Jurisprudence; Surgery, Practice of Medicine, and Midwifery, 3,000 each. The very large amount of space required for Anatomy, includes what is needed not only for Class Teaching Purposes, but also for the Anatomical Museum belonging to the University. This Collection is at present very inadequately accommodated. App. III, p. 65. Qu. 9284.

64. Such a scheme of extension as that indicated above could obviously not be carried out except at very considerable expense. From the account already given of the financial situation of the University, it will be evident that it has no capital of its own to apply for the purpose of erecting new buildings. "The University," we were told by Professor Turner, by whom the Report was laid before us, "has to ask for money, both for buying the ground and for building the necessary structures. We propose to go to the public and endeavour to raise what we can in the way of subscription. But I Qu. 9295.



“ may state that the people of Edinburgh and of the surrounding district have, during the past four or five years, raised a sum of upwards of 70,000*l.* for building a New Infirmary, so that the public pocket has been, we think, very materially drained for that purpose; and although we may raise, and I hope we shall raise, a considerable sum of money, yet we do not anticipate that we shall be able to collect all that will be needed, and we are desirous of obtaining aid in this respect from the Government.” \* \* \*

At a public meeting held in London on December 7, 1874, it was stated by his Royal Highness the Duke of Edinburgh, who presided, that no less than 70,000*l.* had already been subscribed towards the cost of the University Buildings. The necessity for increased accommodation was at the same meeting explained by the Earl of Derby, who stated that at the time when the existing buildings were erected,—

“The accommodation which it was thought necessary to provide was for a number not much exceeding 600, certainly not exceeding 700 students in all, the number of professors being then 21. At present, as you have heard from his Royal Highness, the number of students falls little short of 2,000, and the number of the professors is 35, and though I cannot actually prove it from figures or facts, I have very little doubt that the still further growth of the University has to some extent been checked by that very great want of space for which we desire to provide a remedy.”

At the same meeting, the Right Hon. Lyon Playfair made use of words to the following effect:—

“As a Professor of lengthened experience, he might be allowed to testify that the Laboratories of Chemistry, Physics, Anatomy, Physiology, and Biology were altogether unworthy of such an important University.”

App. III,  
p. 65.

65. We are informed by the Principal of the University that, since the date of the above proceedings, the subscriptions have increased up to a sum of over 75,000*l.* The site for the new Medical School, and for the University Hall, in immediate proximity to the New Royal Infirmary at Edinburgh, has been purchased for a sum which, with law and other expenses, will reach about 34,000*l.* It will, however, be impossible to complete the buildings, even in the plainest style, under a cost of 75,000*l.*, while the internal fittings are estimated at 20,000*l.* A further sum of 20,000*l.* will, it is contemplated, be required, in order to adapt the old Medical Class Rooms in the present College for the uses to which they will in future be put.

#### *Assistants and Apparatus.*

66. The Scientific Professors are much embarrassed by the want of a sufficient number of Assistants. This also is attributable to the Inadequacy of the Resources of the University. Among the powers vested in the Commissioners appointed under the Universities (Scotland) Act, is that “of making Ordinances in order to found new Professorships where they are required, and to provide for the Appointment of Assistants to such Professors as from the nature and duties of their Professorships require assistance, and to provide for the remuneration of such Assistants.” Under these powers, a certain number were appointed. The Commissioners state in their Report that they were strongly urged to provide Assistants for a greater number of Chairs, but that they found it impossible with the means at their disposal to do so. They were, therefore, compelled to select for such help those Professorships which appeared to them to stand most in need of assistance. The Professors are consequently still either without the necessary staff, or obliged to provide it at their own expense.

See para. 22.

67. It is, however, requisite to bear in mind that, in the case of those Professors by whom a special fee is charged for admission to their Practical Classes, apart from that payable for attendance on the Course of Lectures, an increase in the number of pupils, while necessitating increased expense for the payment of Assistants, serves also to increase the emoluments of the Chair.

68. In the University of Edinburgh there are, it appears, three Classes of Assistants:—

- 1st. Assistants allowed by an Ordinance of the University Commissioners, and associated by them with certain Chairs.
- 2nd. Assistants appointed by the Professors, whose appointments are confirmed by the Senatus.

(Both these Classes receive their salaries from the general fund of the University, and discharge similar functions.)

- 3rd. Assistants appointed by the Professors on their own responsibility, and paid by the Professors themselves.

69. The number of Assistants and their emoluments are, as we have already said, often inadequate. The Professor of Physiology has only 100*l.* a year allowed for his Assistant, whose time is entirely taken up, and who, during nine or ten months of the year, is

Qu. 9301.

working the greater part of the day. The Professor of Chemistry has four assistants, two of whom are paid at the rate of 100*l.* a year, each, under the Ordinance, the Professor providing from his own resources for the payment of the other two. In addition to this he finds himself obliged to increase the salaries allowed under the Ordinance in order to obtain the services of properly qualified persons. Qu. 9348  
Qu. 9359.

70. Several of the Assistants throughout the University receive the very small sum of 25*l.* a year; a remuneration so inadequate for a man who has already been obliged to provide for his own professional training, that its amount can only be explained by the assumption that these appointments are sought for by Science Students on account of the opportunities for improvement which they afford, rather than for the emoluments attached to them.

71. It is of the highest importance that the Scientific Professors should be provided with Assistants qualified, at all events, to take charge, and to make use, of the apparatus and collections entrusted to them. One Assistant, at least, of those attached to each Chair should be competent to relieve the Professor of the routine work of his Practical Classes. These duties cannot be effectually discharged except by a person of some standing and attainments, who has by habit and acquaintance become familiar with the work of the Class and the methods adopted by the Professor in treating his subject. It is idle to expect such qualifications from an Assistant whose services are required so slenderly as to render him anxious to transfer them as quickly as possible to some better remunerated employment.

72. It is fair to assume that the salaries allowed by the Commissioners of 1858 were fixed with reference to the limitation to which we have already referred in the amount of the Annual Grant. We desire to record our opinion, that, in the present day, they can be no longer expected to command or to retain the services of a properly qualified staff. The Professor of Natural Philosophy has given us the following Evidence on this question:— See para. 22.

"You are also very much inconvenienced, are you not, by the want of proper assistance?—That again is a source of excessively unnecessary labour to myself, owing to the small amount of money which I receive for the payment of a mechanical assistant. I am not speaking of teaching assistance, but simply of assistance in keeping in order and setting up for experiment my apparatus. My difficulty in that respect is very great, but that again is merely a question of money. The mechanical assistant whom I have at the present moment is a man between 70 and 80 years old, who, I may mention, was in Sir John Leslie's service. He was door-keeper when Sir John was Professor of Mathematics in the University of Edinburgh, and served him as mechanical assistant the whole time he was Professor of Natural Philosophy, and he served the whole or the principal part of his time with Principal Forbes in all his experiments, and he has served me since my appointment to the Chair. This is his 58th session in the University, and he is at present the sole mechanical assistant that I have, seeing that his son is temporarily disabled." Qu. 9420.

"He is paid by the College, is he not?—Yes, he is paid out of the same fund as that from which I get 100*l.* a year for class expenses." Qu. 9421.

"Have you any teaching assistant?—I have a class assistant, and I have already alluded to his giving Tutorial Lectures. He helps me not only by giving those Tutorial Lectures, but also by superintending the Laboratory when I cannot be present myself; and besides that by relieving me of the excessively tedious work of looking over the answers to the examination papers. In the course of his looking over those answers to examination papers merely, he has, on the average, about 1,500 answers to examine once a fortnight. Then he spends the greater part of five hours each day in the Laboratory, in addition to what Tutorial Lectures he is giving for me at the time." Qu. 9422.

"How is he remunerated?—He gets 100*l.* a year from the Exchequer. I may mention that when you contrast the amount of work which he has to do for me with the pay which he receives, it is not at all wonderful that during the short period that I have had such an Assistant, I have had almost every second or third year to train a new one, because the salary is utterly inadequate to the work expected of him." Qu. 9423.

"Is it not a consequence of so much work falling upon the Professor that he has not sufficient leisure for original work?—When matters are at the best, I have very little leisure for nine months in each year; but at the present moment I may say that I have absolutely no leisure at all. \* \* \* I may say that it is hardly possible, without a large sum, to hire a really trained assistant; no improvised assistant would be capable of giving me the least help, and, therefore, during the temporary disablement of my own assistant I must simply do his work myself as well as my own. It would take at least two months or more of training before I could trust a man with the apparatus." Qu. 9425.

73. On pages 12-14, Appendix V., Vol. II., will be found a Recapitulation of the principal wants of the University in respect of Scientific Instruction and the Advancement of Science; and it will be observed that the want of increased and better paid assistance felt by the Professors to whose Evidence we have already referred, is experienced in almost every one of those Departments of the University in which Scientific Teaching is carried on. It will be evident from what has been already stated with regard to the finances of the University, that it has no funds out of which these requirements can be sufficiently complied with. Minutes of Evidence, vol. II.

74. The Inadequacy of the Staff of Assistants causes an encroachment upon the time which the Professor might otherwise devote to original work. The poverty of the Laboratory accommodation is also a serious impediment. The Professor of Chemistry stated in Evidence: "Before I became Professor, while I was what we call an Extra Academic Lecturer (which corresponds to the *privat docent* in German Universities), Qu. 9367.

" at the Laboratory which I had at that time, I had more opportunity for carrying on original investigations than I have at present in the University; because our space is "insufficient." The Evidence of the Professor of Natural Philosophy, already quoted, is to the same effect.

Eighth Report.

75. We shall deal in a separate Report with the subject of the Endowment of Scientific Research: in connexion with the present branch of our Inquiry, it will be sufficient for us to express our conviction that it is of the highest importance to these National Universities that the amount of work assigned to their Professors should not be such as to render Original Work on their part impossible from mere lack of time and physical strength. In the case of the University of Edinburgh, that time is often taken up, and that strength overtaken, by the performance of duties which a moderately paid assistant is competent to discharge. We have not overlooked the fact that the summer vacation of six months, allowed in this and other Scottish Universities, affords to some of the Professors a long period of continuous relief from the work of teaching. It does not, however, appear to us that this period is excessive, considering that the Lectures are given throughout the whole Session, and that the careful preparation which they require must, to a great extent, take place during vacation time. Others of the Professors are required to give, in addition to their Winter Courses, a Summer Course, and it is obvious that these can have but slender opportunities for Original Work, unless the aid which they receive from Assistants is sufficient to relieve them from a considerable portion of the routine work of their Classes.

Qu. 9349.

76 The Apparatus possessed by the University is very far from being adequate to the Modern Requirements of Scientific Teaching. The Professor of Chemistry is supplied with only "a collection of old apparatus, mostly inapplicable to the purpose, which belongs to the University, the remains of old collections. There is also a collection of specimens for the illustration of lectures which was presented to the University by Professor Playfair when he retired from the chair. The remainder of the apparatus, both what is used in the laboratory for practical work, and what is used for lecture purposes," belongs to the present Professor. He purchased what belonged to Professor Playfair, whose private property the apparatus was. The University grant of 100*l.* a year for the purpose of keeping up and renewing the apparatus is insufficient. The same want is also expressed, in the Statement to which we have already referred, on behalf of the Chairs of Natural Philosophy, Practical Astronomy, Engineering, Physiology, Anatomy, Botany, Medicine, Pathology and Clinical Medicine.

Minutes of Evidence, Vol. II, Appendix V, pages 12-14

77 The different wants which we have now noticed *seriatim* are thus recapitulated by the Professor of Anatomy in his Evidence:—

Qu. 9312.

" If we possessed proper buildings for teaching purposes, if we possessed proper appliances in the way of apparatus, and if we possessed sufficient funds to remunerate and retain about us a good staff of well-qualified assistants, I think that the University would be enabled to develop itself as a teaching body, in connexion with affording general scientific instruction, much more so than it has hitherto been able to do."

#### *Conclusion and Recommendations.*

78. The Resources of the University of Edinburgh are comparatively small, and it would be unreasonable to expect from local sources contributions sufficient for the complete removal of the defects which we have noticed.

79. We are, therefore, of opinion that, considering the largely increased numbers of Students attending the University, and the demand now universally made in all the great centres of National Education for Scientific Instruction of a very complete and practical kind, the University of Edinburgh has established a claim to increased assistance from Government.

80. We Recommend that such Assistance should be given; both in the form of a Capital Sum in aid of a Scheme of Extension, such as that to which our attention has been specially directed; and of an Annual Grant sufficient to enable the University to increase the Number, and, in some cases, the Emoluments of Assistants; to make more ample provision of Apparatus for Teaching; and to revise the Salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees.

Fifth Report.

81. We further Recommend, as we have already done in the case of Owens College Manchester, and the Metropolitan Colleges, that the Grant of the Capital Sum in aid of the Extension of the University should be contingent upon the receipt of substantial contributions from Private Sources; and that an account of the Expenditure of any Annual Grant be submitted to the Government, with a view to the exercise of Parliamentary control.

## GLASGOW.

*The Science Curriculum.*

82. There are Four Faculties in this University, and the Students are distinguished into Students of Arts, Theology, Law and Medicine, according to the nature of their principal studies. The position assigned to Science in the Arts Curriculum is governed, as in the other Universities, by the Provisions of Ordinance 14.

83. Since the date when we received Evidence from this University, the Senatus has instituted Degrees in Science with four alternative Courses of Study, viz., Law, Biological Science, Geological Science, and Engineering Science. No Faculty of Science has yet been instituted, but the Faculty of Medicine, and that of Arts are said "to contain between them in their provinces nearly all of what is commonly called Science."

See Glasgow University Calendar for 1873-74, p. 87.

84. The Degrees in Science were instituted in consequence, as we have been informed by Professor Allen Thomson, of a feeling that Science was too much neglected in the old Arts Degree, and "it was thought best to institute a separate Degree in Science, for which also facilities existed from the fact of its being recognised in the last Reform Act for Scotland as a qualification for the University franchise. The Representation of the People of Scotland Act recognises the Bachelorship of Science as a degree qualifying to vote. There is no mention of a degree in science in the University Act, nor in the Report of the Commission of 1858; but the Commissioners took evidence from the professors and others with respect to the question whether there was reason to modify the degree in Arts." Professor Thomson suggested "that the topics included in the Curriculum of Arts were too various and too extensive to enable any candidate to acquire a sufficiently good knowledge of them to appear for an examination," and "that the Degree in Arts should be modified, somewhat after a plan of divergence in four directions; that a curriculum of two years, which all should be required to go through, including, of course, languages and mathematics, should form a common foundation, and that then the degree might be given to the candidates who pursued their studies and passed Examinations in four different sections—classics, literature, and languages for one; philosophy, meaning mental philosophy, for another; mathematics, physical science, and natural philosophy, for a third; the fourth, which would probably require subdivision, being natural science or biology and geology."

Qu. 9864

On further consideration it was decided that candidates for the Degree of Master of Arts should be permitted to graduate in any of the four courses of study to which we have referred. The present arrangements have thus been described to us by the same Witness:—

Qu. 9865.

"In the Scheme which has been adopted by the Senatus, while the scientific branches are recognised separately, they are in each department combined with a part of the arts curriculum. Our degree in law has hitherto been only an honorary degree, and it was held to be desirable that we should have the means of giving a degree upon study, and law is accordingly one of the departments. A certificate in engineering had already been given, and it was considered desirable to raise that into the rank of a degree; that is the second department, viz., of engineering and mechanics; the third department is that of natural science, divided into two, the biological, and the geological, sections. In each of these three departments the branches of study which were considered most immediately necessary, and specially connected with the department are made to constitute the curriculum; and then, in somewhat different proportions, the residuum is made up of a varying number of branches taken from the curriculum of arts at the choice of the candidates."

Qu. 9867.

85. We extract from the Calendar of the University, for 1873-74, the following account of the Subjects required for Graduation in each of the Departments in Science:—

Glasgow University Calendar for 1873-74, pp. 87, 88.

**IN LAW.**—1. Scots Law. 2. Conveyancing. And any five of the Classes in the Arts Curriculum: provided always that in the event of a Student taking either Civil Law or Forensic Medicine, or, in conjunction with any University course, consisting of not less than 25 lectures, Political Economy or History, he shall be allowed to dispense with one of the Arts Classes.

**IN BIOLOGICAL SCIENCE.**—Any four of these five.—1. Chemistry. 2. Anatomy. 3. Physiology. 4. Zoology (including Comparative Anatomy). 5. Botany. And any four of the Classes in the Arts Curriculum.

**IN GEOLOGICAL SCIENCE.**—1. Geology. 2. Chemistry. 3. Zoology (including Comparative Anatomy). 4. Higher Natural Philosophy. And any four of the Classes in the Arts Curriculum: provided always that in the event of a Student taking Geodesy in conjunction with any University Class of not less than 25 lectures, he shall be allowed to dispense with one of the Arts Classes.

**IN ENGINEERING SCIENCE.**—1. Mathematics (1 or 2). 2. Natural Philosophy (1 or 2). 3. Inorganic Chemistry (1). 4. Geology (1). 5. Civil Engineering (2). And any two of the Classes in the Arts Curriculum except Mathematics and Natural Philosophy: provided always that in the event of a Student taking Geodesy in conjunction with any University Class of not less than 25 lectures, he shall be allowed to dispense with one of the Arts Classes.

86. This classification is open to the apparent objection that the Student is expected to show, upon the occasion of a final examination for his Degree in Science, proficiency in a more or less numerous group of subjects unconnected with that which he has specially selected.

87. We have assumed throughout this and other Reports that there are certain kinds of knowledge and certain forms of intellectual discipline which constitute the essential elements of general Culture, and fall under the two heads of Literature and Science. We have further assumed that means should be taken to ensure the possession of this general culture by all persons who receive an University education, and that it is desirable to permit the Student who has given evidence of this general culture to devote his attention exclusively either to Literature or to Science, and to obtain his Degree by passing an Examination conducted in such a manner as to test the reality and extent of his acquaintance with the subject to which he has devoted himself.

Glasgow  
University  
Calendar  
for 1874-75,  
p. 78.

88. We learn that in the University of Glasgow the Student who has attended the Lectures on any subjects for the requisite number of Sessions is permitted to present himself for examination in those subjects at the next examination for degrees, and is not again examined in the same subjects as a condition of his taking the Degree of Master of Arts. The regulation under which this privilege is accorded does not, however, ensure freedom from distraction, during the later part of his University Course, to the Student who desires to devote himself more particularly to some one branch of Study, inasmuch as there is nothing to prevent him from postponing, until the end, his preparation for passing an examination in those subjects in which he is content with showing a competent knowledge. Nor does it seem to contemplate, as the normal practice of the larger number of the Students, that bifurcation of which we have maintained the importance, and which we have already suggested in the 33rd paragraph of this Report. The documents printed in the Appendix show that the Regulations for granting Degrees in Science are now under revision; and we, therefore, take occasion to invite the attention of the University Authorities to the above observations.

App. IV.,  
p. 67.

#### Financial Statement.

Minutes of  
Evidence,  
Vol. II.,  
App.V., p. 7.

89. We have received from the Clerk of the Senate the following Statement of Sums applied to the Advancement of Science or to Scientific Instruction in the University of Glasgow, which are derived from Endowments or from Parliamentary Grants:—

#### I. Endowments of Chairs.

	From (1) University and Revenues	(2) Parliamentary Grants
Natural Philosophy - - - - -	£287 4 5½	£21 0 0
Shuna Rents - - - - -	20 0 0	—
Assistants and Class Expenses - - - - -	100 0 0	100 0 0
	<u>£387 4 5½</u>	<u>£121 0 0</u>
Mathematics - - - - -	230 0 0	62 0 0
Shuna Rents - - - - -	20 0 0	—
Assistant - - - - -	—	100 0 0
	<u>£250 0 0</u>	<u>£162 0 0</u>
Astronomy - - - - -	£220 0 0	£50 0 0
Assistant - - - - -	100 0 0	—
Wilson Astronomical Fund for Instruments, &c. - - - - -	45 0 0	—
	<u>£365 0 0</u>	<u>£50 0 0</u>
Civil Engineering - - - - -	—	£275 0 0
Natural History - - - - -	—	200 0 0
Chemistry - - - - -	—	200 0 0
Assistants and Class Expenses - - - - -	£70 0 0	200 0 0
Botany - - - - -	—	200 0 0
Shuna Rents - - - - -	20 0 0	—

#### II. Bursaries, Prizes, &c.

Watt Prize of 10*l.* annually for an Essay on a Scientific subject.

Walker Prizes in Civil Engineering and Mechanics; annual value, 15*l.*

Cleland Gold Medal (10*l.* 10*s.*), awarded every second year to a Student of Natural Philosophy.

Breadalbane Scholarships (two, each of 50*l.* annual value) in Mathematical and Natural Science.

Sir William Thomson Experimental Scholarships (three, each of 20*l.* annual value).

Neil Arnott Prizes in Natural Philosophy, consisting of the free annual value proceeds of Dr. N. Arnott's gift to the University of 1,000*l.*

90. A Statement of the total Emoluments of the Professors, inclusive of Fees, will be found in the Appendix. It will be observed that there is a great disparity in the amounts received. Appendix IV, pp. 68, 69.

91. In addition to the Annual Grants, a statement of which has been given, very considerable assistance was afforded by the Government to the University at the time of its removal to the site which it now occupies. When this transfer was made, a sum of nearly 100,000*l.* was contributed locally, chiefly in the city of Glasgow. The sale of the Old College and ground produced 100,000*l.* A further sum of 17,500*l.* represented the principal and interest of the compensation obtained by the University from the Monkland Junction Railway Company for the non-fulfilment of their agreement. In consideration of the importance of the work, and the public interest excited by it, the Government of the day announced their intention to ask Parliament for the sum of 120,000*l.* in six annual instalments, on condition of a like amount being raised by subscription and expended on the buildings. This proposal was assented to by Parliament, and the sixth instalment of 20,000*l.* was paid in 1873-74, the public subscription towards the combined extension, including the erection of a hospital, having then reached the large sum of 171,642*l.* Glasgow University Calendar, 1873-74, pp. 16-18.

*Number of Students ; Fees ; and Bursaries.*

92. The number of the Matriculated Students attending the University Course in the past Session was 1,456,—distributed in the following manner between the different Faculties :—

Faculty of Arts	-	-	-	904	
Faculty of Medicine	-	-	-	339	
Faculty of Law	-	-	-	153	
Faculty of Divinity	-	-	-	60	
Total				1,456	

App. IV,  
p. 70.

93. Each Student attending the University pays annually a Matriculation fee of 1*l.*, and also a Class fee to each Professor whose lectures he attends, the fee for each Course being 3*l.* 3*s.*, with the following exceptions, viz., Natural Philosophy, Scots Law, Civil Law, Conveyancing, 4*l.* 4*s.* each; Astronomy, 1*l.* 1*s.*; Political Economy, 1*l.* 11*s.* 6*d.*; and higher Metaphysics, 1*l.* 11*s.* 6*d.* App. IV,  
p. 70.

94. It appears from the Calendar that Bursaries, varying in value from 4*l.* to 50*l.* a year, are attached to this University. Of these eight only are, we observe, specially available as rewards for Proficiency in Science. A large majority of these prizes are restricted to inhabitants of particular localities, members of particular families, or they are otherwise strictly limited.

*The Engineering School.*

95. The situation of the University of Glasgow, in one of the Industrial Centres of this Empire, and in the midst of a densely-inhabited district, upon the face and under the surface of which manufacturing and mining enterprise are widely spread, has tended to increase the attention paid in its course of Instruction to branches of Science admitting of Application to Commerce and Manufactures. It has, accordingly, become the seat of an important Engineering School. The Chair of Civil Engineering and Mechanics itself was instituted in 1840, and is endowed by a Parliamentary Grant. The present Department of Engineering Science was not, however, established until about 12 years ago. The functions of this Department are not limited to the preparation of Students for the Degree in Engineering Science. It was described to us by the late Professor Rankine as "consisting of a course of study in the various branches of Science that are applicable to Engineering, and followed by a System of Examinations, and the granting of what we call a Certificate of Proficiency." Professor Rankine continues :

"We had a reason for giving it that title of Engineering Science; because we do not profess to teach pure practice, but the art of applying scientific principles to practice; and we did not want our certificate to pass as a certificate that the holder of it was fit to practise the profession, but only as a certificate that he possessed the requisite scientific knowledge. As to the details of the course of study, there is, in the first place, Mathematics, which the student studies for one or two years, according to what his previous preparation seems to render necessary. If he has not passed through a preliminary examination, he has to study Mathematics for two years at least. There is a preliminary examination, by the passing of which the minimum time which he has to devote to Mathematics is reduced to one year. When I say a year, I mean the University session for one year. Secondly, in Natural Philosophy or Physics, if he studies for the minimum period of one session, it may be increased to two, according to the proficiency

which he shows. Thirdly, as to Inorganic Chemistry, he studies until he has attained a knowledge of the fundamental principles of Chemistry; of the Chemistry of the more ordinary metals used in engineering structures and machines, such as iron, zinc, tin, copper, and so on, of the chemistry of building materials, such, for example, as cementing materials and building stones, and of the chemistry of air and water, and such elementary matters as that. The fourth subject is Geology, and in Geology his studies are specially directed to what the writers of the present day call Lithology, a branch of Geology that relates to stone and the substances that are used as building materials; he also studies Petrology and Stratigraphy, which have a bearing upon the execution of earthwork. Those are the parts of Geology which are more especially applicable to engineering. Then the fifth branch of this department of study, which concludes the list of the compulsory branches, is civil engineering and mechanics, which is studied for two seasons. This branch relates to the art of applying the principles of the other branches of Science mentioned to practical purposes. There is a special mode of treating such principles where they are to be applied practically; for instance, to engineering field work, to engineering structures, and to machines; a special method different from a purely scientific treatment. I will mention one of the special characters of the application of scientific principles to practice. For any given practical purpose there is a certain degree of precision required inferior to the precision required for purely scientific purposes; and the student ought to be able to judge of the degree of precision that is wanted in applying Science to a particular practical purpose, in order that time and labour and expense may not be wasted on an unnecessary degree of precision. It is a very important and rather difficult subject, and I could exemplify it at great length, but I suppose it is not necessary to occupy the time of the Commission by giving detailed examples of it. Then, on passing a satisfactory examination in those five branches, a student receives a Certificate of Proficiency in Engineering Science."

96. Before the Certificate referred to in the foregoing Evidence can be obtained, the Student must show a proficiency in Mathematics and Natural Philosophy sufficient to qualify him for Second Class Honours in Arts. No Literary Subjects are, however, required for the Certificate, which denotes merely "Proficiency in Engineering Science," but not that the Student is qualified to execute or superintend works. Should he desire to obtain not only this Certificate but also a Degree, he must study any two additional subjects taken from the Curriculum of Arts, and of those two, one must be Literary or Philosophical. The Degree may be with or without Honours; the subjects prescribed for Graduation will be found in the Table extracted from the University Calendar, already given in para. 84. There is no Compulsory Entrance Examination in this Department; there is, however, a Voluntary Examination, by passing which a Student may, if he means to take the Arts Degree, shorten the duration of his attendance by about a year.

Qu. 9507. 97. Professor Rankine stated that his pupils usually came to him fairly prepared in Mathematics. Preparatory study is, he considered, scarcely wanted in the remaining subjects, with the exception of Drawing, for the teaching of which there is no provision in the University. "There is evidently," the Professor remarked, "a deficiency of good instruction in Drawing throughout the country generally."

The same Witness has given us important Evidence with regard to the Association of Scientific Teaching with the Applications of Science:

Qu. 9509. "The main point which has been impressed upon me by my experience is the advisability of carrying on scientific study and practical study as completely separate and independent departments. When I first became professor the lectures were attended to a considerable extent, and to some extent they are attended now, by young men who are actually engaged in business at the time, and who are working at some practical business as civil engineers or as mechanical engineers during one part of the day, and get leave of absence, or find leisure, somehow or another, to attend the lectures also. From my experience that does not answer. It is too great a strain for one thing upon the mental faculties; and then the states of mind required in practical operations and in scientific study are so different that a sudden change from the one state of mind to the other at different periods of the day is injurious to both. In the earliest years of my holding this professorship, I was induced to give evening lectures. In fact, my predecessor lectured in the evening, and I followed the same plan, in order that not only young civil engineers' assistants, but young men engaged in mechanical engineering works and in workshops might be able to attend, but I found those evening lectures were all but useless. The students were very attentive, but when I came to examine them I found that the instruction given to them had taken little hold upon their minds. I found, in fact, that from the state of bodily and mental fatigue in which they were, there was little or no permanent benefit gained."

Qu. 9511. 98. Professor Rankine's experience led him to think that lectures given in the evening, or during the intervals between working hours, will not be practically useful to the students, and "that the best way to combine practical and scientific instruction is what we actually practise, indeed, to a great extent, or induce our students to practise as far as we can, that is, to devote the winter half of the year to scientific study, and the summer half to practical work." The following further definition of the limits within which Applied Science may be taught within an University was given us by the same Witness:

Qu. 9511. "I think it useless to attempt to give instruction in practice proper in an University. If, for instance, we set up a mechanical workshop with machine tools in it in our University, or if we got, say a mile or two of railway, and set our students to superintend the works, this would be worse than useless. The difference between doing things on a small scale like that, and doing things on a great scale, as in actual practice, is so great that the students would only be led to fancy that they had more knowledge than they really did possess, and, therefore, I am for having the practical knowledge acquired at separate times and places by practice on a great scale. There is one rather apparent than real exception to that. I think that a certain degree of

instruction in mechanical manipulation would be useful in our University, or in any University indeed, but rather in connexion with experimental physics than with engineering: such instruction as would make a student, if he were engaged in scientific inquiry, able to make his own apparatus. That actually goes on in the University of Glasgow in the physical laboratory. A great deal of the apparatus used there is made by the students themselves, under the superintendence of the professor and his assistants. This would be useful to young engineers as well as to other students; but they should not be led to suppose that in practising mechanical manipulation on that scale they are at all qualifying themselves for the practice on the great scale that one meets with in engineering workshops, or in the execution of lines of railway or other engineering works."

"The proper functions [of an University] are, first, to teach those branches of science proper that are applicable to engineering and mechanics, and, secondly, to teach the special art of applying scientific principles to practical purposes. The University having given the student this instruction, and having examined him to see that he is properly proficient in it, can then certify that he is a proficient in engineering science, but not that he is one qualified to execute or to superintend works. I think there is a limit to the function of an University, which is to impart and to certify the scientific knowledge, but not to certify the practical skill, of the candidate." Qu. 9512.

99. Engineering has now become a profession comparable in importance with reference to the wants of the present time to Law and Medicine. In the University of Glasgow, as well as in some other Universities, there is a tendency to claim for it recognition as a Faculty. When this claim is conceded, this new Faculty, with that of Medicine, will stand in the same relation to the Faculty of Science as that in which the Faculties of Theology and Law at present stand to that of Arts; and just as we should maintain that a Degree in Medicine ought to be preceded by an Examination in Science, and Degrees in Law or Theology by a General Examination in Arts, so, also, we should be of opinion that Candidates for a Degree in Engineering should be required to pass a Preliminary Examination of a general kind in Science.

100. The Certificates to which we have above referred are awarded to Candidates showing Proficiency in Engineering, unaccompanied by any evidence of General Culture, either Literary or Scientific; but the distinction between the "Certificate" and Degree is, we consider, sufficiently marked to justify the dispensation with such evidence in the case of the Certificate. We are, moreover, of opinion that by granting such Certificates to Students who may be unable to follow the complete course of study prescribed for Graduates, the University has been able to extend its benefits to a large class which might otherwise be excluded from them, and which, living as it does in the immediate neighbourhood of the University, should certainly be as far as possible brought into contact with its influences.

#### *Museums, &c.*

101. The University is fortunate in the possession of a good Museum, called the Hunterian Museum. This Museum contains a general collection bequeathed to the University in 1783 by Doctor Wm. Hunter, together with 8,000*l.* for the erection of a building and the maintenance of the collection. The collection has been accommodated in the New University Buildings; it contains an important Anatomical Department, besides a Library of rare books and manuscripts, coins, and antiquities, pictures, and natural history specimens. The Museum is available for teaching purpose, and maintained by the University at a cost of about 300*l.* per annum, the whole of the original bequest having been expended. The University has also an Observatory with a considerable collection of instruments. The Professor of Anatomy has a collection of his own and another purchased by the University, the two together forming a large Illustrative Class Museum. Some of the other Professors possess small Class Collections. There are a Botanic Garden and Collections in the city of Glasgow to which the University has access.

102. We learn, however, that there is a total want of funds for the maintenance of the Museums, both public and private, and that the expense of supporting the private Museums has fallen entirely on the Professors.

#### *The Chair of Natural History.*

103. Our attention has been called to the position of the Chair of Natural History, the occupier of which has represented to us "that, as the Chair is at present arranged, it is perfectly impossible for the holder of that Chair to do justice to the work that is expected of him; that in the first place he is required to teach Zoology to Medical Students; in the second place he is required to teach Geology to Students of Engineering; that those two offices are incompatible, since to discharge the one adequately he would require to spend his whole year in dissections and indoor study; and to do the work of the other, he would require to be the major part of the year in the field, making investigations in geology, and that the combination of the two duties renders



"it imperative upon the teacher to neglect, to some considerable extent, one or the other. In my own case," says Professor Young, I have been obliged to surrender "the Geological Section of my work to some extent, so as to attend more thoroughly to the Medical Students, the requirements of the General Medical Council making it imperative upon me that I should do my best for the very large number of Medical Students who attend my class."

This Chair receives 200*l.* altogether from a Parliamentary Grant, and the fees amount to about 260*l.* Sir Wm. Thomson expresses his opinion that it is, perhaps, the most insufficiently endowed of all the Professorships in the University. There is a complete concurrence of testimony with regard to the objectionable character of the arrangement under which this Professor has charge of the two subjects of Zoology and Geology, and as to the inadequacy of this Endowment. Dr. Allen Thomson, the Professor of Anatomy, is of opinion that there would be great advantage in separating the two subjects and assigning them to distinct Chairs.

Qu. 2741.

Qu. 9797.

104. In this opinion we entirely concur; and we Recommend that provision be made out of moneys voted by Parliament for the Endowment of an additional Chair between which and that to which we have just referred the subjects now dealt with by Professor Young should be divided in the manner most advantageous to the University.

#### *Deficiencies as regards Assistants.*

105. In this University, as in that of Edinburgh, the want of sufficient and competent assistance to the Professors forms an obstacle in the way of the efficient Teaching and Study of Science. It appears from the table quoted on p. 16 that no provision is made either from Parliamentary Grants or from University Revenues for the payment of Assistants to the Professors of Civil Engineering, Natural History, or Botany.

106. The Natural History Professor states that—

Qu. 9576.

"But for the accident that I am Keeper of the Museum, I should be absolutely without assistance. There is an Assistant Keeper of the Museum, who receives a salary of 100*l.* a year from the University; and in my own interest I pay him 25*l.* a year out of my own pocket to secure his co-operation in the Geological Course. Other assistance I have none as regards the Chair. What assistance I have, therefore, comes entirely out of my own pocket, and no provision in the Universities' Act admits of my receiving such assistance, because the terms of the Act go to forbid an increase of the emoluments of any Professor."

Qu. 9601.

The same Professor complains that in his own department he suffers "from the want of some one who would undertake especially the Histological Course, requiring a great deal of time to be expended upon the preparation of the specimens, and upon the instruction of the students in the method of preparing those specimens. In Geology I am practically at a standstill, as regards the special training of Engineering Students, from want of some one who could undertake a sufficiently good course of instruction in Mining. For three years, at my own expense, I procured the assistance of a medical student who had come to the profession from the pit, who gave a course each year of 10 or 12 lectures upon Practical Mining. I paid him, and I supplied him with the necessary plant and all the expenses required for taking the party out to the field for practical instruction."

107. The Professor of Engineering makes the following statement:—

Qu. 9513.

"In connexion with the teaching of the scientific principles of Naval Architecture, which I have mentioned as one of the subjects of my lectures, there should be an assistant, a lecturer, or a teacher of some kind, to teach a variety of details that are not properly the subject of lectures, but such details as are taught in the Royal School of Naval Architecture, namely, the preparation of the plans of a ship and the making of a set of routine calculations which in designing a ship are always required. This, in fact, can only be done by the help of some assistant or teacher for that purpose."

Qu. 2680.

108. Sir William Thomson observes, "that it is absolutely necessary, for the efficiency of the teaching and for the position of the Professors in respect to the Advancement of Science, that there should be a sufficient number of assistants of the Tutorial Class."

Qu. 9825.

109. The Professor of Anatomy states that, in conducting his practical or laboratory work, he has the aid of a Demonstrator and several Assistants, and that such employment is much desired by young men of merit.

110. The Professor of Chemistry has two Assistants under the Ordinances of the Commissioners; these are both Skilled Assistants and receive 100*l.* a year each from a Parliamentary vote.

#### *Conclusion and Recommendation.*

111. Upon a review of this Evidence we are of opinion that an increase in the payments on account of Assistants to the Scientific Professors is essential to the promotion of the Teaching of Science in this University; and we recommend that the Government Grant

be augmented sufficiently to permit the University to make this increase, and to revise the Salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees; an account of the expenditure of this Annual Grant being submitted to the Government with a view to the exercise of Parliamentary control.

#### THE ANDERSONIAN INSTITUTION.

112. Before leaving the subject of Scientific Instruction in Glasgow, we desire to refer briefly to the Evidence we have received as to an Institution in that City known as "Anderson's University." This Institution was founded under the will of John Anderson, Professor of Natural Philosophy in the University of Glasgow, towards the close of the last century, with the object of affording a higher education to the working classes of Glasgow. It is governed by eighty-one Trustees, and by nine Managers elected by the Trustees. In the will of its Founder, it is designated an University, and has Departments which are termed Faculties of Arts, Medicine, Law, and Theology, but as it has neither a Charter nor the power of granting Degrees, it is not an University, nor has it Faculties, in the usual sense of those terms. The Faculty of Arts includes Physics, Mathematics, and Chemistry. The Faculties of Law and Theology are both in abeyance.

It is stated in the Evidence that, "with the exception of philosophical apparatus Qu. 9943. and personal effects, there was little else than the formation of the system mentioned in "the will wherewith to carry out the intentions of the Founder."

The Institution, of which the system was indicated in the will, has, we are told, Qu. 9944. been maintained, up to the present day, in its present efficient condition, through the "perseverance of the Trustees and the occasional gifts from time to time of the citizens "of Glasgow." The Trustees have also, it would seem, at different times, made purchases of property which has been mortgaged to banks, the Institution paying the interest of the loan. More recently the Institution has received liberal gifts of 10,500*l.* Qu. 9985. from Mr. Young "for the purpose of establishing a Chair of Technical Chemistry"; and 9987. of 2,100*l.* from Mr. Euing for building purposes; and of 5,000*l.* from Mr. Freeland for the extinction of debt. No endowments have, however, been attached to any of the Faculties, and the Lecturers are dependant upon fees. Until lately they were obliged to pay rent for lecture-rooms.

113. The attendance on the Scientific Classes appears to be fairly numerous. In addition to these, Popular Classes have, from the first, been carried on in the evening, and the attendance at these appears to be increasing. 7,500*l.* has been assigned by Qu. 9969. Mr. Freeland, and 3,000*l.* by Mr. Euing of Glasgow, in support of these classes. The number of the Students attending the Institution in 1873-74 is shown by the Calendar to have been 2,499. Calendar for 1874-75, pp. 31, 32.

114. The fees payable are as follows:

##### Faculty of Arts —

Chemistry (lectures and demonstrations), 2*l.* 2*s.* per course of six months.  
Technical Chemistry, 18*l.* per session of nine months, 7*l.* for three months, or 2*l.* 10*s.* for one month.

Ibid.,  
pp. 19, 20.

##### Faculty of Medicine:—

Class fees for each course of lectures: First session 2*l.* 2*s.*, second session 1*l.* 1*s.*, afterwards free.

Anatomy class fees, for both courses (lectures and demonstrations): First session 4*l.* 4*s.*; second series 4*l.* 4*s.*; summer session, with dissection, &c., 1*l.* 1*s.*

Practical Anatomy: the Dissecting room is free for two Sessions to those who attend both courses of Anatomy; after the second year, the fee for Practical Anatomy is 1*l.* 1*s.* per Session.

Ophthalmic Surgery: Attendance gratis by paying a Matriculation Fee of 5*s.*

The fees for all the Lectures and Hospital Practice required of Candidates for the Diplomas of Physician and Surgeon amount to 50*l.*

The fee for attendance at the Evening Classes is 2*s.* 6*d.* or 3*s.*, except in the case of Qu. 9980. one Course, that of Applied Mechanics, in which a fee of 10*s.* 6*d.* is charged; the payment of these fees entitles the Student to admission to a library of 6,000 volumes.

115. There does not appear to be any regular System of Examinations in connexion with the Evening Classes; the Students can, however, present themselves at the Examina-

- Qu. 9975. tions of the Science and Art Department. We have received from Mr. McClelland, one of the Trustees of the Institution, a table showing the occupations of over a thousand of the Students by whom these Evening Lectures are attended. This table proves that the working classes of Glasgow are in the habit of availing themselves extensively of them; the order of students, on the other hand, who attend the Faculties of Medicine and of Arts, is pretty much the same as that by which the Glasgow University is attended. We observe that Students attending these Classes are drawn from all parts of the United Kingdom.
- Qu. 9989. 116. It has been suggested to us that this Institution might, under certain circumstances, receive a Charter, in order to enable it to compete, on more equal terms, with the University of Glasgow. In this suggestion we are not able to concur; the proper function of the Institution is, we believe, to afford facilities for education to those classes whose means or opportunities do not permit them to follow an University course. The competition for students of the same class to which we have already referred is, perhaps, inevitable, but should not, at all events, be encouraged; nor do we believe that an increase in the number of Degree Giving Bodies in Scotland is desirable in the interests of the Higher Education of that Country.

It has also been suggested to us that the Institution might be used as a Central Establishment for the Training of Scientific Teachers, and that it might receive a Government Endowment for this purpose.

#### St. ANDREW'S

##### *The Colleges and Scientific Chairs.*

117. This University contains two Colleges, the United College of St. Salvator and St. Leonard, and St. Mary's College.
118. The Scientific Department of the University consists of five Chairs, comprising Mathematics, Natural Philosophy, Chemistry, a Chair of Civil History and Natural History, and of Medicine and Anatomy. A certain degree of acquaintance with the subjects taught by the Professors occupying the first three of these Chairs is required of all Students Graduating in Arts. The Theological Students are required to attend the lectures of the Mathematical and Natural Philosophy Professors.
- Qu. 9618. 119. The Professor of Mathematics "teaches in the junior class six books of Euclid, Algebra as far as Simple Equations, including ratio and proportion, and the Theory of Arithmetic. In the second class Algebra, Plane Trigonometry, the application of Algebra to Geometry, Trigonometry, and Conic Sections. In the third, or senior class, for three days a week he teaches Analytical Trigonometry, Analytical Conic Sections, and Differential and Integral Calculus."
- Qu. 9623. 120. The Professor of Natural Philosophy "teaches one class, lecturing seven hours a week. His subjects are the Properties of Matter and of Force, including Inertia, Gravitation, Molecular Forces, Laws of Motion, Conservation of Energy, &c., Dynamics or Mechanics, including Hydrostatics and Pneumatics, Sound, Heat, Light, Electricity, Astronomy, and Meteorology."
- Qu. 9625. 121. The Professor of Chemistry "teaches one class, lecturing an hour each of the teaching days, that is five days a week, and he has a practical class, lecturing three additional hours. The subjects taught are Chemical Physics, including the Chemical Relations of Cohesion, Adhesion, Heat, Light, and Electricity; Chemical Philosophy, including the Atomic Theory; the Non-Metallic and Metallic Elements and their Compounds, and Organic Chemistry."
122. Of the Chair of Civil and Natural History, which is in private patronage, we have received the following account from the Principal of the University:—
- Qu. 9629. "It was originally the Chair of History, which was interpreted to mean Civil History. The University Commissioners gave it the name of the Chair of Civil and Natural History. The Chair does not belong to the curriculum, and it has not been practically an useful Chair ever since I recollect, and my recollection extends to the period when I was a Student, as well as since I became officially connected with the University. Dr. Ferrie was the Professor when I was a Student, and he lectured occasionally upon General History. The class was attended for three or four lectures, and then it ceased. Dr. McDonald, the present Professor, has occasionally managed to get a class, but from many causes the class has not been regular."
- Qu. 9630. "Then you would say that the University at present gives no instruction in any branch of Natural History?—I cannot say that it does."

This condition of things was, however, described by another Witness as only temporary, and we learn that on the death of Dr. Macdonald, a Naturalist was appointed to this Chair.

123. The Professor of Medicine and Anatomy has a class described to us by the Principal as a semi-popular one, the lecture being chiefly devoted to the hygienic aspects of the subject. No Examination is held in this Class, which generally numbers about 30 and is chiefly attended by the Senior Students.

*Museum and Library.*

124. The University Museum is represented to us as fairly good; the collection is mainly a local one, but it is pretty complete in all the Departments of Natural History, and as a Teaching Museum it is in excellent condition.

The University Library is a very extensive one, consisting of about 110,000 volumes; but the buildings in which it is placed do not afford proper accommodation for the books. These buildings, like most of those in the Scottish Universities, are the property of the Nation, and the expediency of a grant for their extension has, we are informed, been under the consideration of different Governments during recent years.

*Financial Statement.*

125. The Capital Fund of the University is about 21,000*l.*, and its annual income consists of the interest on this sum, and the Matriculation and Graduation Fees, amounting to 500*l.* or 600*l.* a year. A sum of 600*l.* a year, received as commutation of the University's right to books from Stationers' Hall, is spent upon the Library. The total expenditure upon this, however, including salaries to librarians, exceeds this amount. The income of the Colleges may be taken at 2,670*l.*, but the appropriation of the whole of the College revenues is determined by Act of Parliament or by Ordinance of the Commissioners, so that there is no surplus revenue from College Funds available for other purposes. We have received from the Senior Principal the following Statement of the only sums which can, in his opinion, be considered as applied from Endowment, or from Votes by Parliament to the Advancement of Science or to Scientific Instruction in the University of St. Andrew's:

EMOLUMENTS of the following CHAIRS in the UNIVERSITY of St. ANDREW'S (year 1870).

	£	s.	d.
<b>MATHEMATICS</b>			
Salary under Act 20 George II, c. 32	71	0	0
Estimated share of surplus College revenues	129	18	0
Parliamentary vote—			
Present	55	11	0
*New	53	9	0
Estimated fees	199	0	0
	200	0	0
	<hr/>		
	2509	18	0
	<hr/>		
<b>NATURAL PHILOSOPHY:</b>			
Salary under Act 20 George II, c. 32	89	0	0
Estimated share of surplus College revenues	129	18	0
Parliamentary vote—			
Present	55	11	0
*New	94	9	0
Estimated fees	150	0	0
	85	0	0
	<hr/>		
	2444	18	0
	<hr/>		
<b>NATURAL HISTORY:</b>			
Salary under Act 20 George II, c. 32	60	0	0
Estimated share of surplus College revenues	129	18	0
Parliamentary vote—			
Present	55	11	0
*New	44	9	0
Estimated fees	100	0	0
	80	0	0
	<hr/>		
	2369	18	0
	<hr/>		

Minutes of Evidence, Vol. II, App. V, pp. 5, 6.

\* These sums represent the additions to the Emoluments of the Chairs recommended by the Commissioners of 1858.

## CHEMISTRY :

Income from Dr. Gray's Foundation, estimated by Commissioners at 125 <i>l.</i> , but does not exceed	£	s.	d.	£	s.	d.
*New Parliamentary vote	-	-	-	90	0	0
Estimated fees	-	-	-	125	0	0
				80	0	0
				<u>£295 0 0</u>		

## MEDICINE :

Salary under Act 20 George II., c. 32	-	-	-	60	0	0
Estimated share of surplus College revenues Parliamentary vote—	-	-	-	129	18	0
Present	-	-	-	55	11	0
*New	-	-	-	44	9	0
Estimated fees	-	-	-	100	0	0
				30	0	0
				<u>£819 18 0</u>		

App. V., pp. 70. 71. 126. A similar return for the past year will be found in the Appendix. It will be seen that the emoluments of the Scientific Professors are uniformly low.

*Number of Students, and amount of Fees.*

App. V. P. 71. 127. The number of Students attending the Classes in the Faculty of Arts during the Session 1874-75 was 118. The number attending the Faculty of Theology was 23, making a total of 141 Students, thus distributed among the Colleges:

Number of Matriculated Students at the United College	118
Number of Matriculated Students at St. Mary's College	23

App. V. P. 71. 128. Students attending the United College pay a Matriculation Fee of 1*l.* on entering, and a fee of 3*l.* 3*s.* for each Class they may attend during the Session. Should they attend three Classes, which is the average number, the annual payment made by each Student amounts to 10*l.* 9*s.* In the event of their proceeding to Graduation in Arts, a further fee of 1*l.* 1*s.* is payable for each of the three Departments of Examination. Students of St. Mary's College pay a Matriculation Fee of 1*l.*, and a Fee of 2*l.* 2*s.* for each of the Classes they attend, which is in general three in number.

*Deficiency as regards Assistants and Apparatus.*

129. The Scientific Instruction given in the University of St. Andrew's suffers equally with that given in the other Scottish Universities from the want of Skilled Assistants.

130. With regard to Laboratories and Apparatus, we have it in Evidence that although the Professors of Chemistry and of Civil and Natural History, and of Medicine and Anatomy, have their respective apparatus, and receive annually from the University a grant for the purpose of adding to and restoring it, the apparatus is very inadequate and the sum allowed insufficient for the purpose for which it is intended. The Principal of the University expresses his conviction that the University requires additional apparatus and appliances for teaching, and states that the University has no funds available for the purpose.

Qu. 9643.

131. The Professor of Chemistry receives from the University an annual grant of 52*l.* 10*s.* for all the working expenses, including apparatus, chemicals, and Assistants. It is scarcely matter for surprise that the whole of this sum should not have sufficed to provide the two former items, and that the Professor has in consequence never had any assistance at all except that which one of the Senior Students has, from time to time, been, in his own interests, willing to afford. The Professor has given it as his opinion that, "in present circumstances, an assistant at a salary of not less than 80*l.* is absolutely necessary; and it would require a sum of from 100*l.* to 120*l.* for the purchase of apparatus and chemicals, and waste of materials," that being the amount of the sum which he has voluntarily made up out of his own pocket, in order to keep the class in efficient working.

Qu. 9780.

132. The Professor of Natural Philosophy receives also 52*l.* 10*s.* for all expenses, and out of this sum 12*l.* only is, he informs us, available for the payment of an assistant. When

\* These sums represent the additions to the Emoluments of the Chairs recommended by the Commissioners of 1858.

asked, "Do you feel the want of an assistant of a different kind from that which you are enabled to provide under the present arrangements?" the Professor replied: Qu. 9737.

"I do very much indeed. Indeed, I am obliged every day that I give an experimental lecture to work for a great many hours, never less than four hours, doing a great deal of work which an assistant ought to do. Then on the other alternate days, by anticipation, I am also obliged to work in preparing experiments, so that a great deal of time is occupied in doing common work, which an assistant might do. Even our present stock of apparatus is valuable, and will, every year, become more so; and in the event of increased grants, we may expect to have a very valuable stock of apparatus in a few years. It is extremely desirable that some Curator of such a collection of apparatus should be provided, able to take care of it. Such an assistant as I have, at 12*l.* a year, although he is an extremely intelligent and perfectly honest man, has not knowledge enough to be entrusted with such a collection. It would need a man specially educated to take charge of such a collection."

133. The Scottish Universities Commissioners, who, in consequence of the inadequacy of the resources at their command, provided very insufficiently for the appointment of Para. 22. Assistants to the Scientific Staff of the other Universities, did not recommend a grant for this purpose to the University of St. Andrew's, which has accordingly been obliged to fall back upon its own slender resources.

134. It is our opinion that the Teaching of Science should be encouraged in this, as in every other University, as a part of the groundwork of a Complete System of Education, and that the Staff of the University, and the Appliances at its disposal, should be sufficient to secure this end. We are not, however, disposed to suggest any steps which might have the effect of erecting at St. Andrew's Technical or Medical Schools such as those of Glasgow or Edinburgh.

#### *Proposed Connection with Dundee.*

135. The University of St. Andrew's is distant 11 or 12 miles in a direct line from the town of Dundee, from which, moreover, it has been hitherto effectually separated by the intervening Frith of Tay. The completion of the bridge now under construction will, however, render the town and the University much more accessible to each other, and it has been suggested that advantage should be taken of their vicinity in order to connect them for purposes of education.

136. We have received Evidence with regard to the expediency of establishing Classes, taught by the University Staff, for artisans in the town of Dundee, and of founding in Dundee a School of Science affiliated to, and in close relations with, the University. A large building known as the Albert Hall, and containing a Public Library, has been designated as suitable for some such purpose. Whatever may be the decision ultimately arrived at, it must be obvious that no such instruction could be given in Dundee by the University Staff, unless that staff were very considerably increased. The Professors have already as much work as they are able to undertake. We have pointed out that they are far from being adequately provided with skilled assistance, and it would, we think, be unreasonable to expect that they should, in addition to their present lectures and practical classes, travel backwards and forwards between St. Andrew's and Dundee in order to lecture, to working men in the evening, or to attend to such Students as might be unable or unwilling to make the short journey between the two places.

137. A certain number of the Students are natives of Dundee, and we may expect that the number will increase. Many of these Students would, in the event of effect being given to such a scheme as that which has been indicated to us, probably cease to reside at St. Andrew's, and would lose thereby the opportunities offered them for acquiring the groundwork of a sound general education. It is further to be observed that the Establishment of a separate Science School in Dundee would necessitate, not only an increase in the University Staff, but also additional Laboratories, and of other appliances which could not be provided except at a very large increase of expense; while, as we have already stated, there are no funds at present available for these purposes. Such an arrangement could only be justified on the grounds of its absolute necessity, and of this we are by no means satisfied, taking into consideration, on the one hand, the ease with which a student who is able to devote the greater part of the day to his studies will be able to attend the St. Andrew's Courses, and, on the other hand, the partial and limited character of the Instruction which artisans, or other persons most of whose time is engaged in professional or commercial pursuits are likely to derive from attendance at Evening Classes.

110138: We desire, also, to express our disapprobation of the suggestion which has, it would appear, been made to the University, that the Scientific Chairs of St. Andrew's University should be transferred bodily to Dundee, and that a separate Faculty of Science should be created in that town. It seems to us almost needless to insist on the hardship which such an arrangement would involve to those Students who now undergo, while in residence at St. Andrew's, a course of combined Literary and Scientific Instruction, and who might be called upon to attend possibly during the same day classes in each of the two towns. We should object to the Scheme on this ground alone, but we do so still more from our conviction that it is undesirable to decentralise and separate the different Faculties of the same Universities. Such a System tends in the direction of narrow and specialised education, widely different from that general and broadly grounded culture which is the true province of an University to promote.

110139: Since the date at which our Evidence was received, we have been made aware of the existence of a Scheme which has met with considerable encouragement in the town of Dundee, and of which the intention is to found in that town a College in which might be "acquired the highest attainments in Literature, Science, and Art." Such a College might, it was suggested, be affiliated to the neighbouring University, the connection implying that the Teaching of the College is recognized by the University as sufficient to authorize the Students in that College to compete for Degrees conferred by the University. The cost of giving effect to such a Scheme is estimated by its promoters at a sum not less than £25,000. We have no Evidence of the probability of a sum of this magnitude being raised by local or other contributions, and we do not, therefore, feel called upon to express any opinion with regard to the merits of the Scheme, of which the outline only has been before us. We cannot, however, believe that an University so ancient and so distinguished as that of St. Andrew's, possessing a complete University Organization, and a Town of the wealth and enterprise of Dundee, are likely to remain long dissociated; or that the citizens of Dundee, in the event of the establishment of easier and more rapid communication with St. Andrew's, will be slow to avail themselves of the advantages afforded by the proximity of the University.

110140: If, in consequence of such an association, the University were required greatly to extend its establishments for the Teaching of Science, we should not hesitate to recommend that local efforts to meet the necessary expenditure should be supported by a further contribution from Public Funds.

*Conclusion and Recommendations.*

110140: The University of St. Andrew's enjoys an admirable situation, and it is supported by the traditions and associations of a long and interesting history; it needs, we believe, in order to the full development of its usefulness for the purposes of Scientific Instruction, only such assistance as will enable the Professors to give efficiently that education which, with the limited means at their disposal, they are now endeavouring to provide.

110141: We Recommend that such assistance should be afforded by an increase of the Government Grant sufficient to enable the University to provide the Professors with an adequate Staff and with the proper appliances for Instruction in Science; and to revise the salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees; an account of the Expenditure of the Annual Grant being submitted to the Government, with a view to the exercise of Parliamentary control.

110142: If this be done, we see no reason why the University should not be able, without dismemberment or removal, to enlarge considerably the area to which its benefits extend.

ABERDEEN.

143. It will be observed, on reference to the Correspondence printed in the Appendix to this Report, that the University of Aberdeen has declined to avail itself of the opportunities offered to it of tendering Evidence before this Commission. Appendix, VI., p. 72.

144. We have, however, received from the Principal, the following Statement of the sums (derived from Endowments or from Parliamentary Grants) which are available for Scientific Instruction in the University:—

	Endowments	Grants.	Total	Minutes of Evidence, Vol. II., Appendix V., p. 72.
	£ s. d.	£ s. d.	£ s. d.	
<i>Professorships, &amp;c.</i>				
Chair of Mathematics (average)	124 0 0	78 0 0	200 0 0	
Assistant to ditto	62 0 0	38 0 0	100 0 0	
Chair of Natural Philosophy (average)	186 0 0	114 0 0	300 0 0	
Assistant to ditto	62 0 0	38 0 0	100 0 0	
Chair of Natural History (average)	186 0 0	114 0 0	300 0 0	
Chair of Anatomy	—	150 0 0	150 0 0	
Assistant to ditto	—	100 0 0	100 0 0	
Chair of Institutes of Medicine or Physiology	—	200 0 0	200 0 0	
Chair of Chemistry (average)	165 10 0	40 8 8	205 18 8	
First Assistant to ditto	—	100 0 0	100 0 0	
Second ditto	—	50 0 0	50 0 0	
For class expenses	—	100 0 0	100 0 0	
Chair of Botany	—	300 0 0	300 0 0	
Chair of Materia Medica	—	150 0 0	150 0 0	
Joint Assistant to ditto, and Chair of Medical Jurisprudence.	—	50 0 0	50 0 0	
For class expenses	—	50 0 0	50 0 0	
<i>Scholarships and Prizes.</i>				
Four Scholarships to Graduates for distinction in Mathematics, including Natural Philosophy, each 65 <i>l.</i>	260 0 0	—	260 0 0	
Neil Arnott Scholarship for most distinguished student in experimental branches of Natural Philosophy.	35 10 0	—	35 10 0	
Simpson prize to first most distinguished Graduate in Examination for Honours in Mathematics.	70 0 0	—	70 0 0	
Boxill prize to second ditto	28 0 0	—	28 0 0	
	<b>£1,178 10 0</b>	<b>£1,670 8 8</b>	<b>£2,848 18 8</b>	

145. The Arts Curriculum in this University does not appear to differ materially, in so far as the Scientific Subjects which form a part of it are concerned, from that of the other Scottish Universities, with the exception that, under Ordinance 18, it has required all Candidates for Graduation to attend the Lectures of one of the Professors in the Department of Natural Science.

146. No Degree is given in Science, but Candidates for Graduation with Honours in Arts may offer themselves for examination in the Department of Natural Science, which includes, as in the other Universities, Geology, Zoology, Chemistry, and Botany. The Regulations for Graduation appear to us to be judicious, and in accordance with the principles which we have advocated should be adopted elsewhere.

147. The University contains a Medical School, and we learn from the Calendar that there is a Museum of Natural History containing collections of Zoological, Geological, and Mineralogical Specimens, and that there are other Collections used for purposes of illustration in connection with the different Classes of the Medical School. Calendar for 1874-75, p. 24.  
Calendar for 1874-75, pp. 10, 11.

148. The number of Students attending the University Courses in the University of Aberdeen during the past Session (1874-75) was as follows:— Appendix VI., pp. 72, 73.

Faculty of Arts	336
Faculty of Divinity	36
Faculty of Law	14
Faculty of Medicine	227
	<b>613</b>
Students in both Arts and Medicine	8
Students in both Divinity and Medicine	2
<b>Total number of Students</b>	<b>603</b>



Appendix,  
VI., p. 78.

149. The average amount of the fees payable by the Students per annum is as follows:—

	£	s.	d.
Faculty of Arts	7	12	0
Faculty of Divinity	5	13	4
Faculty of Law	5	4	0
Faculty of Medicine	12	0	6

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150. As in the other Scottish Universities, a large number of bursaries, or scholarships, are annually distributed among the Students. These bursaries are, we are informed, 240 in number, and worth about 4,000*l.* a year. With the exception of those referred to in the above table, we do not learn that any of these are specially available as rewards for Proficiency in Science. We are, however, reminded by Professor Bain, in a letter printed in the Appendix, that "the effect of these bursaries is to educate and assist in maintaining upwards of 200 young men while pursuing a mixed Curriculum of Literature and the Sciences, the Literature consisting of the three languages, English, Latin, and Greek; the Sciences being Mathematics, Natural Philosophy, Natural History, Logic, and Moral Philosophy." The bursaries vary in value from about 10*l.* to about 35*l.* a year, and average about 17*l.*, while the cost of education is under 10*l.* a year. We are glad to learn from Professor Bain that—"Nearly two thirds of the bursaries are given by public competition, the collective annual value of these being about 2,500*l.*, but the subjects of competition were in former days confined to Classical Literature. For several years one fourth of the marks has been given for Mathematics, and by a Scheme, coming into operation next year, Chemistry and Zoology are admitted into the list of subjects. The obvious tendency of such a competition is to make the bursaries instrumental in stimulating the study of Science in the Schools preparatory to the University."

#### Summary of Recommendations with regard to the Universities of Scotland.

151. In conclusion of our Inquiry into the Universities of Scotland, we beg leave to submit the following Summary of the Recommendations which we have had occasion to make in the course of the above Report:

Paras. 80, 81.

With regard to *The University of Edinburgh* we have Recommended:

I. That increased assistance be given, both in the form of a Capital Sum in aid of a well-considered Scheme of Extension, and in that of an Annual Grant sufficient to enable the University—(1) To increase the number, and, in some cases, the emoluments of Assistants; (2) To make more ample provision of Apparatus for Teaching; and (3) To revise the Salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees.

II. That the Grant of any Capital Sum in aid of the Extension of the University be contingent upon the receipt of substantial contributions from private sources.

Paras. 104,  
111.

With regard to *The University of Glasgow*, we have Recommended:

I. That the Chair of Natural History be divided in the manner most advantageous to the University; and that provision be made out of moneys voted by Parliament for endowing a new Professorship.

II. That the Government Grant be augmented sufficiently to enable the University to make an increase in the Payments on account of Assistants to the Scientific Professors, and to revise the Salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees.

Para. 141.

With regard to *The University of St. Andrew's*, we have Recommended:

I. That assistance be afforded by an increase of the Government Grant sufficient to enable the University to provide the Professors with an adequate Staff and with proper Appliances for Instruction in Science; and to revise the Salaries of the Scientific Professors, regard being had to the disparity of their endowments, and to the income which they derive from fees.

Paras. 81,  
111, & 141.

We have also Recommended generally:

I. That an account of the Expenditure of any Annual Grant made to the Universities above referred to, be submitted to the Government, with a view to the exercise of Parliamentary control.

Para. 32.

II. That for the future, two Classes be recognized in the Natural Science Honours List.

### III. The University of Dublin and Trinity College.

152. The University of Dublin contains only a single College, Trinity College, which was founded by Queen Elizabeth in 1591, and created a Corporate Body, consisting originally of a Provost, three Fellows, and three Scholars. The Foundation has been enlarged from time to time, and there are now 7 Senior and 26 Junior Fellowships, and 70 Foundation Scholarships.

153. The principal subjects, referred to in the Evidence, which we have taken with regard to the University of Dublin and Trinity College, are the following:

- I. The Courses of Study and the Examinations.
- II. The Exhibitions, Scholarships, and Studentships.
- III. The Provostship and the Fellowships.
- IV. The Professoriate.
- V. Museums and other Scientific Institutions.
- VI. The Council.

#### I.—THE COURSES OF STUDY AND THE EXAMINATIONS.

154. For admission into the University, a Student has to pass an Entrance Examination, which includes Classical and other Literary Subjects, together with Arithmetic and the elementary parts of Algebra. At the Entrance Examination there is a further Examination for Honours which is confined to Classical and other Literary Subjects.

155. Sizarships, tenable for four years, may be obtained at Entrance. They are awarded by the result of a Competitive Examination, which, however, is open only to Students of limited means. One Sizarship is awarded annually for proficiency in Mathematics.

156. As regards the mode of obtaining a Bachelor of Arts Degree, the University of Dublin occupies a position intermediate between the older English Universities, on the one hand, and the University of London, on the other. At Dublin, as at Oxford and Cambridge, a certain number of Terms must be kept before the Degree can be obtained, and provision is made for the Instruction and Discipline of Resident Students; but a Non-resident Student is accounted as having kept a Term if he passes an Examination held at the beginning of the following Term. There are thus two distinct ways in which a Term may be kept: (1) by actual residence, combined with attendance at the prescribed Courses of Lectures; (2) by passing the Term Examination.

157. There are three Terms in each year,—the Michaelmas, Hilary, and Trinity Terms,—and the Undergraduate Course extends over four years. It is not, however, essential that the Student should keep all these twelve Terms. He must, pass in succession through the four Classes of Junior Freshman, Senior Freshman, Junior Sophister, and Senior Sophister, Classes which are designed to consist of Students of the first, second, third, and fourth years respectively. To pass from Junior to Senior Freshman, the Student must have kept at least one Term *by examination* in his first year. To rise to Junior Sophister, he must have kept at least three Terms in all, of which one at least (which may be kept in either way) must be kept in the Senior Freshman's year, and he must further pass an Examination at the beginning of the third year. The Final Examination for the Degree of Bachelor of Arts is held in the Michaelmas Term of the Senior Sophister year, and before admission to it the Student must have kept one Term by Examination as Junior Sophister, one Term either way as Senior Sophister, and a third Term either way in either year.

158. Thus, a Student, before presenting himself for the Final Examination for the Degree of Bachelor of Arts, must have kept at least six Terms, properly distributed, of which two at least must have been kept by Examination, and he must have passed one Examination besides the Entrance Examination and those by which Terms are kept.

159. The natural operation of these rules would be that Resident Students would, as a rule, keep many more Terms than the minimum required, for the sake of profiting by the Lectures, while Non-Residents would content themselves with passing the Examinations absolutely required, with, perhaps, such additional days of examination as are given to Candidates for Honours. Thus, as regards Residents, although only six Terms, of which two must be kept by Examination, are nominally required in the whole of the four years, the system practically agrees with that which prevails at Oxford and Cambridge; while, as regards Non-Residents, although a larger number of examinations are required to be passed than at the University of London, the position of the University towards the Student is in principle the same, and the University acts merely as an Examining Board.

- Qu. 12,738. 160. It is stated by Mr. Jellett, that it is the general opinion at Trinity College that this substitution of attendance on Lectures for a part of the Examinations which would otherwise be required for Degrees works satisfactorily; and that it is generally thought that attendance at a Course of Lectures, which are, in a large degree, catechetical, is a more satisfactory test, and communicates to the Student a greater amount of knowledge than a simple preparation for an examination, no matter how good the examination may be. It is found in practice that Candidates for Honours almost universally attend Courses of Lectures.
- Qu. 12,739.
- Qu. 12,744. 161. The obligatory Subjects of Study in the several years are as follows:—In the first year Mathematics and some Classics; in the second, Logic, a certain amount of Metaphysics, and again Classics; in the third, Mathematical Physics, namely Mechanics and Astronomy, and either Classics or Experimental or Natural Science; in the fourth, Astronomy and Ethics, and two out of the four branches—Classics, Experimental Physics, Mathematical Physics, Natural Science.
162. In the designation of these Courses, it should be observed that the term "Natural Science," being distinguished from "Experimental Science," is used in a restricted sense. The subjects embraced in it are Zoology, Botany, Geology, and (in the case of Moderatorships) Physiology and Comparative Anatomy.
163. A Student is free to devote himself to Science alone from the end of his second year, and the first year is allowed to be accounted, by passing an Entrance Examination held near the end of the third Term, and one First-year Examination held at the beginning of the first Term of the following academical year, a Science Student may be free from the obligation to study Classics (after) little more than a year from entrance; and, supposing he takes his Degree of Bachelor of Arts at the usual time, he has then two years left of his Undergraduate Course, which he may devote to the Study of Science.
164. At each Term Examination, there are Examinations for those Students who are qualified to become Candidates for Honours in the several Departments of Undergraduate Studies in that class. The Honours Courses are as follows:—(1.) Junior Freshmen; Mathematics; Classics. (2.) Senior Freshmen; Mathematics; Classics; Logic. (3.) Junior Sophisters; Mathematical Physics; Classics; Metaphysics; Experimental Science; Natural Science; Modern History; Modern Literature. (4.) Senior Sophisters; Mathematical Physics; Classics; Ethics; Experimental Science; Natural Science; History and Political Science; Modern Literature.
165. At the Examination for the Bachelor of Arts Degree, which is held in the Michaelmas Term of the fourth year, examinations are held for Special Honours called Moderatorships. There are seven Courses in which Moderatorships may be obtained; namely, 1. Mathematics and Mathematical Physics; 2. Classics; 3. Mental and Moral Philosophy; 4. Experimental Science; 5. Natural Science; 6. History and Political Science; 7. Modern Literature. In each subject the Moderators are arranged in two Divisions, Senior and Junior, according to merit.
166. There are four Professional Schools recognized by the University; namely, Divinity, Law, Medicine and Surgery, and Engineering. Degrees are granted in those several Faculties, but only after the Preliminary Degree of Bachelor of Arts has been obtained. Professional Students follow the usual Arts Course for the first two years, after which they are at liberty to commence their Professional Studies. If they do so, they are excused a portion of the Arts Course, for which they may substitute more strictly Professional Studies. The Professional Studies occupy two years at the least.
- THE EXHIBITIONS, SCHOLARSHIPS, AND STUDENTSHIPS.
167. It has been already mentioned that Sizarships are obtainable at Entrance. These, however, being designed to assist the poorer class of Students, and being restricted to those whose parents or guardians are of limited means, do not fall under the head of emoluments awarded purely according to merit.
168. In 1870 it was resolved by the Board that 20 Exhibitions, of the value of 25*l.* a year each, and tenable for two years, should be awarded annually, provided sufficient merit were shown by the Candidates. Of these Exhibitions 12, which are called Junior Exhibitions, are offered for competition to Students of the first year, and the remaining 8, which are called Senior Exhibitions, are obtainable at the close of the second year.
169. The Junior Exhibitions are awarded according to the result of an Examination held in Classics and other Literary Subjects, and, in Mathematics as far as Elementary Trigonometry.

170. The Senior Exhibitions are awarded according to the marks obtained partly in a Special Examination in subjects similar to the above, and in Logic and Locke; partly in the Prize Examinations in Mathematics, Classics, Logics, and English Literature and Composition.

171. There are 70 Foundation Scholarships, tenable from the time of election till the holder is of M.A. standing. The Scholars are of two classes, elected for Scientific and for Classical Merit respectively. Candidates for Science Scholarships are examined in Pure and Applied Mathematics, together with a certain amount of Logic and Metaphysics. The value attached to the several branches in the Examination is expressed by the following numbers: Pure Mathematics, 250; Applied Mathematics, 250; Logic and Metaphysics, 100. Candidates for these Scholarships are at liberty to substitute the course in Experimental Physics of the Junior Sophister year for the course in Logic.

172. There are also seven Scholarships of Private Foundation, for subjects not connected with Science, and 30 Scholarships founded by the Commissioners of Education in Ireland for Students from the Royal Schools of Armagh, Dungannon, Enniskillen, or Cavan. These latter are awarded for general proficiency in a course comprising Classics, English Language and Literature, Modern Languages, and Science. The number of marks assigned to Scientific Subjects is 100 out of 450. The principal Scientific Subject is Pure Mathematics as far as Plane Trigonometry. The Examination includes, however, Physical, as well as Descriptive Geography.

173. By a Royal Statute of 22 Victoria, 14 Studentships were founded in Trinity College open to candidates of all religious denominations to be tenable for a period not exceeding seven years, with a salary to be fixed by the Provost and Senior Fellows, not exceeding 100*l.* a year. Two Students are elected every year according to the results of the Moderatorship Examinations. The award is decided by the aggregate merit in two Courses, one Primary and one Secondary, which bear credit as 3 to 2. The Primary Course may be one of the two—Mathematics and Physics, or Classics. The Secondary Course may be either the remaining one of those two, or any other of the Moderatorship Courses.

THE PROVOSTSHIP AND THE FELLOWSHIPS

174. The Provost, who is the Resident Head of the College, is appointed by the Crown. Besides presiding over the whole College, he is, in common with the Senior Fellows, responsible for the Examinations which devolve on the Board.

175. There are 33 Fellowships, which are tenable for life, irrespective of the restriction of celibacy, and are now open to all without distinction of creed. These are divided into 7 Senior and 26 Junior. The Senior Fellowships are filled by co-optation from the Junior; the Junior, by an annual election in case there be a vacancy. The average number of vacancies has latterly been hardly more than one per annum.

176. The Fellowships are awarded in accordance with the results of a Special Examination extending over a wide range of subjects comprised in four principal courses, the relative importance of which is approximately determined by numbers representing the maximum obtainable by the highest possible answering in the several courses. These numbers are as follows:

Mathematics, Pure and Applied	-	-	-	-	-	1,000
Experimental Science	-	-	-	-	-	300
Classics	-	-	-	-	800	900
Hebrew and Cognate Languages	-	-	-	-	100	
Mental and Moral Science	-	-	-	-	500	

177. It will be seen that Classics and Mathematics rank considerably above any other course. Mr. Jellett says in his evidence, "If a student's object is to obtain a Fellowship, he must, practically speaking, be either a good mathematician or a good classical scholar. I think that a man who is neither a good mathematician nor a good classical scholar would have a very slight chance indeed of obtaining a Fellowship." Qu. 12,750.

178. The award being made strictly in accordance with the result of an examination, there is no provision for taking account of Original Research in the estimate of the merit of a candidate. Mr. Jellett observes on this point: "The thing I know has been talked of several times, but we never could see a practical way of carrying out such a thing." Qu. 12,759.

179. It is understood that the emoluments of a Senior Fellowship in Trinity College, Dublin, are much greater than at Oxford or Cambridge. As regards the Junior Fellows, their income is, to a great extent, dependent upon their being all engaged in College work. Mr. Jellett says, "All our Fellows are engaged in teaching. We have no Fellowships of the nature that they have at Oxford and Cambridge; they are more" Qu. 12,754.

"of the nature of prizes. We take a man's life, and we require him to give his life to it."

180. Formerly, there was a certain number of Non-Tutorial Junior Fellowships, but now all the Junior Fellows have to give lectures, whether they be Professors or not. As the staff is large, and the lectures of the Fellows naturally harmonise with their own pursuits they, or, at least, many of them, have a good deal of leisure, and have, therefore, an opportunity of engaging in Original Research, which is by no means neglected.

181. A Junior Fellow may look forward to succeeding in time to the seniority. The Senior Fellows are exempt from the duty of lecturing, but, with the Provost, form a Board to which, within the limits prescribed by the Statutes, or by any Regulation made by the Senate at large, is entrusted the General Management of the University. On this Board devolves also the Duty of Examining for Fellowships, Scholarships, and Sizarships; but it is at liberty to avail itself of the aid of Assistant Examiners chosen from among the Professors or Junior Fellows. Such, at least, were the rules prior to the Establishment of the New Council.

#### THE PROFESSORIATE.

182. Most of the Professorships in the University of Dublin, which are of ancient foundation, were established to promote the study of Divinity or Literature, but several have of recent years been founded in various branches of Science, and the University possesses the power of establishing additional Professorships as they may seem to be required. The following is a list of the Scientific Professorships at present existing, including therein those which refer to Professional Studies of a Scientific Nature:—

Designation of Professor.	Foundation of Professorship.
Regius Professor of Physic	1761
Lord Donegal's Lecturer in Mathematics,* about	1660
Astronomer Royal of Ireland	1791
Erasmus Smith's Professor of Natural and Experimental Philosophy	1724
Erasmus Smith's Professor of Mathematics	1762
University Professor of Natural Philosophy	1847
Regius Professor of Surgery	1852
Professor of Anatomy and Surgery	1785
Professor of Chemistry	1785
Professor of Botany	1735
Professor of Surgery	1849
University Anatomist	1873
Professor of Comparative Anatomy	1872
Professor of Zoology	1871
Professor Extraordinary of Civil Engineering	1842
Professor of Geology	1844
Professor of Applied Chemistry	1844
Professor of Mineralogy	1845
Professor of Civil Engineering	1852

These Professors are appointed by "Trinity College, but belong to "the School of Physic in Ireland," which is a Medical School formed by an amalgamation of the Schools of Trinity College and of the College of Physicians. It was constituted by the Statute of 10th Geo. III. c. 84. and brought into its present form by the Statute of 30th Vict. c. 9.

#### THE COUNCIL.

183. Prior to the issue of Letters Patent, dated the 4th of November 1874, the Board, formed of the Provost and Senior Fellows, was the sole Governing Body of the College and, practically, to a considerable extent, of the University. To it was committed the regulation of the Studies, Lectures, and Examinations preliminary to obtaining Degrees in

\* This Lectureship is now held by the Assistant to Erasmus Smith's Professor of Mathematics.

Arts or Faculties in the University, and the appointment and election of Professors. But by the Letters above mentioned, a Council has been established to co-operate and have a share in the Regulation of the Studies, Lectures, and Examinations of the College, and in the Appointment and Election of Professors, and the Regulation of the tenure of office and of the duties of such Professors.

184. The Council consists of seventeen members, the Provost (or in his absence the Vice-Provost) being *ex officio* Member and Chairman, and the remaining sixteen being elected out of the Members of the Senate, or Public Congregation of the University, four by the Senior Fellows, four by the Junior Fellows, four by the Professors who are not Fellows, and four by those Members of the Senate who have not voted, nor been entitled to vote, at the last Election of any existing Member of the Council, either as Senior Fellows, as Junior Fellows, or as Professors.

185. The Council has the nomination to all Bursarships, except those the nomination to which is provided for by Act of Parliament, or by the Directions of Private Founders.

186. The nomination of the Council is subject to the approval of the Board, except in the case of Bursarships in the School of Divinity. If the Board should refuse to approve a nomination of the Council, the decision rests with the Chancellor.

187. It is also provided, with certain exceptions, that any new Rules or Regulations, and any alterations in existing Regulations respecting Studies, Lectures, and Examinations, or respecting the qualifications, duties, and tenure of office of any Professor, shall require the approval both of the Board and of the Council.

#### MUSEUMS AND OTHER SCIENTIFIC INSTITUTIONS.

188. The following Museums are used for the purposes of Practical Instruction in Trinity College: the Museum of Natural Philosophy; the Museum of Zoology and Archæology; the Museum of Geology and Mineralogy; the Museum of Engineering Models; the Museum of Anatomy, Materia Medica, and Midwifery; the Museum of Botany. In connexion with the last must be mentioned the College Botanic Garden, which is situated about a mile from the College, and contains eight acres of ground.

189. About 20 years ago the College erected a handsome and commodious building in the College Park to contain their collections, and to provide working rooms for the Students.

Trinity College has three Chemical Laboratories. The first of these is intended for the use of the Professor and for Original Research. The second, or Student's Laboratory, is entirely devoted to Students who are learning Chemistry as a Practical Science. It is capable of accommodating 56 Students. The third Laboratory is attached to the Lecture Theatre in Applied Chemistry, and belongs more especially to the Engineering School.

190. The University possesses an Astronomical Observatory, which is available for the Instruction of Students. The Professor of Astronomy has charge of the Observatory, and is the Royal Astronomer of Ireland. This Office was founded in 1783, and since that date has been held by such distinguished men as Dr. Brinkley, Sir William Rowan Hamilton, and Dr. Brünnow.

Professor Jellett informs us that "The Astronomical Observatory has lately received large additions and improvements. The large object glass presented to Trinity College by Sir James South has been mounted as an Equatorial in an Observatory specially constructed to receive it, and a new Meridian Circle, with all the modern improvements, and carrying a telescope of six inches aperture and eight feet focal length, has been ordered from Messrs. Pistor and Martin, of Berlin, and is expected to be completed in the course of the next month."

Minutes of Evidence, Vol. II., Appendix V., p. 17.

There is also an Observatory, "erected for the special purpose of Observations in Meteorology and Terrestrial Magnetism. In this Observatory an elaborate series of Observations at stated hours has been carried on during a lengthened period; and the Results of these Observations for the first eleven years have been recently published in two quarto volumes."

Minutes of Evidence, Vol. II., Appendix V., p. 17.

191. There is at present no Laboratory specially appropriated to Physics. The University Authorities appear to be fully conscious of this defect in their Scientific Arrangements, and the erection of a Physical Laboratory on an extended scale is in contemplation.

#### GENERAL REMARKS.

192. In Trinity College, Dublin, as in the old English Universities, the prospect of obtaining a Fellowship furnishes the highest class of Students with a powerful motive

for exertion, and the studies for proficiency in which Fellowships are usually awarded accordingly attract special attention. The proportion of Students who are directly influenced by such considerations must, however, be considerably smaller at Trinity College, Dublin, than at Oxford or Cambridge. For not only are the Fellowships much less numerous, in proportion to the number of Students, than at the English Universities, but, inasmuch as they are tenable for life, irrespective of marriage, the succession is slower; nor could this state of things be changed without an entire remodelling of the System of Fellowships, which we do not think desirable. The great mass of Students, and even of the more promising Students, must, therefore, soon perceive that they have no chance of obtaining a Fellowship.

193. Accordingly, any alteration in the studies which have a predominant influence in the award of Fellowships would, at least in its direct influence, affect only a much smaller number of Students than at Oxford or Cambridge. Indirectly, no doubt, such change would not be without influence, for the fact that the most powerful minds are turned towards particular studies by preference, must tend to commend those studies to the great mass of the Students.

194. The rarity of vacancies renders it exceedingly difficult to reward by election to a Fellowship proficiency in any one of a variety of branches of study. There is probably but one Fellowship to be bestowed in a year, and if one or two great branches of study are selected as exercising a predominant influence, highly qualified candidates are sure to present themselves; and it would be a matter of extreme difficulty to compare first-rate claims in three or four different great branches of study.

195. We think, however, that it would be very desirable that in the election to Fellowships important Original Research should be regarded as a substantial Element of Merit; and we believe that if this were done, it would be possible, without lowering the Standard of the Examination, to enlarge the Range of the Scientific Subjects included in it. We have already mentioned that the subject has not been overlooked by the University Authorities, though hitherto no practical method of dealing with it has presented itself.

196. From their Tenure and the Conditions of their Award, one object for which the Studentships are designed would seem to be, to assist those who are reading for Fellowships. The subjects, therefore, for which they are chiefly awarded naturally, agree with those which enter into the Examination for Fellowships.

197. The number of Foundation Scholarships, however, annually awarded is much greater, and there appears to be no reason why they should all follow in the line of the Fellowship Examination, and be either mainly for Pure and Applied Mathematics, or else mainly for Classics. We think that some Foundation Scholarships might well be assigned as a reward for eminent proficiency in Physical or Biological Science,

#### IV.—The Queen's University in Ireland.

##### FOUNDATION AND ADMINISTRATION.

198. The Queen's University in Ireland was founded by Royal Charter, dated the 3rd of September, 1850. A Supplementary Charter was granted on the 17th of July, 1851; but, subsequently, both these Charters were revoked, and a New Charter was granted on the 8th of October, 1864, under which the University is at present constituted.

199. The circumstances which led to the Foundation of the Queen's University are well known, and need not be referred to here. They are sufficiently indicated by the Provisions which prohibit the University from imposing any Religious Test, from Granting any Distinction whatever or any Degree in Theology, or even from admitting any person to a Theological Examination.

200. The General Legislation, Government, and Administration of the University under the Charter, and in cases not provided for by it, are vested in the Senate of the University. The Senate consists of nineteen persons nominated, in the first instance, by the Crown, and holding their offices at the will and pleasure of the Crown. As vacancies arise, the Charter provides that every alternate vacancy shall be filled by the Convocation of the University until six places in all have been so filled up. The Senators elected by Convocation are to be elected from the Members of Convocation not holding office in any of the Colleges of the University, and each Senator so elected holds office for three years from the date of his election, or during the will and pleasure of the Crown. Outgoing Senators may be re-elected.

201. The Convocation of the University consists of the Chancellor, Senators, Secretary, Professors, and Registered Graduates of the University for the time being; all Graduates of two years' standing being entitled to register. The Powers of Convocation, besides that, already referred to, of appointing six Senators, are extremely limited. They have, however, the right of discussing any matter whatsoever relating to the University, and of declaring the opinion of Convocation thereon; due notice being given, a week previously, of any such discussion. But it is expressly provided that Convocation shall not be entitled to interfere in, or to have any control over, the affairs of the University.

202. The principal duty of the Senate is to make Byelaws and Regulations touching the Examinations and Qualifications for Degrees, and other University Distinctions; such Byelaws have, however, to be submitted to the Lord-Lieutenant, and to be approved of by him.

203. The three Queen's Colleges at Belfast, Cork, and Galway were founded at the same time as the Queen's University, and are declared in its Charter to be Colleges of the University. The Presidents of the three Colleges are, *ex officio*, Members of the Senate. Each of the Colleges has a Charter of its own, and, in all matters of internal government, is independent of the others, and of the University. The Governing Body of each College consists of a President, and of a Council composed of six Professors elected by the Professors of the College.

##### COURSE OF STUDY AND THE EXAMINATIONS.

204. In its general outlines the Course of Study in the Colleges is regulated by the Byelaws of the Senate, which determine the character of the University Examinations, but the manner in which the Students are to be prepared for these Examinations is left entirely to be arranged by each College. The Degrees of the University are granted only to Students who have resided and have gone through a Course of Instruction in one of the three Colleges. The Medical Degrees form, to a certain extent, an exception, as only one year of study in a Queen's College is required from a Candidate for a Medical Degree, and the remainder of his instruction may be obtained in any other Medical School. The Professors in the three Colleges have, by Charter, the *status* of Professors of the Queen's University, and conduct the University Examinations in that capacity; although they lecture only in their capacity as College Professors. Thus, the Examinations are under the immediate control of the University, but the Teaching in the Colleges is so only indirectly. (Nevertheless, Sir Robert Kane contends that the Queen's University "may be regarded quite as much as the University of Edinburgh, or the



Qu. 13,205. "University of Oxford or of Cambridge, to be strictly and properly a Teaching University." "We attach," he adds, "some importance to that question" . . . . .  
 "The Colleges are Colleges of the University, not, as in the London University, where the Degrees are given to any person who presents himself, and who chooses to pass through certain Examinations, without reference to whether he has ever gone through any really Educational Course in a Collegiate Institution or not."

205. The Queen's University grants Degrees in Arts, in Law, in Medicine, and, besides, the Degree of Bachelor in Engineering. For the Degree of Bachelor in Arts, the Student has to pass two University Examinations, called, respectively, the First University Examination in Arts and the Degree Examination in Arts. The Pass Examination in the First University Examination in Arts includes Greek, Latin, a Modern Continental Language, and Mathematics and Mathematical Physics. For the Degree Examination in Arts, the Student has to select a certain number of subjects from a list prescribed by the Senate. The Degree of Bachelor of Arts is attainable without any knowledge of Science beyond that included in the Course of Mathematical Physics, which comprises Mechanics, Hydrostatics, Optics, and Elementary Astronomy, as treated in very elementary works.

Qu. 13,208. 206. In addition to these Examinations, each College imposes a Matriculation or Entrance Examination, and Sessional or Class Examinations. No Student who does not pass the Matriculation Examination is admitted to the College, and no Student who does not pass the Sessional Examination or a Supplemental Examination, which is held to provide for cases of failure in the Sessional Examination, is allowed to count his Session, but is obliged to go through the course of study of that year over again. It is stated, in the Evidence, that the Sessional Examinations for promotion are conducted very strictly, so that, for example, in the Examination held in Cork at the close of the Session of 1870-1, in the Faculty of Arts, out of a total of 50 Students, 23 were promoted and 27 were not promoted. . . . . In the Faculty of Law there were nine Students, of whom five were promoted and four were not promoted. In the Faculty of Engineering, out of 30 Students, 14 were promoted and 16 were not promoted; so that of 89 Students, 42 were promoted and 47 were not promoted; but a large number of that 47 would get in in October, by means of the Supplemental Examination."

Qu. 13,207. The University Examinations are all held in Dublin. Formerly they used to be conducted in the Colleges, although by the University Professors, and on papers sent down from the University; but it has been now arranged by the Senate that even at the First University Examination all the Students must be examined in Dublin. This, it is stated, has been found more conducive to the proper conduct of the Examinations, and to the convenience of the Students themselves. The Standard of the University Examinations is said to be fully as high as the Standard in Trinity College, Dublin.

Qu. 13,214. 207. So far as the Degrees in Arts, Law, and Engineering are concerned, the Examining Body is entirely composed of the Professors, acting not as College Professors, but as University Professors. "The three Professors in each branch of Science or Letters, for instance, the three Professors of Chemistry, or the three Professors of Mathematics, form a Board of Examiners, and the Examination Papers are prepared in common, a portion of the papers being prepared by each Professor. Then the Students are examined on those papers, and the value of the answers is judged by the Professors conjointly acting together." With regard to the Medical Degrees, those parts of the Examination which refer to Practical Medical Subjects are conducted by outsiders.

Qu. 13,215. "The University Senate reserve to themselves the power of appointing any Examiners that they wish, and, generally speaking, they appoint some of the most eminent Dublin men from the Dublin Medical Schools to examine. They consider that they probably get a somewhat higher class of Medical Practitioners from Dublin than they could get from merely provincial towns, and also remove the suspicion of partiality in the Professors examining their own pupils."

#### SCHOLARSHIPS.

208. In each of the Colleges there are forty-six Junior Scholarships—thirty of the value of 24*l.* each, for Students pursuing the Course prescribed for the Degree of A.B.; eight of the value of 25*l.*, for Students pursuing the Course prescribed for the Degree of M.D.; three of the value of 20*l.*, for Students in Law; and five of 20*l.*, for Students of Civil Engineering. The Junior Scholarships are awarded annually, by a General Examination, and are tenable for one year only, with the exception of those awarded to Students in Arts of the second year, which are tenable for two years. The Scholars of any year are not disqualified from being candidates for Scholarships the succeeding year. There are also in each College eight Senior Scholarships, of the value of 40*l.* a year, of which

one is given each year to Greek and Latin, one to Modern Languages and Modern History, one to Mathematics, one to Natural Philosophy, one to Metaphysical and Economical Sciences, one to Chemistry, one to Natural History, and one to Law. All Graduates in Arts of the Queen's University are eligible to the Senior Scholarships; these Scholarships are awarded by examination, and are tenable for one year only, the Scholar not being re-eligible. Certain duties are imposed both upon the Junior and the Senior Scholars, the Senior Scholars in particular being required to assist the Professors in the Matriculation and Class Examinations, and in conducting the business of the special Departments of Literature and Science to which their Scholarships severally belong. They are also required to pursue, under the superintendence of a Professor, an Advanced Course of Study in one or more of the branches in which they have been examined for the Scholarship. If no candidate of sufficient merit presents himself, the Scholarship (whether Senior or Junior) is not filled up. During the five years, from 1866-67 to 1871-72, "in Qu. 13,209. " the Faculty of Arts the total number of Scholarships available was 185, that is, including " both Senior and Junior Scholarships taken altogether, and the number awarded was " 129, or 69½ per cent. In the Faculty of Arts there were, thus, only seven-tenths of the " Scholarships conferred. In the Faculty of Medicine, out of 40 Scholarships available, " in the five years, there were 35 conferred. In the Faculty of Engineering, out of 25 " available, 22 were conferred; and in the Faculty of Law, out of 20 that were available, " 19 were conferred; and the total result was, out of 270 Scholarships, 205\* were given, " or it may be taken as 76 per cent. of the Scholarships. Those 270 Scholarships, in " the five years, were competed for by 1,190 Students, which gives an average of about " five Students competing for each Scholarship." It is unquestionable that young men of ability are attracted to the Queen's Colleges by the probability of obtaining these Scholarships, and we may infer from the Evidence that the Standard of Instruction in the Colleges would be much lower if it were not for the presence of this class of Scholars. Thus, Professor Purser states, " My principal difficulty arises from the widely different Qu. 13,256. " degrees of progress Students have made before they enter College. We grant, in " Queen's College, Belfast, Scholarships to Students at entrance, and half of them are " given for attainments in Pure Mathematics. These are very eagerly competed for, and " consequently we find a contingent of the Students come up well prepared. On the " other hand, the greater number of the Students in Arts know but the first elements " of Mathematics."

209. Besides the Junior and Senior Scholarships, to which reference has just been made, a certain number of Exhibitions and of Prizes has been established in the Queen's University with funds raised by a public subscription originated by Sir Robert Peel in 1861. In the Faculty of Arts there have thus been provided three Exhibitions of 20*l.*, three of 15*l.*, and two of 10*l.*, all tenable for three years. In the Faculty of Medicine, and also in the School of Engineering, there are each year two exhibitions, one of the total value of 40*l.*, the other of 30*l.* All these Exhibitions are given away, in accordance with the Results of the University Examinations, to Students who satisfy certain conditions as to standing, &c. Some of the Exhibitions are assigned in equal proportions to the three Colleges; the remainder are competed for by Students in any one of the three. They have not been established in perpetuity, but only for a period of 10 years. A fund, however, amounting, at present, to 3,408*l.* is being raised with a view to the future continuance of the endowment.

## NUMBER OF STUDENTS.

210. The Number and Distribution of Students under Instruction in the Queen's Colleges in Ireland in the Session 1873-74, was as follows:— Appendix VII., p. 74.

	Belfast.	Cork.	Galway.
In the Faculty of Arts - - -	118	64	55
"    Law - - - -	26	7	9
"    Medicine - - -	205	170	83
School of Engineering - - -	20	19	10
Not pursuing any special Course or Faculty	13	—	8
	382	260	165
Attending two Faculties - - -	7	10	9
Total Number of separate Students -	375	250	156

Appendix  
VII, p. 74.

211. The Number of Students in the Session 1874-75, was as follows:—

	Matriculated.	Non-Matriculated.	Total.
Belfast	345	47	392
Cork	226	23	249
Galway	148	6	154

Qu. 13,302.

212. At the Queen's College, Belfast, the number of Arts Students showed a tendency to diminish during the eight or ten years preceding 1872-73. Two causes are assigned for this falling off by Professor Purser: (1), "that the number of Candidates for the Presbyterian Ministry has of late years diminished," whereas such Candidates usually took the Arts Course in the Queen's College before entering the Presbyterian Theological College, and (2), that during a period of commercial prosperity, there is an inducement to prepare young men for trade and business rather than for a profession. A decided increase is shown by the Returns for 1873-74, and 1874-75.

Appendix  
VII, p. 74.

#### THE SCIENTIFIC CHAIRS.

213. The following are the Professorships of Science in each of the Queen's Colleges:—Mathematics, Natural Philosophy, Chemistry, Natural History, Civil Engineering, Geology and Mineralogy, Anatomy and Physiology. In Belfast, there is a Professor of Agriculture, and, on the other hand, the Professorship of Natural History is united with the Professorship of Geology and Mineralogy.

214. The stipends of the Professors are partly derived from a fixed salary and partly from the fees of the Students. The fixed salaries vary from 150*l.*, in the case of the Medical Professors, to 330*l.* in the case of the Professors of subjects included in the Arts Course.

#### APPLIANCES FOR TEACHING.

215. With regard to the appliances for teaching, the Evidence tends to show that they are in some respects insufficient. Each College receives 7,000*l.* a year from the Consolidated Fund, but this amount is entirely appropriated to the payment of the stipends of the Professors and of the other Officers of the College. In addition to this, there is an annual Parliamentary Grant of 1,000*l.* a year to each of the Colleges at Cork and Galway, and of 1,374*l.* to the College of Belfast, out of which the whole of the establishment expenses of the Colleges, and any augmentations of the Museums, Libraries, or Collections of Apparatus have to be provided. The annual grant was originally 1,600*l.* a year, but it was reduced to the present amount about ten years ago, when the inadequacy of the Professorial Salaries was brought under the notice of the Government. The salaries were augmented, but the funds required for the augmentation were obtained by trenching on the only resources available for the supply of apparatus and books.

Qu. 13,307.

216. With regard to Belfast, it is stated that the apparatus in the Laboratory of the Professor of Chemistry, if fully maintained, would be sufficient for the Practical Instruction of the Students, but that to maintain it properly with the present funds of the

Qu. 13,304.  
-6,

College is hardly possible. It may be mentioned that at Belfast a fee of 3*l.* is charged to those Medical Students who attend a Summer Course in Practical Chemistry. But the Students who go through a more extensive course of training in the Chemical Laboratory are elected by Examination, and are admitted gratuitously by Professor Andrews, who not only himself pays the salaries of the Assistants, but also provides gratuitous instruction to such Laboratory Students. The apparatus at the disposal of the

Qu. 13,308.

Qu. 13,329.

Qu. 13,330.

Professor of Natural Philosophy is described as decidedly inadequate. Professor Cunningham, who holds the united Professorships of Natural History and Geology and Mineralogy, says that there is "a museum in which the Geology and the Zoology are best represented, upon the whole, but we have a very fair Herbarium of British Plants, and there is the Botanical Garden belonging to the town, which allows us specimens of plants during my course, on payment of a certain sum by the College to the Garden." The Professor has no Assistant, and his share of the annual grant of 1,000*l.* is about 50*l.* or 60*l.* The Senior Scholars who are required to assist the Professors are not found to supply adequately the place of regular Assistants. Professor Cunningham says, "I have

Qu. 13,340.

"a Senior Scholar, who is appointed annually in my Department, and he is supposed to

“ give me some help when I call upon him to do so in connexion with other duties. . . . If he is a very good man, I may occasionally get a little help from him in the Museum, but nothing very essential.” And Professor Purser states that it is “ exceedingly difficult for the Professor to teach all [the, Mathematical Students] at the same time. I and my predecessors have endeavoured to meet this difficulty; to a certain extent, by making use of the Senior Mathematical Scholar, a Graduate who has been elected to a Scholarship for one year after taking his Degree. I have derived in this way much valuable aid from the Senior Scholars, but such aid is quite insufficient, and a regular and permanent Assistant to my chair is most urgently needed, to render the training in the Mathematical School thoroughly efficient.” Nor are the services of the Senior Scholars always ready at the disposal of the Professor. . . . “ In many cases the Senior Scholars are studying for a Profession or some Civil Service Appointment, and it becomes very irksome to them to have their time drawn upon to any large extent, and the College feel a difficulty in doing so.”

Qu. 13,256.

Qu. 13,257.

217. In Cork similar deficiencies exist. Sir Robert Kane states that of the grant of 1,000*l.* annually voted by the House of Commons (to which must be added about 100*l.* derived from fees paid by the Students to the College), no less than 550*l.* were absorbed by the Establishment and Administration Expenses of the College in the year ending the 31st of March 1872, leaving for the whole of the Scientific and Literary Departments only about 500*l.* This is a sum which must be regarded as totally insufficient, when it is considered that there are four Literary Departments to be conducted, and Collections of Books to be kept up in a satisfactory state, besides the several Scientific Departments! Sir Robert Kane adds, “ we have done our best with the funds that were at our disposal for providing apparatus and illustrations of all kinds, but we have been obliged to do it with such parsimony, I may say, that we are possessed only of the material that is absolutely indispensable for anything like proper teaching.” . . . . “ We have no means whatever at our disposal for advancing Science. All that by any possibility we can pretend to do, is, so far as our means allow, to represent to the Students the actual condition of Science, but we have no means whatsoever by which we could pretend to advance it.” At Cork, however, the Departments of the Natural History Museum are described, with one exception, as being in a tolerably satisfactory condition. There has been formed in the grounds of the College “ a small garden containing such plants as are useful in illustrating Lectures on Botany and on Materia Medica in the Medical School, as will grow in the open air in these countries, but we have no conservatories. We have had no funds available for the purpose, and the Government has never conceded to us the means of erecting a stove house, in which we could have a collection of such Tropical or Sub-Tropical Forms as would render our illustrations of living plants more complete. \* \* \* \* That is, I think, almost the only point in which our means of illustration in Natural History, or at least in Botany, is defective.”

Qu. 13,226.

Qu. 13,227.

Qu. 13,202.

218. In Galway the Chemical Laboratory is described as adequate, and the Museum of Natural History is tolerably well supplied with Zoological and Botanical Specimens, and with Diagrams. “ The Geological Museum is well supplied with fossils, which are ranged stratigraphically; there is a very good supply of rocks, both native and foreign, and of course Irish; and there is a very good supply of models of crystals, along with diagrams and geological maps and sections, that are used for lecturing purposes.” There is no Practical Instruction in Physics.

Qu. 13,155.

### Conclusion and Recommendations with regard to the Queen's University in Ireland.

219. In Founding the Queen's Colleges, the State did not adopt the Principle of Assisting and Stimulating Local Efforts, and if we except the Exhibitions and Prizes, to which reference has been already made, as having been provided by public subscription, and a few other Exhibitions which have been founded at Belfast, no voluntary contributions have been received by them. They are Institutions for which the State has made itself responsible, and in which, as part of an University System, a complete Scientific Training is implied.

220. As we think it of great importance that the sanction of the State should not be given to the Teaching of Science on a scale inadequate to ensure its efficiency, we recommend;

- I. That an increased Annual Grant be made to the Queen's Colleges for the purpose of providing Assistants, Apparatus, and the other necessary Appliances of Practical Scientific Teaching.

We further recommend :

- II. That the Professorship of Natural History in the Queen's College, Belfast, be separated from that of Geology and Mineralogy.

All of which we humbly beg leave to submit for Your Majesty's gracious consideration.

(Signed) DEVONSHIRE.  
LANSDOWNE.  
JOHN LUBBOCK.  
JAMES P. KAY-SHUTTLEWORTH.  
BERNHARD SAMUELSON  
W SHARPEY.  
THOMAS H. HUXLEY.  
G. G. STOKES.  
HENRY J. S. SMITH.

J. NORMAN LOCKYER,  
*Secretary.*

June 18th, 1875.

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**APPENDICES.**

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# APPENDIX TO SEVENTH REPORT.

## APPENDIX I.

### PAPERS RELATING TO THE UNIVERSITY OF LONDON.

para. 3. I.—CORRESPONDENCE relating to the FEES received in the FINANCIAL YEAR 1874-75.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, London, S W.  
June 19, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to furnish, for the information of the Commissioners, a statement of the amount of the fees received by the University of London, and paid into the Exchequer, in the financial year 1874-75.

I have, &c.,  
J NORMAN LOCKYER,  
Secretary

University of London, Burlington Gardens, W.,  
June 22, 1875

SIR, IN reply to your letter of the 19th inst, I beg to inform you that the fees received by the University of London, and paid into the Exchequer, in the financial year 1874-75, amounted to 4,202l 10s 10d.

I am, &c.,  
WILLIAM B. CARPENTER,  
Registrar.

Norman Lockyer, Esq., F R S.

para. 3. II.—EXTRACTS from the CIVIL SERVICE ESTIMATES for the FINANCIAL YEAR 1875-76.

SALARIES AND WAGES -	2,728
EXAMINERS -	5,180
EXHIBITIONS, SCHOLARSHIPS, &c. -	1,665
LAW EXPENSES -	20
INCIDENTAL EXPENSES -	475
	10,068

The Extra Receipts for 1875-76 are estimated at 4,000l

#### DETAILS of the above

<b>A.—SALARIES AND WAGES</b>	
Registrar -	1,000
Assistant Registrar and Librarian -	500
Clerk to the Senate -	321
Supplemental Clerk -	113
Occasional Assistance in the Office -	40
Clerk of Convocation -	200
Office-keeper -	120
Porter -	60
Housekeeper -	75
Messenger and Printer -	104
Messenger and Library Assistant -	94
Assistant Messenger -	24
Housemaid -	39
Assistant Housemaid -	13
Additional Attendance during Examinations and Meetings of Convocation -	25
Total for Salaries, &c	2,728

<b>B.—EXAMINERS</b>	
Two in Classics, 200l each -	400
Two Assistant Examiners in Classics, 50l each -	100
Two in Mathematics and Natural Philosophy, 200l each -	400
Two Assistant Examiners in Mathematics, 50l each -	100
Two in Chemistry, 175l each -	350
Two Assistant Examiners in Chemistry, 30l each -	60
Two in Experimental Philosophy, 100l each -	200
Two Assistant Examiners in Experimental Philosophy, 25l each -	50

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Two in Botany, 75l each -	150
Two in Geology and Palaeontology 75l each -	150
Two in English Language and Literature, 120l each -	240
Two Assistant Examiners in English, 50l each -	100
Two in Logic and Moral Philosophy, 80l each -	160
Two in Political Economy, 30l each -	60
Two in the Text of Scripture, and Scripture History, 50l each -	100
Two in the French Language, 100l each -	200
Two Assistant Examiners in French, at 25l each -	50
Two in the German Language 30l each -	60
Two in Jurisprudence, Roman Law, International Law, and the Principles of Legislation, 100l each -	200
Two in Equity and Real Property Law, 50l each -	100
Two in Common Law, and Law and Principles of Evidence, 50l each -	100
Two in Constitutional History, 25l each -	50
Two in Medicine, 150l each -	300
Two in Surgery, 150l each -	300
Two in Anatomy, 100l each -	200
Two in Physiology, Comparative Anatomy, and Zoology, 150l each -	300
Two in Obstetric Medicine, 75l each -	150
Two in Materia Medica and Pharmacy, 75l each -	150
Two in Forensic Medicine, 50l each -	100
Contingent Examiners -	300
Total for Examiners	5,180

#### C.—EXHIBITIONS, SCHOLARSHIPS, PRIZES, AND MEDALS

##### Exhibitions at Matriculation

One in June 1873, 30l per annum, two quarters -	15 0
One in June " 20l " " " -	10 0
One in June " 15l " " " -	7 10
One in Jan 1874, 30l " " year -	30 0
One in Jan " 20l " " " -	20 0
One in Jan " 15l " " " -	15 0
One in June " 30l " " " -	30 0
One in June " 20l " " " -	20 0
One in June " 15l " " " -	15 0
One in Jan. 1875, 30l " " " -	30 0
One in Jan. " 20l " " " -	20 0
One in Jan " 15l " " " -	15 0
One in June " 30l " " two quarters -	15 0
One in June " 20l " " " -	10 0
One in June " 15l " " " -	7 10

##### Exhibitions at First B.A. Examination.

One in 1873, 30l per annum, two quarters -	15 0
One in 1874, 40l " " year -	40 0
One in 1874, 30l " " " -	30 0
One in 1875, 40l " " two quarters -	20 0
One in 1875, 30l " " " -	15 0

##### Exhibitions at First B.A. and First B. Sc. Examinations.

One in 1873, 40l per annum, two quarters -	20 0
One in 1874, 40l " " year -	40 0
One in 1875, 40l " " two quarters -	20 0

##### Exhibitions at First B Sc and Preliminary Scientific M B. Examinations.

Two in 1873, 40l per annum each, two quarters -	40 0
One in 1874, 40l " " year -	40 0
Three in 1875, 40l " " each, two quarters -	60 0

G



<i>Exhibitions at First M.B. Examination:</i>		<i>University Law Scholarships:</i>	
Two in 1873, 40l per annum each, two quarters	£ 40 0	One in 1874, 50l per annum, year	£ 50 0
Two in 1874, 40l " " year	80 0	One in 1875, 50l " " "	50 0
Three in 1876, 40l " " two quarters	60 0		
<i>Exhibitions at First LL.B. Examination:</i>		<i>Prizes:</i>	
One in 1874, 40l per annum, year	40 0	At Matriculation, June, 1875 and Jan. 1876	40 0
One in 1875, 40l " " "	40 0	" First B.A. Examination, 1875	20 0
		" B.A. Degree, 1875	30 0
		" Scriptural Examinations, 1875	30 0
<i>University Scholarships in Arts:</i>		<i>Medals:</i>	
One in 1872, 50l per annum, three quarters	37 10	One Gold Medal at LL.D. Degree, 1876	20 0
One in 1875, 50l " " one quarter	12 10	" M.D. " 1876	20 0
		" M.S. " "	20 0
		Three " M.A. " " 20l each	60 0
		Fourteen " in Medicine " " 5l each	70 0
			1,915 0
<i>University Scholarships in Arts, and Science:</i>		Deduct Amount that may not be payable	250 0
One in 1873, 50l per annum, year	50 0		
Two in 1874, 50l " " each, year	100 0	Total for Exhibitions, Scholarships, Prizes, and Medals	£1,665 0
Two in 1875, 50l " " one quarter	25 0		
<i>University Medical Scholarships:</i>		D.—LAW EXPENSES	20 0
Two in 1873, 30l per annum, each, three quarters	45 0		
One in 1874, 50l per annum, year	50 0	E.—INCIDENTAL EXPENSES:—	
Two in 1874, 30l " " "	60 0	Expenses at Scientific and Medical Examinations	75 0
One in 1875, 50l " " one quarter	12 10	Maintenance of Library	100 0
Two in 1875, 30l " " each	15 0	Advertisements	150 0
<i>University Surgical Scholarships:</i>		Sundries, including Postage, Carriage of Papers, and Expenses of Convocation	160 0
One in 1874, 50l per annum, year	50 0	Total for Incidental Expenses	£475 0
One in 1875, 50l " " one quarter	12 10		

## APPENDIX II.

## PAPERS RELATING TO THE UNIVERSITIES OF SCOTLAND GENERALLY.

See para. 23. I.—CORRESPONDENCE relating to the AMOUNT at the DISPOSAL of the COMMISSIONERS under the UNIVERSITIES (SCOTLAND) ACT of 1858.

[In reply to a telegram.]

SIR, 38, George Square, Edinburgh, June 14, 1875.

ON receipt of your telegram, asking me for documentary evidence regarding my statement that the Scottish Universities Commissioners (under the Act of 1858) were limited to the annual sum of 10,000l to be voted by Parliament for the better endowment of the Scottish Universities, I wrote to the Lord Justice-General as by far the best authority on the subject. I have received (and with it permission to use it as I may think fit) the enclosed statement of facts in reply.

I beg leave to forward it for the use of the Royal Commission, and ask that it may be permitted to appear as an Appendix to my Evidence

I AM, &c  
P. G. TAIT.

J. N. Lockyer, Esq.

MY DEAR PROFESSOR, Edinburgh, June 10, 1875.

In reply to your note of yesterday, I am unable to give you a reference to any Documentary Evidence in support of your statement, that the Universities Commissioners appointed by the Act of 1858 were limited to the sum of 10,000l per annum as the amount of the total additions which they were to make to the Endowments of the Scottish Universities. But I can give you positive assurance of the fact I was, as you know, Lord Advocate at the time, and obtained the sanction and consent of the Cabinet to the measure which I introduced, and which was passed in the Session of 1858, on the distinct condition that the additional sum to be provided by Parliament should not exceed 10,000l per annum.

Afterwards, as Chairman of the Commissioners appointed by the Act, I had the best means of knowing that the Commissioners considered themselves to be limited by this condition, and would, but for this condition, have been disposed to draw much more liberally on the funds to be provided by Parliament.

It is highly probable that this matter forms the subject of a Treasury Minute, of which, I dare say, a copy could be obtained. But I never thought it of any importance

to ask for any such evidence, because the arrangement between the Cabinet and myself was so distinct.

Believe me, &c.

JOHN INGLIS.

Professor P. G. Tait.

II.—EXTRACTS from the CIVIL SERVICE ESTIMATES for the FINANCIAL YEAR 1875-76.

A—UNIVERSITY OF ST. ANDREW'S	2,105
B—UNIVERSITY OF ABERDEEN	3,811
C—UNIVERSITY OF GLASGOW	3,165
D—UNIVERSITY OF EDINBURGH	6,804
	£15,885

## DETAILS OF THE ABOVE.

## A.—ST. ANDREW'S UNIVERSITY:

Principal*	93 0 0	93
Professor of Ecclesiastical History	86 1 8	86
" Hebrew and Oriental Languages	186 1 8	187
" Divinity	87 0 0	87

United College of St Salvator and St. Leonard.

The Factor or Steward, for the use of the Principal and

Masters	157 17 0	158
Principal	240 0 0	240
Professor of Greek	100 0 0	100
" Logic	150 0 0	150
" Moral Philosophy	150 0 0	150
" Humanity	120 0 0	120
" Natural Philosophy	150 0 0	150
" Mathematics	109 0 0	109
" Medicine	100 0 0	100
" Civil History	100 0 0	100
" Chemistry	125 0 0	125
Three Examiners	50 0 0	150

Total for St. Andrew's University £2,105

\* The present holder of this office receives 400l a year as a Member of the Board of Education, Scotland, Class IV., Vote 15, Sub-head A.

B.—ABERDEEN UNIVERSITY.

	Salary	Amount for Estimates.
Principal	260 0 0	260
Faculty of Arts :		
Among 7 Professors and 4 Assistants	821 6 8	821
Faculty of Divinity :		
Professor of Systematic Theology	82 0 0	82
Divinity and Church History	123 0 0	123
Divinity and Biblical Criticism	20 0 0	20
Oriental Languages	103 0 0	103
Faculty of Law :		
Professor of Law	130 8 8	131
Faculty of Medicine :		
Professor of Institutes of Medicine	200 0 0	200
Practice of Medicine	150 0 0	150
Chemistry	40 8 8	41
Assistants	—	150
Class Expenses	—	100
Anatomy	150 0 0	150
Assistant	100 0 0	100
Surgery	150 0 0	150
Materia Medica	150 0 0	150
Assistant	50 0 0	50
Class Expenses	—	150
Midwifery	150 0 0	150
Medical Jurisprudence	75 0 0	75
Class Expenses	—	35
Botany	300 0 0	300
Three Examiners in Arts	80 0 0	240
Three Medical Examiners	60 0 0	180
Total for Aberdeen University		£3,811

C.—GLASGOW UNIVERSITY :

Principal	250 0 0	250
Professor of Anatomy	30 0 0	30
Mathematics	62 0 0	62
Assistant	100 0 0	100
Moral Philosophy	11 0 0	11
Natural Philosophy	21 0 0	21
Assistant	100 0 0	100
Greek	20 0 0	20
Assistant	100 0 0	100
Logic	11 0 0	11
Medicine	10 0 0	10
Oriental Languages	20 0 0	20
Humanity	25 0 0	25
Assistant	100 0 0	100
Astronomy	50 0 0	50
Natural History	200 0 0	200
Midwifery	100 0 0	100
Chemistry	200 0 0	200
Two Assistants	—	200
Surgery	100 0 0	100
Botany	100 0 0	100
Materia Medica	100 0 0	100
Forensic Medicine	100 0 0	100
Assistant to the two preceding	50 0 0	50
Institutes of Medicine	150 0 0	150
Civil Engineering and Mechanics	275 0 0	275

	Salary.	Amount in Estimates.
Professor of English Language and Literature	200 0 0	200
Three Examiners in Arts	80 0 0	240
Three Medical Examiners	80 0 0	240
Total for Glasgow University		£3,165*

D.—EDINBURGH UNIVERSITY :	£	s.	d.	£
Principal†	848	17	10	849
Professor of Greek	130	0	0	130
Assistant	100	0	0	100
Moral Philosophy	130	0	0	130
Logic	130	0	0	130
Humanity	130	0	0	130
Assistant	100	0	0	100
Mathematics	80	0	0	80
Assistant	100	0	0	100
Natural Philosophy	130	0	0	130
Assistant	100	0	0	100
History	150	0	0	150
Church History	100	0	0	100
Hebrew and Oriental Languages	215	0	0	215
Rhetoric and English Literature	200	0	0	200
Public Law	250	0	0	250
Civil Law	150	0	0	150
Natural History‡	160	0	0	160
Chemical Surgery	100	0	0	100
Surgery	100	0	0	100
Botany §	160	0	0	160
Institutes of Medicine	150	0	0	150
Practice of Physic	100	0	0	100
Chemistry	200	0	0	200
Midwifery	100	0	0	100
Materia Medica ¶	100	0	0	100
General Pathology	100	0	0	100
Medical Jurisprudence	100	0	0	100
Practical Astronomy	300	0	0	300
Sanskrit	200	0	0	200
Civil Engineering ¶¶	200	0	0	200
Agriculture **	150	0	0	150
Geology, Mineralogy ††	200	0	0	200
Theory and Practice of Teaching †††	200	0	0	200
Three Examiners in Arts	80	0	0	240
Three Medical ditto	100	0	0	300
Maintenance and Repair of College Buildings	—	—	—	500
Total for Edinburgh University				£6,904

\* 800*l.* of this amount is in lieu of the lease of the rents of the Archbishopric of Glasgow, formerly held by the College.

† The present holder of this office receives also 400*l.* a year as Member of the Board of Education, Scotland, Vote 10, Class IV Sub-head A.

‡ The present Professor of Natural History also receives 1,000*l.* a year as Director of the Scientific Staff of the Deep Sea Exploring Expedition, see Class VII, Vote 2, Sub-head A.

§ The present holder of this office has an allowance of 120*l.* a year in lieu of a house under Sub-head F of this Vote.

¶ The present Professor of Materia Medica receives also 100*l.* a year as Visiting Physician at the General Prison, Perth, Vote 21, Class III, Sub-head D.

\*\* This Professorship has been founded by a gift of 5,000*l.* from Sir David Baxter, Bart.

†† Conditional on contribution of a similar amount by the Highland Society.

††† This Professorship has been founded by a gift of 5,000*l.* from Sir Roderick Impey Murchison, Bart. The present Professor has also a salary of 500*l.*, rising by 25*l.* a year to 600*l.*, as Director of the Geological Survey for Scotland, Class IV, Vote 2, Sub-head Q, &

‡‡ Endowed with 5,000*l.* by the Trustees of late Dr Bell.

## APPENDIX III.

## PAPERS RELATING TO THE UNIVERSITY OF EDINBURGH.

- I.—System of Examinations for Degrees in Science in the University of Edinburgh.  
 II.—Non-Professorial Examiners in the Faculty of Medicine in the University of Edinburgh.  
 III.—Statement of the total Emoluments of the Professors and Assistants, and Schedule of Lectures and Laboratory work.  
 IV.—The Number of Students attending the University.  
 V.—Statement of the Fees payable by the Students.  
 VI.—The proposed New Buildings for the University of Edinburgh.

See para. 30-46.

I.—SYSTEM OF EXAMINATIONS FOR DEGREES IN SCIENCE IN THE UNIVERSITY OF EDINBURGH.

[In reply to a telegram]

University of Edinburgh,

DEAR SIR, May 1st, 1875.  
 UP to this time the Examinations for the Degrees in Science have been almost entirely conducted by the Professors, each Professor examining on his own subject. Some assistance has been given by the Non-Professorial Examiner in Natural History, and also by myself in the absence of the Professor of Natural History, but the Professors of the Scientific Subjects examined on are the responsible Examiners. I believe that the question of appointing additional Examiners, not Professors, for the Degrees in Science, has been under the consideration of the University Court; but in this, as in other matters affecting the University, useful reforms and advisable modifications are retarded through want of funds to pay the additional Examiners, for I should explain that the Professors examine without receiving any remuneration for their labour as Examiners, so that the University obtains the benefit of their services in that capacity without any cost. The number of Candidates for the Degrees in Science is as yet small, not amounting, I think, to more than eight or ten in the year, the fees also are small, so that the revenue derived by the University from this source is trifling.

The University Court, however, has thoroughly recognised the principle of associating with the Professors additional Examiners who are not Professors, and has, as I explained in a former letter to the Commissioners, carried this out in the Examinations for Degrees in Medicine. I have no doubt that, did the funds of the University permit, the Court would appoint Non-Professorial Examiners for the Degrees in Science.

I hope that I have now accurately apprehended the question and given you the information required; but should the Commissioners still desire further information on this or other matters appertaining to the University, I shall be happy, so far as lies in my power, to supply it.  
 Believe me, &c.

J. N. LOCKYER, Esq.

W. TURNER.

P.S. Since writing the above I have seen Mr. Christian, the Secretary to the University Court, who informs me that there is doubt whether the Court has powers, under Ordinance No 8, Section 6, as amended on 6th of August last, to call upon the Non-Professorial Examiners in Medicine to examine also for Degrees in Science. If the money difficulty, however, did not exist, the Court, by the powers it at present possesses, could at once provide Non-Professorial Examiners in Science.

W. T.

REGULATIONS FOR GRADUATION IN SCIENCE.

(From the University Calendar, 1875-76)

[Referred to in Professor Turner's Letter of May 1st, 1875]

Two Degrees in Science are conferred by the University of Edinburgh, viz., Bachelor of Science (B.Sc.) and Doctor of Science (D.Sc.) Both these Degrees are conferred in Physical and Natural Science, in Public Health, and in Engineering. In Mental Science and Philology, the Degree of Doctor of Science only is conferred.

SECTION A.—PHYSICAL AND NATURAL SCIENCE.

I. QUALIFICATIONS REQUIRED IN CANDIDATES.

1. Candidates for a Degree in Physical and Natural Science must give proofs of having received a liberal education by being either—

- (a) Bachelors or Masters of Arts, by examination, of British or recognised Colonial Universities.

- (b) Bachelors or Doctors of Medicine of British or recognised Colonial Universities.  
 (c) Holders of two Departmental Certificates in the Faculty of Arts of this University.  
 (d) Matriculated Students of the University of London, if certified for Greek and for Logic or Moral Philosophy.

2. Failing any of these qualifications, the candidate must pass a Preliminary Examination in English, Latin, Arithmetic, the Elements of Mathematics, and the Elements of Mechanics; and he must also pass an Examination on at least two of the following subjects: Greek, French, German, Higher Mathematics, Natural Philosophy, Logic, and Moral Philosophy.

Candidates for this Preliminary Examination are examined at the same time as those for entrance into the Study of Medicine. For further details as to the Preliminary Examinations, see Notices under "Medical Graduation" in the Calendar.

3. They must also produce evidence of attendance on qualifying Classes embracing the subjects included in the Science Examination which they purpose to undergo.

4. The attendance on such classes must extend over three Academic years, one of which must be passed at the University of Edinburgh, the other two years either at this University or at Universities or Institutions\* recognised by and approved by this University.

5. Each Academic year must be constituted by attendance on Science Classes during at least two courses of not less than 100 lectures each, or one course of 100 lectures and two courses of 50 lectures each.

6. Every Candidate for a Degree in Science must be matriculated for the year in which he appears for Examination.

7. The First and Second Examination for Degrees in Science must in each case be taken at a single period.

II. EXAMINATIONS.

For the Degree of Bachelor of Science there are two Examinations, conducted by written questions, as well as orally and practically.

(a) First Bachelor of Science Examination.

1. The First Examination for B.Sc. is as to the general knowledge of the Candidate on the following subjects, viz.:

Mathematics.	Zoology, including Comparative Anatomy.
Natural Philosophy.	Botany.
Chemistry.	

2. The Examinations in Mathematics and Natural Philosophy take place on the days of Examination for these subjects, announced in the Regulations for Graduation in Arts.

3. The Examinations in Chemistry, Zoology, and Botany take place at the same time as the examinations on these subjects, announced in the Regulations for Graduation in Medicine.

4. Exemptions from Examination:

(1.) Persons possessing the following qualifications are exempted from the whole of the First B.Sc. Examination:

a. Masters of Arts who have taken honours in the Natural Sciences after passing the examinations for M.A. in this University.

b. Bachelors and Doctors of Medicine and candidates for these Degrees who have taken honours in the Natural Sciences at their professional examinations in this University, and who have also passed with distinction in Higher Mathematics and Natural Philosophy in their extra-professional or preliminary examinations.

(2.) Holders of certificates from the classes devoted to any of the above subjects in Science in the University of Edinburgh, showing that the candidate obtained at least 80 per cent. of the available marks during the Session, will be exempted from the written examination on that subject.

(3.) Masters of Arts are exempted from Examination in Mathematics and Natural Philosophy.

\* The Institution to be approved of by the University must be of a high class, such as the Royal School of Mines, London, the Ecole Centrale, or the Ecole des Mines, Paris.

See p. 51.

(b) *Second Bachelor of Science Examination*

1. The Second B.Sc. Examination is divided into the following groups, one of which must be professed by the candidate:—

- (a) The Mathematical Sciences { Higher Mathematics, Natural Philosophy
- (b) The Physical Experimental Sciences { Experimental Physics, Chemistry
- (c) The Natural Sciences { Zoology, Botany, Physiology, Geology.

2. The Examinations in the first two of these departments (except in Chemistry) will take place at the same time as the Examination for the Degree of M.A., and in the last (and in Chemistry) at the same time as the Examination for the First M.B. Professional Examination.

3. A Candidate who has passed the First B.Sc. Examination may proceed to the Second after an interval of six months.

4. A Candidate who has passed the First and Second B.Sc. Examinations will be recommended to the Senate for that Degree, which will be conferred at one of the usual times appointed for giving Degrees.

(c) *Doctor of Science Examination*

1. A Candidate who has received the Degree of B.Sc. may proceed to that of Doctor of Science, after a lapse of twelve months.

2. A Candidate for the Degree of D.Sc. must profess one of the above-mentioned sciences, of which he will be expected to have a thorough knowledge.

3. He must submit a Thesis containing some original Researches on the subject of his intended Examination, and such Thesis must be approved before the Candidate is allowed to proceed to Examination.

4. The Degree of D.Sc. will not be conferred on any Candidate who has not completed his 21st year.

III. FEES.

The following is the scale of fees which are charged for the Degrees in Science (sects A and B) —

1. For the Preliminary Examination, or for Registration of Qualification	£1	1	0.
2. For the First Bachelor of Science Examination	2	2	0.
3. For the Second Bachelor of Science Examination	2	2	0.
4. For the Doctor of Science Examination	5	5	0.
	£10	10	0.

Candidates for Science Examinations should announce their names and addresses to the Registrar, and pay the fees, before the 5th of March or the 1st of October. In the event of a Candidate not passing either of the B.Sc. or D.Sc. Examinations in Sections A, B, and E, the fee is not returned, but he may appear at one subsequent examination without paying an extra fee, and at any future examination on paying one half of the fee.

IV. OUTLINE OF SUBJECTS REQUIRED IN EXAMINATIONS FOR DEGREES IN SCIENCE.

*First Bachelor of Science Examination.*

1. Mathematics.

Euclid, Books 1.—vi., with the first twenty-one Propositions of Book xi.

Elementary Trigonometry and Conc Sections. Elementary Algebra, including Progressions, Surds, the Binomial Theorem, &c.

2. Natural Philosophy.

(a.) Applied Mathematics, including the treatment by Elementary Geometry, Algebra, and Trigonometry, of the following subjects (such as may reasonably be acquired in one or two sessions' attendance at a course of Natural Philosophy)

Kinematics, including Velocity, Acceleration. Angular Velocity, Simple Harmonic Motion, &c. and their composition and resolution.

Abstract Dynamics, including Elementary Statics, Kinetics, Hydrostatics, and Hydrokinetics. Geometrical Optics. Plane Astronomy.

(b.) Experimental Physics, including—

Laws of Motion. Properties of Matter. Sound and Harmonics.

Light, with the fundamental principles of the Undulatory Theory.

Heat, with the fundamental principles of the Dynamical Theory.

Electricity, including the Experimental Laws of Static and Galvanic Electricity, Induction, Magnetism, and Electro-Magnetism.

Conservation of Energy as the experimental law of physical phenomena.

3. Chemistry

Classification of Elements. General Laws of Chemical Combination and Action, as illustrated in the simpler compounds of the more commonly occurring elements. Symbolic Notation.

Preparation and Properties of the Non-Metallic Elements and their chief Compounds. Manufacture of Sulphuric, Nitric, and Hydrochloric Acids and Ammonia.

Classification and General Properties of Acids, Bases, and Salts.

Manufacture and Properties of Soda, Potash, Nitre, Gunpowder, Limestone, Lime, Mortars, Cements, Clay, Earthenware, Porcelain, and Glass.

Metallurgical operations in general. Preparation of Iron, Zinc, Copper, Lead, Tin, Mercury, and Silver, from their Ores. Principal salts of these metals. Alloys. Preparation, Properties, and Composition of Cast-Iron, Wrought-Iron, and Steel.

Classification of Organic Compounds. Alcohol, Acetic Acid, Wood, Sugars, Starch, Coal Gas, Coal-Tar, Oils, and Fats, Saponification.

Simple Quantitative Analysis [The Examination in Analysis is conducted practically].

4. Zoology, including Comparative Anatomy.

Distinctive characters of the three great Kingdoms of Nature.

Ideas involved in "Specialisation of Function" and "Morphological Type."

Homology and Analogy.

The general structure and physiology of the following groups of Animals.—

Mammalia, Aves, Reptalia, Amphibia, Pisces. Insecta, Myriapoda, Arachnida, Crustacea, Annelida, Rotifera, Nematelmenthes, Platelmenthes.

Echinodermata.

Cephalopoda, Gasteropoda, Pteropoda, Lamellibranchiata, Brachiopoda, Tunicata, Polyzoa.

Actinozoa, Hydrozoa.

Infusoria, Rhizopoda, Sponginae, Gregarinae.

The candidate will be required to refer to its proper group, among those named above, any specimen which may be exhibited for this purpose by the Examiner.

Physical Geography, in so far especially as it is concerned with the geographical distribution of organic beings.

5. Botany

Candidates to be examined on the structure and functions of plants, the principles of classification, classes, sub-classes, and sections of the Natural System, and a few of the principal Orders, as enumerated below.

Text Book—Balfour's Class Book, or his Manual of Botany.

More specific statement of Subjects.

Elementary Tissues of Plants, their chemical constituents, contents, and mode of development.

General characters and functions of the Root, Stem, Leaf, envelopes of the Flower, Stamen, Pistil, Fruit, and Seed.

Phyllotaxis, Inflorescence, Anthotaxis, Metamorphosis, Vernation, Estivation, Stipulation, Placentation.

Respiration and Transpiration. Movement of Sap and its causes.

Embryogenic process in Phanerogamic and Cryptogamic Plants.

Germination. Propagation by Buds and by Division.

Classification of Plants. Cellular and Vascular Plants, Phanerogamous and Cryptogamous, Dicotyledons (Angiospermous and Gymnospermous), Monocotyledons, Acotyledons; Exogens, Endogens; Acrogens, Thallogens.

Botanical characters to be demonstrated on conspicuous specimens of the following Natural Orders.—

Ranunculaceae, Papaveraceae, Cruciferae, Carophyllaceae, Malvaceae, Sterculiaceae, Leguminosae, Rosaceae, Onagraceae, Umbelliferae, Dipsacaceae, Compositae, Campanulaceae, Boraginaceae, Labiatae, Scrophulariaceae, Primulaceae, Euphorbiaceae, Salicaceae, Corylaceae, Coniferae, Cycadaceae, Orchidaceae, Amaryllidaceae, Musaceae, Liliaceae, Palmae, Cyperaceae, Gramineae, Filices, Musci.

Derivation and meaning of the more important Botanical terms.

*Second Bachelor of Science Examination.*

## (a.) The Mathematical Sciences.

## 1. Mathematics

Algebra, including the Theory of Equations.  
Trigonometry, Plane and Spherical.  
Analytical Geometry of two and three dimensions.  
The Differential and Integral Calculus.

## 2. Natural Philosophy.

For the Second Examination, the same subjects will be taken as in the First, but they will be carried out with a higher application of Mathematics, and with a more strict examination into the candidate's acquaintance with the Experimental part of the subject.

## (b.) The Physical Experimental Sciences.

## 1. Experimental Physics.

Candidates will be required to show considerable familiarity with the processes required for the determination of physical constants, such as, for instance, the Specific Heat, the Specific Inductive Capacity, the Thermal and Electric Conductivity of a substance, the Velocity of Light or of Sound, the Magnetic Dip, Variation, and Horizontal Intensity, &c., &c.

## 2. Chemistry

The same subjects as for the first Bachelor of Science Examination, but carried out in greater detail, and in addition, the connexion between Chemical Composition and Crystalline Form, and Optical and Thermo Properties.

Complex Qualitative Analysis. [The Examination in Analysis will be conducted practically.]

## (c.) The Natural Sciences.

## 1. Zoology, including Comparative Anatomy.

Same subjects as for First Bachelor of Science Examination, but carried out in greater detail.

## 2. Animal Physiology.

- 1 The alimentary substances appropriate for the food of animals
- 2 The processes of mastication, insalivation, and deglutition.
- 3 Digestion in the stomach—the effect of the gastric juice upon the food, and the nervous influences acting on the stomach
- 4 The functions of the liver.
- 5 The secondary digestion, and its influences on the blood
- 6 The general functions of secretion.
- 7 Comparison of the structure and actions of the circulatory and respiratory organs in the various classes of animals
- 8 The general functions of the nervous system.
- 9 Sensibility and sensation
- 10 Muscular contractibility.
- 11 Functions of the cerebral lobe and of the cerebellum.
- 12 Functions of the spinal cord.
13. Theory of reflex or disjunctive functions.

## 3. Botany. (Specialised.)

Vegetable Histology, Vegetable Morphology, Vegetable Physiology, including Development.

Systematic Botany—The structure and physiological characters of the principal Natural Orders of the Vegetable Kingdom.

Botanical Geography, Distribution of Plants in Britain.

## 4. Geology, including Palæontology and Mineralogy.

*Physical Geography, Meteorology, and Dynamical Geology.*—The nature and operation of Geological agents: Rain, Rivers, Ice, the Sea, Earthquakes, Volcanoes, Movements of Upheaval and Depression.

*Mineralogical and Petrographical Geology.*—Characters of Rock-forming Minerals: Composition, Origin, and Distribution of Rocks.

*Structural Geology.*—The Structure of Rock-masses: Joints, Bedding, Cleavage, Foliation, Metamorphism, Faults, Unconformability, Denudation.

*Stratigraphical Geology.*—The History of the Geological Formations of the British Islands.

*Paleontological Geology.*—Characters and Distribution in time of the more important Genera and Orders found fossil in Britain.

*Doctor of Science Examination.*

## 1. Mathematics.

The candidate will be required to show very high attainments in one of the following subjects:—

1. Geometry and Trigonometry.
2. Analytical Geometry.
3. Algebra.
4. The Differential Calculus generally.
5. Special departments, such as the Calculus of Variations, the Theory of Determinants, Quaternions, &c.

## 2. Natural Philosophy.

Candidates are required to pass a searching examination in one of the following subjects or groups of subjects (in all its details), and to show more than a mere elementary knowledge of at least two others:—

## (A.) Applied Mathematics.

1. Abstract Dynamics, including Kinematics.
2. Acoustics and Theory of Light.
3. Conservation of Energy including the Dynamical Theory of Heat
4. Electricity, including the mathematical theories of Static and Voltaic Electricity, Induction, Magnetism, and Electro-Magnetism.
5. Physical Astronomy, including the Lunar and Planetary Theories, the Figures of the Earth, Precession, and Nutation.

## (B.) Experimental Physics, or Science of Observation.

6. Properties of Matter.
7. Sound and Light.
8. Heat and Energy (generally).
9. Electricity, Magnetism, &c.

## (C.) Practical Astronomy.

1. Nautical Astronomy, and such applications of received science as are necessary in finding angular positions, as latitude and longitude, in voyaging over the surface of the globe.
  2. Terrestrial Astronomy, and those processes, both of observation and computation, which are employed in determining the size and figure of the earth, as a base line for further measures.
  3. Cosmical Astronomy, and the determination, by the most refined operations, of the distances, magnitudes, masses, and movements of the heavenly bodies.
- In each of these branches, of the principles of the usual instruments employed in them will be required; some observations with one at least of them, and upon one or more of the problems, must have been taken under the open sky; and practical ability shown, in eliminating by calculation instrumental and terrestrial errors, as well as in exhibiting the numerical value of the astronomical result, both with regard to what has been done by previous good observers in the same field, and to the predictions of the best theory.

## 3. Chemistry

The candidate will be required to pass a searching examination in one of the following branches:—

1. The Chemistry and Chemical Technology of Inorganic Bodies, including Metallurgy.
2. Organic Chemistry.

And to show a thorough practical acquaintance with Chemical Analysis in all its branches.

## 4. Zoology, including Comparative Anatomy.

The more important special modifications, structural and physiological, in each of the groups included in the First Bachelor of Science Examination, and also the leading phenomena of development throughout the various classes of the Animal Kingdom.

## 5. Animal Physiology

In addition to any of the subjects in the Bachelor of Science Examination—

1. Functions of the ganglionic system of nerves.
2. Functions of the elementary structures of the body.
3. General properties and functions of the blood.
4. General ideas as to vitality and vital functions.
5. The function of reproduction, and the phenomena of development.

## 6. Botany.

Structural and Physiological characters of the Natural Orders of the Vegetable Kingdom, together with a practical knowledge of the genera and species of some particular group to be selected by the candidate, and approved by the Examiners; along with Botanical Geography and Fossil Botany.

## 7 Geology, including Palaeontology and Mineralogy

In addition to a more searching test of the knowledge of the subjects prescribed for the Second Bachelor of Science Examination, Candidates will be required to show some acquaintance with the Geology and Palaeontology of foreign countries as well as of the British Islands. It will be necessary that they evince sound practical knowledge. To test their acquirements in this respect, they will be asked to identify and describe specimens of minerals, rocks, and fossils placed before them, and from a geological map, which will be furnished to them, to write a paper (with sections) on the geology of the district to which the map refers.

J. H. BALFOUR,  
ALEX. ORUM BROWN,  
Joint Conveners.

## SECTION B.—ENGINEERING.

The Degrees of Bachelor of Science and Doctor of Science are open to Candidates submitting themselves for examination in Engineering according to the subjoined Rules

1. Candidates must also have the qualifications required by paragraphs 2, 3, 4, and 5 of Section A, p. 46

2. There will be two Examinations in Science for the Degree of Bachelor of Science, and a third Examination for the Degree of Doctor of Science. The examinations will be written, oral, and practical

3. The first examination is as to the general knowledge of the Candidate on the following subjects, viz. —

Mathematics  
Natural Philosophy  
Chemistry

4. This examination is called the First Bachelor of Science Examination in Engineering, and is compulsory on all who do not possess the qualifications which entitle a Candidate to be exempted from the First Bachelor of Science Examination in Section A.

5. The Candidate who has passed the First Bachelor of Science Examination (or has the qualification necessary to exempt him from this Examination), may proceed to the Second Examination after an interval of six months. This is called the Second Bachelor of Science Examination. The Candidate will be examined in the following subjects:—

Mathematics applied to Mechanics  
Engineering  
Drawing

6. The Candidate, after passing the Second Examination, shall be recommended to the Senate for the Degree of Bachelor of Science.

7. A Candidate who has received the Degree of B.Sc., and who desires to proceed to the Degree of Doctor of Science, may present himself for a third examination, after the expiry of twelve months.

8. The Examinations for Degrees will be conducted by University Examiners, and an Examiner appointed by the University Court.

9. The Degree of D.Sc. will not be conferred on any Candidate who has not completed his 21st year.

*First Bachelor of Science Examination*

## (a.) Mathematics—

Arithmetic.

*Algebra*.—To the end of Quadratic Equations inclusive, with Progressions, the Binomial and Exponential Theorems, and Logarithms.

*Geometry*.—Equivalent to the first four and sixth Books of Euclid, and part of the eleventh.

Conic Sections, treated geometrically

*Plane Trigonometry*.—Angles and Triangles, with their relations.

*Analytical Geometry*.—The Rudiments in two and in three Dimensions.

## (b.) Natural Philosophy

- (a.) Applied Mathematics, including the treatment by Elementary Geometry, Algebra, and Trigonometry, of the following subjects (such as may reasonably be acquired in one or two sessions' attendance at a course of Natural Philosophy)—
- Kinematics, including Velocity, Acceleration, Angular Velocity, Simple Harmonic Motion, &c., and their composition and resolution
- Abstract Dynamics, including Elementary Statics, Kinetics, Hydrostatics, and Hydrokinetics
- Geometrical Optics.
- Plane Astronomy.

## (b.) Experimental Physics, including

Laws of Motion.

Properties of Matter.

Sound and Harmonics

Light, with the fundamental principles of the Undulatory Theory

Heat, with the fundamental principles of the Dynamical Theory

Electricity, including the Experimental Laws of Static and Galvanic Electricity, Induction, Magnetism, and Electro-Magnetism.

Conservation of Energy as the Experimental Law of Physical Phenomena

## (c.) Chemistry

Classification of Elements. General Laws of Chemical Combination and Action, as illustrated in the simpler compounds of the more commonly occurring elements. Symbolic Notation.

Preparation and Properties of the Non-Metallic Elements and their chief Compounds Manufacture of Sulphuric, Nitric, and Hydrochloric Acids and Ammonia.

Classification and General Properties of Acids, Bases, and Salts.

Manufacture and Properties of Soda, Potash, Nitre, Gunpowder, Limestone, Lime, Mortars, Cements, Clay, Earthenware, Porcelain, and Glass

Metallurgical operations in general Preparation of Iron, Zinc, Copper, Lead, Tin, Mercury, and Silver, from their Ores. Principal salts of these metals Alloys. Preparation Properties, and Composition of Cast-iron, Wrought-iron, and Steel.

Classification of Organic Compounds. Alcohol Acetic Acid, Wood, Sugars, Starch Coal-Gas, Coal-Tar, Oils, and Fats, Saponification Simple Qualitative Analysis [The Examination in Analysis is conducted practically]

*Second Bachelor of Science Examination*

## (a.) Mathematics applied to Mechanics.

The Applications of Mathematics (as far as the Elements of the Differential and Integral Calculus) to

Kinematics

States of Rigid Solids, Elastic and Perfectly Flexible

Bodies, and Perfect Fluids

Kinetics of a Particle and of Rigid Solids

The Simpler Portions of Kinetics of Perfect Fluids

## (b.) Engineering.

*Properties of Materials*.—General Properties, with special knowledge of their Strength, and the Purposes to which they are applied, with some knowledge of their Cost

*Strength and Stability of Structures Designed by Civil Engineers*.—Metal and Wooden Bridges and Roofs. Arches in Masonry Walls Retaining Walls Embankments Cuttings. Breakwaters.

Aqueducts. Pipes. Canals

Strength and Forme of the Elements of Machinery.

*Design of Combined Structures*.—An Elementary knowledge of the Design of Bridges and Roofs, of Reservoirs, Embankments, collecting and distributing Machinery of Waterworks, and of the main features of Railway construction, Harbours, and Drainage

*Design of Machinery*.—An Elementary knowledge of the construction of the Steam Engine, stationary and locomotive, of Prime Movers driven by Water, of Mill-wright work, and the general arrangement of Factories

*Prime Movers*.—Sources of Power Estimate of Power required Measurement of work done. Application of the Principles of Dynamics

## (c.) Drawing

The Student must be able to represent neatly, in the style used by Engineers, Plans and Sections of Buildings and Machinery, and also to make Engineering Sketches with Figured dimensions from actual objects.

The candidate who successfully passes the two examinations will be recommended to the Senate for the Degree

*Doctor of Science Examinations.*

1. Every candidate for this Degree must prove that he has passed under a civil engineer in practice. He must then profess one, and not more than one, of the subdivisions in each of the two following groups of subjects:

## 1 Practical Engineering :

- (a) The design of Machinery, with complete Drawings, Specifications and Estimates
- (b) The preparation of Designs, Specifications, and Estimates for Civil Engineering work

## II. Applied Science .

- (a) Applied Mathematics.
- (b) Chemistry
- (c) Geology.
- (d) One Branch of Natural Philosophy.
- (e) Telegraphy.

2. The class of machinery, or the special engineering work on which the student is examined, will be chosen with reference to the special work in which he has been engaged during his pupillage

3. The Examinations in Group I will consist in requiring the actual execution of the required work by the student within a month of his receiving the instructions of the Examiners. At the end of that time he will send in his drawings, specifications, estimates, and calculations. When these have been examined and approved, the Student will be required to submit to an oral examination in connection with the work submitted as his own. By this examination the authenticity of the work will be tested.

4. A high degree of proficiency will be required in the special branch chosen by the Student.

J. H. BALFOUR,  
ALEX. CRUM BROWN,  
Joint Conveners.

## SECTION C.—DEGREE OF DOCTOR IN MENTAL SCIENCE.

The Degree of Doctor of Science is also open to Candidates highly proficient in the Mental Sciences

1. The Candidate must be a Bachelor or Master of Arts, by examination, of a British or recognised Colonial University

2. He must be a Matriculated Student of this University for the year in which he appears for Examination

3. He must have attended for at least one Academic year in this University, and during that year he must have taken at least two classes on the subjects embraced in the Examination

4. The Candidate must, in evidence of literary and philosophical culture, present, at least one month before proceeding to Examination, an original Thesis on a subject in Mental Science approved by the Examiners

5. The Thesis being accepted, the Candidate may then proceed to an Examination, which shall include Logic and Metaphysics, Moral Philosophy, and the History of Philosophy, both Metaphysical and Moral, in particular on any of the subjects embraced in the following Programme —

## LOGIC AND METAPHYSICS

(a) *Logic*—The Province of Logic. Formal Logic—The Theory and details of Propositional and Syllogistic Forms, with their recent Developments, especially by Hamilton, De Morgan, and Boole. Fallacies. Verbal Logic—Definition—the Predicables—Nominalism and Realism. Material Logic—The different sorts of Evidence. Authority and Science. The methods of Scientific Induction. The philosophical questions involved in the Theory of Induction

(b) *Metaphysics*.—Personality.—Classification of the facts of Consciousness, with relative Psychological and Physiological Questions, Externality and External Perception—Matter—Space and Time—Causation and Power. The origin, nature, and limits of Human Knowledge—The finite and the Infinite

## MORAL PHILOSOPHY.

Moral Actions. The Moral Faculty. Desires and Emotions. The Will. Moral Obligation. The Existence and Attributes of God. The relation of Absolute Sovereignty to finite Existence, and especially to human will. The Origin of Evil. The Immortality of the Soul. Practical Ethics, including the laws which regulate the formation of moral character, and the guidance of individual and social life.

## HISTORY OF PHILOSOPHY—METAPHYSICAL.

The History of Logic—Formal and Inductive. A general knowledge of the History of Ancient and Modern Psychology and Metaphysics. Special Study of Plato or Aristotle. Special Study of Locke, Berkeley, Hume, and Kant.

## HISTORY OF PHILOSOPHY—MORAL.

The relation of the pro-Socratic Philosophy to Moral Philosophy. The Socratic theory as in the *Memorabilia*. The Platonic theory, as in the *Republic*. The Aristotelian, Stoic, and Epicurean Theories. The Theories of Hobbes, Spinoza, Cudworth, Price, Hume, and Kant, with the later developments of Intuitionist and Utilitarian Ethics.

6. The examinations will be held annually in April and November. Candidates may be tested both orally and by writing.

7. Those who have taken the Degree of Master of Arts in this University with First-Class Honours in the Department of Mental Philosophy, may obtain the Degree of Doctor in Mental Science when a period of not less than three years shall have elapsed after they have obtained such Honours, by submitting a sufficient Thesis on a subject approved by the Examiners, and on giving such other evidence of continued proficiency in the Mental Sciences as may be satisfactory to the Senate.

8. The fee for the Degree of Doctor in Medical Science is 7*l* 7*s*. The fee must be paid at least 10 days before the date of Examination, when the Diplomas and Certificates of the Candidate must be transmitted to the Dean of the Faculty of Arts. In the event of the Candidate not passing, the fee is not returned, but he may appear at one subsequent Examination without paying an extra fee, and at any future Examination on paying one half of the fee.

A. C. FRASER,  
Dean of Faculty of Arts.

## SECTION E.—DEGREE OF DOCTOR OF SCIENCE IN PHILOLOGY.

The Degree of Doctor of Science is also open to Candidates highly proficient in Philology.

1. The Candidate must be a B.A. or M.A. by examination, of a British or recognised Colonial University.

2. He must be a Matriculated Student of this University for the year in which he appears for Examination.

3. He must have attended for at least one Academic year at this University, and during that year he must have taken at least two classes on the subjects embraced in the Examination

4. The Candidate must present, at least one month before Examination, an Original Dissertation on some point of Philological or Archaeological Research. Mere compilations will not be accepted. Only when this Dissertation has been approved of will the candidate be admitted to further examination

5. The Candidate may offer himself for Examination in any one of the following branches:—

1. The Latin and Greek Languages
2. The Semitic Languages.

It is expected that Candidates for a Degree in Philology in this branch, besides being acquainted with the Psalms in Hebrew and the Gospels in Syriac, should know the first four Surat or Chapters of the Koran, and be capable of turning sentences of English into Hebrew, Syriac, and Arabic—supplying, at the same time, the proper vowel and diacritical marks. A Dissertation on Semitic Grammar is also deemed necessary.

## 3. The Sanskrit and Comparative Philology.\*

(a.) Sanskrit Language and Literature. Translation of passages from current Sanskrit Authors into English, and from English into Sanskrit.

(b) Comparative Philology of the Indo-European Languages. Acquaintance with the Principles of the Science, as laid down in the Comparative Grammar of Bopp, Schleicher's "Compendium," and Muller's and Whitney's Lectures.

(c.) Philosophy of Language. Candidates must show some degree of familiarity with the works of Lord Monboddo, "On the Origin and Progress of Language," Horne Tooke's "Diversions of Purley," Lersch, "Sprach-philosophie der Alten;" Heyse, "System der Sprachwissenschaft," Schömann, "Die Lehre von den Redetheilen;" Steinthal, "Der Ursprung der Sprache."

6. Candidates for the Degree of Doctor of Science in Classical Philology will be tested in respect of their general Scholarship by translation from Latin and Greek Authors, and by composition in Latin and Greek Prose. They will further be required to profess a critical knowledge of some

\* Dr John Murr has offered a sum of 100*l* to the most distinguished candidate who shall first succeed in taking the degree of D.Sc. in the Department of Sanskrit and Comparative Philology.

special Department or Epoch of Classical Literature, or of some three or four of the more difficult and important Classical Writers.

7. The Examinations will be held annually in April and November. Candidates may be tested either orally or by writing.

8. Those who have taken the Degree of Master of Arts in this University, with First Class Honours in the Department of Classical Literature, may obtain the Degree of Doctor of Science in Philology, when a period of not less than three years shall have elapsed after they have obtained such Honours, by submitting a sufficient Thesis on a subject approved by the Examiners, and by such other evidence of continued proficiency in Philological Research as may be satisfactory to the Senatus.

9. The Fee for the Degree of Doctor of Science in Philology is 7*l.* 7*s.* The Fee must be paid at least ten days before the date of Examination, when the Diploma and Certificates must be transmitted to the Dean of the Faculty of Arts. The same regulation as to the non-return of fees applies with reference to this Section as to Section D.

A. C. FRASER,  
Dean of Faculty of Arts.

#### Science Fellowship and Scholarships.

The following Fellowship and Scholarships are open to Graduates in Science—

1. The *Falconer Memorial Fellowship*, in Palaeontology and Geology, of the annual value of about 100*l.*, tenable for two years or more, according to circumstance (See under Fellowships, &c.), is open to Graduates in Science or Medicine of this University of not more than three years' standing at the date the Examination. The next competition may take place in October 1876. The present holder of the Fellowship is George Alex. Gibson, B.Sc. of 1874, who obtained the Fellowship in December 1874.

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2. The *Baxter Physical Science Scholarship*, tenable for two years, is awarded to the most eminent of the Bachelors of Science who have passed their Examinations in the Physical Sciences, including Experimental Philosophy and Chemistry, either in the year preceding a vacancy or in the year in which a vacancy occurs. The Scholarship is held subject to the condition that the holder shall have taken the Degree of Doctor of Science in the first year of his tenure of it. Annual value, 60*l.* Next appointment may be made in November 1876. The present holder is Robert Romans, B.Sc., who obtained the Scholarship in November 1874.

3. The *Baxter Natural Science Scholarship*, tenable for two years, is awarded to the most eminent of the Bachelors of Science who have passed their Examinations in the Department of Natural Sciences, including Botany, Zoology, Physiology, and Geology, either in the year preceding a vacancy or in the year in which a vacancy occurs. Annual value, 60*l.* The Scholarship is held subject to the condition that the holder shall have taken the Degree of Doctor of Science in the first year of his tenure of it. The present holder of the Scholarship is Isaac Bayley Balfour, B.Sc., to whom it was awarded in November 1875.

The next competition will take place in November 1875.

#### Notice as to Science Examinations for 1875-76.

##### Sections A and B

1. Preliminary Examinations will take place on Tuesday and Wednesday, 12th and 13th October 1875; and on Tuesday and Wednesday, 14th and 15th March 1876, at 10.30 o'clock A.M.

*Examination on Tuesdays*.—English, Arithmetic, Mechanics, Higher Mathematics, Greek, German, and other Languages.

*Examination on Wednesdays*.—Latin, Elements of Mathematics, Natural Philosophy, French, Logic, and Moral Philosophy.

For further particulars as to the Examination in these subjects see Medical Preliminary Examination in Arts, in CALENDAR

2. First B.Sc. Examination in Mathematics and Natural Philosophy, will take place in April and October, at the same time as the examination in Arts on these subjects, viz., 25th, 26th, and 27th October 1875, and 10th, 11th, and 12th April 1876.

3. First B.Sc. Examination in Chemistry, Botany, and Zoology, will take place in April and October, at the same time as the First Medical Professional Examination, viz., 22nd and 23rd October 1875, and 1st and 3rd April 1876.

4. Second B.Sc. Examinations will take place at the same time as the First Medical Professional Examination.

5. Examinations for D.Sc. will be held in April and October. Candidates must present their Theses at least one month before the date of the Examination.

#### For B.Sc. in ENGINEERING.

First B. Sc. Examination in Chemistry on the 22nd October 1875, and 1st April 1876, at 11 o'clock.

Examination in Mathematics and Natural Philosophy, on 25th, 26th, and 27th October 1875, and 10th, 11th, and 12th April 1876.

#### SECOND B.Sc. in ENGINEERING.

Examination in Engineering and Drawing will take place on 22nd and 23rd October 1875, and 1st and 3rd April 1876.

In Mathematics applied to Mechanics, on 27th October 1875, and 12th April 1876.

#### Section C.—Public Health.

The Examinations will take place on the 22nd and 23rd October 1875, and 1st and 3rd April 1876, at 12 o'clock each day.

#### Sections D. and E.

##### D Sc. in MENTAL SCIENCE and PHILOLOGY.

Monday, November 1st, 1875, and following days, as well as Thursday, 13th April 1876, and following days, at 9 o'clock a.m., are fixed for the Examinations of Candidates for the Degree of Doctor in Mental Science and of Doctor in Philology.

Candidates must present their Theses at least one month before the date of the Examination.

#### II.—NON-PROFESSORIAL EXAMINERS in the FACULTY of MEDICINE in the UNIVERSITY of EDINBURGH. See para. 44.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, London, S.W.

March 23, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to state that the Commissioners are desirous of knowing what has recently been done with reference to the Non-Professorial Examiners in the University of Edinburgh, and to ask if you can favour the Commission with any further information on the subject.

I have, &c.

Professor Turner, J. NORMAN LOCKYER,  
University of Edinburgh, Secretary

University of Edinburgh,

March 25th, 1875

SIR, IN reply to your letter of the 23rd inst., in which you ask for further information relative to the Non-Professorial Examiners in this University, I beg to enclose some documents which will, I think, furnish the Duke of Devonshire and the Royal Commission on Scientific Instruction with the information required.

A, gives the terms of the Resolution of the University Court to increase the number of Non-Professorial Examiners from three "to not fewer than seven persons specially qualified to examine in the subjects of the Medical Examinations."

B, gives the Regulations adopted by the Court relative to the appointment of suitably qualified persons to fill the office of Examiner.

In conformity with these Regulations the Examinerships were advertised in the newspapers, and in the month of January of the present year the University Court selected from a long list of candidates twelve Non-Professorial Examiners, one for each of the subjects embraced in the series of examinations.

The names of the gentleman selected, and the subjects they are appointed to examine on, are given in C.

The Board of Examiners of Candidates for our Degrees in Medicine and Surgery now consists of twenty-four persons, twelve professors and twelve not professors. Each candidate, therefore, will be examined in each subject of examination by two examiners specially qualified for the purpose,—a professor and a non-professor.

Should any further information on this matter be desired by the Duke of Devonshire I shall be happy to supply it.

I may take this opportunity of enclosing for the information of the Commission an extract [D] from the Minutes of the University Court of date 10th June 1874, being a Resolution to add a Department of Public Health to the Departments in which Degrees in Science may be obtained in this University. The first examination for this Degree was held in October last.

It is believed that the institution of this Degree by the University will supply an important public want.

I have, &c.

WM. TURNER.

J. Norman Lockyer, Esq.,

H



**ALTERATION OF ORDINANCE PROVIDING FOR THE APPOINTMENT OF ADDITIONAL (NON-PROFESSORIAL) EXAMINERS IN MEDICINE.**

Extract from the Minutes of the University Court of the University of Edinburgh, of date 6th July 1874, being resolution adopting alterations on Ordinance No. 5, Edinburgh No. 3, and Ordinance No. 23, Edinburgh No. 5, providing for the appointment of additional Non-Professorial Examiners in Medicine, and making regulations relative thereto.

"The University Court of the University of Edinburgh, considering that it is desirable that the number of persons who may be appointed to act as medical examiners for graduation in medicine in the University, in addition to the Professors of the Faculty of Medicine, as provided in Ordinance No. 5, Edinburgh No. 3, of the Commissioners appointed for the purposes of the Universities (Scotland) Act, 1858, should be increased, in order that such persons may in future be appointed with a view to their special qualification to examine in one or two of the subjects of the Examinations for Graduation in Medicine on which they may respectively be appointed to examine, rather than with a view to their qualification to examine in such subjects generally,—resolve

"That the following alteration shall be made on the said Ordinance :

"SECTION *Quinto* of Ordinance No. 5, Edinburgh No. 3, to be deleted, and the following to be substituted therefor.

"SECTION *Quinto*.—That from and after the First-day of January, in this year, Eighteen hundred and seventy-five, the Medical Examiners for all Candidates for Graduation in Medicine in the said University shall be the Professors in the Faculty of Medicine thereof, and in addition not fewer than seven persons specially qualified in the manner herein-after described to examine in the subjects of the Medical Examinations. Such persons shall be appointed annually by the University Court, under such Regulations as may be issued by the said Court from time to time, and shall be eligible for re-election. No such person shall hold the office of Examiner in more than two of such subjects at the same time; two or more of them shall not examine of the same subject, and each of them shall be specially qualified in the subject or subjects on which he shall be appointed to examine. Such persons shall be selected from among the members of the three following bodies, namely, the Royal College of Physicians of Edinburgh, the Royal College of Surgeons of Edinburgh, and the Faculty of Physicians and Surgeons of Glasgow, or shall be persons otherwise fully qualified in the judgment of the University Court. Each of such persons shall receive a fee of Fifty pounds for each year, for each subject on which he shall be appointed to act as examiner.

And further considering that, by the said alteration of Ordinance No. 5, Edinburgh No. 3, instead of three additional Examiners in Medicine, each receiving a sum of One hundred pounds per annum, paid from moneys voted by Parliament for the purpose, under the provisions of Section XLII. of Ordinance No. 23, Edinburgh No. 5, of the said Universities Commissioners, there will in future be in the University not fewer than seven additional Examiners in Medicine, specially qualified in the subjects of the Medical Examinations in the manner above set forth; that these subjects are at present thirteen in number; that each of such Examiners will receive a fee of Fifty pounds for each year for each subject on which he shall be appointed to examine; and, consequently, that it is necessary that the said three sums of One hundred pounds each, paid from moneys voted by Parliament for the purpose, should in future be divided into six sums of Fifty pounds each, and that provision should be made for an additional annual sum for payment of the remainder of the said fees of Fifty pounds each. The University Court further resolve—

"That the following alteration shall be made on the said Ordinance No. 23, Edinburgh No. 5, of the said Universities Commissioners.

"SECTION XLII. of Ordinance No. 23, Edinburgh No. 5, to be deleted, and the following to be substituted therefor—

"XLII.—The sum of Fifty pounds, payable to the additional Examiners in Medicine in respect of each of the subjects on which they may be appointed to examine by the University Court, in terms of Section *Quinto* of Ordinance No. 5, Edinburgh No. 3, as altered by Resolution of the University Court of date 6th July 1874, shall be paid as follows:—The additional Examiners on Anatomy, Physiology, Practice of Medicine, Surgery, Clinical Medicine, and Clinical Surgery, shall be paid out of moneys to be voted by Parliament for the purpose; and the additional

Examiners on the other subjects of the Medical Examinations shall be paid from the General University Fund."

Extracted by

J. CHRISTISON, W.S.,  
Secretary.

Edinburgh, 8th July 1874.

The alterations of Ordinances Nos. 5 and 23, contained in the above Extract Minutes, received the consent of the Chancellor of the University on 20th July 1874; and were approved by Her Majesty by Order in Council dated 6th August 1874.

**B.**

**REGULATIONS RELATIVE TO THE APPOINTMENT OF NON-PROFESSORIAL EXAMINERS IN MEDICINE.**

Extract from the Minutes of the University Court of the University of Edinburgh, of date 9th November 1874, being regulations for the appointment of the Non-Professorial Examiners in Medicine in the University, adopted by the Court under the powers conferred on them by an alteration of Ordinance No. 5, Edinburgh No. 3, approved by Her Majesty by Order in Council on 6th August 1874.

"The University Court considering that by Section *Quinto* of Ordinance No. 5, Edinburgh No. 3, of the Scottish Universities Commissioners, 1858, as altered by the Court by a resolution of date 6th July 1874, which received the approval of Her Majesty in Council on 6th August 1874, the Court are empowered from and after 1st January 1875 annually to appoint additional examiners specially qualified in the subjects of examination for graduation in medicine, under such regulations as they may from time to time issue regarding matters not provided for in the said Ordinance or alteration thereof; and further, considering that it is advisable that the persons so appointed should, under ordinary circumstances, hold office for a fixed term of years; and that other matters relative to the appointment of such persons should be made the subject of formal regulation.—Resolve—

"1. That each person appointed under the said Ordinance as altered, to examine on any of the subjects requisite for graduation in medicine, may, under ordinary circumstances, be re-appointed annually for five consecutive years, but not more.—Provided always, that on the first occasion, the persons appointed to examine on three of the subjects of examination may be re-appointed annually thereto for three years; those appointed to examine on two of such subjects may be re-appointed annually thereto for four years; those appointed to examine on three of such subjects may be re-appointed annually thereto for five years; those appointed to examine on two of such subjects may be re-appointed annually thereto for six years; and those appointed to examine on three of such subjects may be re-appointed annually thereto for seven years.

"2. It shall be competent for the Court, under special circumstances, to re-appoint any person to examine on any subject or subjects, immediately after he has acted as examiner thereon for five consecutive years, for such further term of years as the Court may determine.

"3. No person shall be appointed to examine on two subjects which are in the same division of the examinations for graduation in medicine.

"4. Persons resident in Edinburgh shall not be expected to give in testimonials on applying for such appointments, in the case of persons resident elsewhere, who may give in testimonials, not more than four testimonials shall be given in for each subject of examination, for appointment to which application is made.

"5. All vacancies shall be advertised in such newspapers and medical journals as the Court may direct, not less than one month before the date at which such vacancies are to be filled up."

Extracted by

J. CHRISTISON, W.S.,  
Secretary.

University of Edinburgh,  
10th November 1874.

**C.**

**LIST OF THE ADDITIONAL EXAMINERS IN MEDICINE, RECENTLY APPOINTED BY THE EDINBURGH UNIVERSITY COURT, UNDER THE SYSTEM INTRODUCED BY THE ALTERATION OF THE ORDINANCES RELATING TO THE MATTER, APPROVED BY HER MAJESTY BY ORDER IN COUNCIL DATED 6TH AUGUST, 1874.**

With power of annual re-appointment by the Court for three years.

*Anatomy*.—1. John Chiens, M.D., Lecturer on Surgery, Edinburgh, formerly Demonstrator of Anatomy in the University.  
*Midwifery*.—2. Angus McDonald, M.D., Lecturer on Midwifery, Edinburgh.

*Clinical Surgery*.—3. James Dunsmuir, M.D., formerly Surgeon to the Royal Infirmary, and Lecturer on Clinical Surgery, Edinburgh.

With power of annual re-appointment by the Court for Four years.

*Botany*.—4. Hugh Cleghorn, M.D., formerly St. Andrews, Examiner in Botany to the India Office for the Forestry appointments, and formerly Professor of Botany and Materia Medica, and Botanist to Government, Madras.

*Medical Jurisprudence*.—5. David Ferrier, M.D., Professor of Forensic Medicine, King's College, London.

With power of annual re-appointment by the Court for Five years.

*Chemistry*.—6. James Dewar, F.R.S.E., Jacksonian Professor in the University of Cambridge.

*Practice of Physics*.—7. Dyeo Duckworth, M.D., Assistant Physician to St. Bartholomew's Hospital, London.

*Natural History*.—8. Wm. C. McIntosh, M.D., Murthly, Author of various important original works on Natural History.

With power of annual re-appointment by the Court for Six years.

*Pathology*.—9. Joseph Fi-Fayis, M.B.S.B.S., Assistant Physician to, and late Demonstrator of Morbid Anatomy at St. Thomas's Hospital, London.

*Materia Medica*.—10. Thomas R. Fraser, M.D., F.R.S.E., Medical Officer of Health, Mid-Cheshire, formerly Lecturer on Materia Medica, Edinburgh, and Examiner on Materia Medica in the University of London.

With power of annual re-appointment by the Court for Seven years.

*Surgery*.—11. James Dunsmuir, M.D. (See above).

*Clinical Medicine*.—12. D. R. Haldane, M.D., Lecturer on Practice of Physic and on Clinical Medicine, Edinburgh, Physician to the Royal Infirmary, Edinburgh, and Member of the General Medical Council.

*Physiology*.—13. Arthur Gamgee, M.D., F.R.S.S.L. & E., Professor of Practical Physiology in the Owens College, Manchester, and Examiner on Forensic Medicine to the University of London.

J. CHRISTISON,  
Secretary to Edinburgh University Court.

D.

EXTRACT FROM THE MINUTES OF THE UNIVERSITY COURT ON 10TH JUNE 1874, BEING RESOLUTION ADDING A DEPARTMENT OF PUBLIC HEALTH TO THE DEPARTMENTS IN WHICH DEGREES IN SCIENCE MAY BE OBTAINED IN THE UNIVERSITY OF EDINBURGH.

The University Court of the University of Edinburgh, considering the great demand which now exists for Medical Officers of Health, and the importance to the public of some means of ascertaining that members of the medical profession have specially studied the subject of Public Health, and having, as required by Section xii. 2, of the Universities (Scotland) Act, 1858, held due communication on the matter with the Senatus Academicus, and communicated it to the General Council of the University for their consideration at their meeting of 21st April, last, 1874, Resolve—

I. That a Department of Public Health shall be added to the Departments in which Degrees in Science may be present be obtained in the University at Edinburgh.

II. Candidates for Graduation in Science in the Department of Public Health must be Graduates in Medicine of a British University, or of such Foreign or Colonial Universities as may be specially recognized by the University Court.

III. Candidates who have not passed an *Annus Medicus* in the University of Edinburgh must, before presenting themselves for examination, have attended as matriculated Students in the University at least two courses of instruction, Scientific or Professional, bearing on the Subjects of the Examinations.

IV. There shall be two Examinations for the Degree of Bachelor of Science in the Department of Public Health: Candidates who have passed the First Examination may proceed to the Second after an interval of five months.

V. Candidates must produce evidence that, either during their Medical Studies, or subsequently, they have attended a course of lectures in which instruction was given on Public Health, and that they have studied Analytical Chemistry practically for three months with a recognized teacher.

VI. The Examinations shall be written, oral, and practical, and shall be conducted by University Examiners selected by the University Court.

VII. The Subjects of the Examinations for the Degree

of Bachelor of Science in the Department of Public Health shall be as follows:

FIRST EXAMINATION.

1. *Chemistry*

Analysis of Air, Detection of Gaseous Emanations and other Impurities in the Atmosphere.

Analysis of Waters for Domestic Use, and Determination of the Nature and Amount of their Mineral and Organic Constituents.

Detection, Chemical and Microscopical, of Adulterations in Articles of Food and Drink, and in Drugs.

Practical Examination, including at least two analytical researches.

2. *Physics*

Hydraulics and Hydrostatics, in reference to Water Supply, Drainage, and Sewerage.

Pneumatics, in reference to Warming and Ventilation.

Meteorology, and methods of making Meteorological Observations.

Mensuration, in reference to the Plans and Sections of Public and Private Buildings, Mines, Water-

Works, and Sewers.

3. *Sanitary Law*

Knowledge of the leading Sanitary Acts of Parliament.

4. *Vital Statistics*

Knowledge of statistical methods and data in reference to Population, Births, Marriages, and Deaths.

SECOND EXAMINATION.

1. *Medicine*

Origin, Nature, and Propagation of Epidemic and Contagious Diseases.

Prevention of Contagion and Infection.

Endemic Diseases, and the Geographical distribution of Disease.

Insalubrious Trades.

Overcrowding.

Epidemics, including pathological changes.

2. *Practical Sanitation*

Duties of a Health Officer in reference to,—

Water Supply.

Insalubrious Dwellings and Public Buildings.

Removal and disposal of Sewage and other Refuse and Impurities.

Cemeteries.

Nuisances from Manufactories, etc.

Bad or Insufficient Supplies of Food.

Outbreaks of Zymotic Diseases.

Quarantine.

Disinfectants and Deodorizers.

Construction of permanent and temporary Hospitals.

VIII. Bachelors of Science in the Department of Public Health may, after the lapse of one year, proceed to the Degree of Doctor in the same Department on producing evidence that they have been engaged in Practical Sanitation since they took the said Degree of Bachelor of Science, and on presenting a Thesis on some subject in the Department of Public Health. Every such Thesis must be certified by the Candidate to have been composed by himself, and must be approved of by the Examiners.

IX. The fees for the said Degrees in Science in the Department of Public Health shall be,—

For the first Examination for the Degree of Bachelor	£5 5 0
For the second Examination for the Degree of Bachelor	5 5 0
For the Degree of Doctor	5 5 0
	£15 15 0

Extracted by CHRISTISON, W.S., Secretary.

Edinburgh, 12th June 1874.

Edinburgh, June 15th, 1874.—I approve of the Regulations contained in the foregoing Extract Minute, and sanction the same in terms of the Universities (Scotland) Act, 1858, Section xii. 2.

JOHN ENGLIS,  
Chancellor of the University.

III.—STATEMENT of the total EMOLUMENTS, of the PROFESSORS and ASSISTANTS in the UNIVERSITY OF EDINBURGH; and SCHEDULE of LECTURES and LABORATORY INSTRUCTION.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, London, S.W., May 31st 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to inform you that the Commissioners with a view of making their Report on the Universities of Scotland as complete as possible and, as far as may be, similar in the character of the information it affords, to the Report already issued on the English Colleges, are desirous of including a Statement of the Total Emoluments of the Professors and Assistants in the various Faculties.

With this view, the accompanying Schedules have been drawn up, and I am to ask you to be so good as to further the Inquiries entrusted to the Commission by affording the required information in as complete a form as possible, together with any remarks you may be pleased to make.

I am to add, that as the Report is now nearly ready for presentation to Her Majesty, the Commissioners would be glad to receive the Schedules at as early a date as practicable.

I have the honour to be, &c.,

The Principal of  
The University of Edinburgh.

J. NORMAN LOCKYER,  
Secretary.

[The following Returns have been forwarded to the Royal Commissioners by the Principal of the University of Edinburgh.]

L.—SCHEDULE OF PAYMENTS.

Chair.	Endowment.	Actual Fees received in 1874-75.	Total of Emoluments.	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.	REMARKS.
<b>I.—FACULTY OF ARTS.</b>						
1. HUMANITY (OR LATIN)	£ s. d. 247 0 0	£ s. d. 900 0 0	£ s. d. 1,158 0 0	1	100	In addition to the Endowment and Class fees (which were above the average last year), a small addition is made to the total of emoluments, by the fees for one or two examinations. My assistant receives from 80l. to 100l. more from the fees of two Summer Classes taught by him during the Summer Session.
2. GREEK	About 230l.	About 640l.	About 1,070l.	1	100	
3. MATHEMATICS	198 5 6	845 15 6	1,044 2 2	1	100	There is about 44l. of expenses to be deducted, leaving the clear emoluments at 1,000l.
4. LOGIC AND METAPHYSICS.	306 0 0	470 0 0	776 0 0	1	40	Fees in Session 1874-75, above the recent average. Stipend of assistant not sufficient.
5. MORAL PHILOSOPHY.	322 4 4	409 14 0	731 18 4	1	40	The class of session 1874-5 was considerably higher in numbers than any previous class during my term of office.
6. NATURAL PHILOSOPHY.	302 4 4 with about 86l. from the recent bequest of Sir D. Baxter	668 17 0	937 1 4	2	200	The Baxter Endowment is at the disposal of the University Court, which has begun on the principle of giving less to a professor in proportion as his class is larger.
7. RHETORIC AND ENGLISH LITERATURE.	About 270l.; of which 200l. from Public Money, and about 70l. from Baxter Bequest.	570 0 0	840 0 0	1	40	
8. PRACTICAL ASTRONOMY.						
<p>[With regard to this Chair, the Principal of the University, in a letter dated 3rd July 1875, says—"I take it upon myself to make the following Return for the Chair of Practical Astronomy (no Return having been furnished by the present Professor of this subject) —</p> <p style="text-align: center;">" Endowments :</p> <p style="text-align: right;">Parliamentary Vote - £300</p> <p style="text-align: right;">Sir David Baxter's Bequest (about) - 20</p> <p style="text-align: right;">Fees - —</p> <p style="text-align: right;">Total emoluments (say) - £320</p> <p style="text-align: center;">" Lectures Winter, &amp; Summer, &amp;c.</p> <p>" The Professor is also Astronomer Royal [for Scotland], and receives, in that capacity, 100l per annum additional to his former salary, by a separate Parliamentary Vote. He states that his duties at the Observatory do not admit of his giving regular Courses of Lectures in the University. He offers to advise and assist such Matriculated Students as may apply to him with a view to Instruction in Practical Astronomy (see his Statement in <i>Edinburgh University Calendar for 1875-76</i>, p. 76). The Chair, however, was founded expressly with an educational object in view, and the University Court have lately had a good deal of correspondence with Professor Piazzi Smyth, as to the possibility of his fulfilling the intentions of the Royal Founder of his Chair, by giving Instruction in Practical Astronomy. Should your Commission desire further information on this subject, I should be happy to afford it."</p>						
9. AGRICULTURE AND RURAL ECONOMY.	12 10 0 37 10 0 150 0 0 150 0 0 18 0 0	120 0 0	488 0 0	None	None	None.
	368 0 0 in all.					

Chair.	Endowment.	Actual Fees received in 1874-75.	Total of Emoluments.	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.	REMARKS.
10. MUSIC.	£ s. d. (Reid Fund) 47 5 0 For Assistance, Instruments, Museum, Library, &c., of Class room, 300l. For Annual Reid Commemoration Concert, 300l. Salary of Professor, 420l. Also from Baxter Fund, an item of (average) 17l. 10s	£ s. d. 484 15 0	£ s. d. 484 15 0	1 (Organ) 1 (Pianoforte), 1 (Janitor Custos, &c., of Class room) Total, 3.	£ 150	
11. SANSKRIT AND COMPARATIVE PHILOLOGY.	—	—	—	—	—	
12. ENGINEERING (CIVIL AND MECHANICAL).	400 0 0	220 10 0	620 10 0	1	40 Paid by the University	My assistant receives further payment from me in consideration of work done for me in my private business. I could not otherwise secure a competent assistant for the pay allowed by the University. The fees are received for three classes. The emoluments are not wholly profits, as some small expenses necessarily fall on the Professor, but these expenses are small.
13. GEOLOGY AND MINERALOGY.	200l. and 200l. from annual Parliamentary Vote.	120 0 0	520 0 0	None	—	A sum of about 46l. annually was provided by the Founder of the Chair for class expenses.
14. COMMERCIAL AND POLITICAL ECONOMY AND MERCHANTILE LAW.	450 0 0	126 0 0	576 0 0	None	None	This Chair was founded and endowed by the Edinburgh Merchants' Company. They pay annually 24l for prizes and 50l for class expenses, including class library, purchase of diagrams, &c., &c

II.—FACULTY OF THEOLOGY.

1. DIVINITY	£ s. d. 442 2 2	£ s. d. 119 14 0	£ s. d. 566 16 2	None.	£ None.	The sum under the head of "Endowment" is that given in the University Calendar, as I have no other means of knowing, owing to Professor Crawford's absence. The amount of Fees is that received from 57 students, at two guineas each. There were other fees, but these, according to the Professor's instructions, were admitted to the class without a fee.
2. DIVINITY AND CHURCH HISTORY.	350 0 0	79 16 0	429 16 0	—	—	
3. BIBLICAL CRITICISM AND BIBLICAL ANTIQUITIES.	629 0 0	68 0 0	697 0 0	—	—	There were 42 students, of whom 12 received free tickets. The fee is 2l 2s. The income is rapidly and steadily diminishing, as it is drawn from the tithes of the Chapel Royal, and parish ministers in 14 parishes have a right to augmentation of stipend from these tithes. Each has a right every 20 years.
4. HEBREW AND ORIENTAL LANGUAGES.	300 0 0	71 8 0	371 8 0 *2 2 0 373 10 0	Had an assistant for three weeks for the first time in 37 sessions.	—	* Add for two Students of Elementary Hebrew.

Chair,	Endowment.	Actual Fees received in 1874-75.	Total of Emoluments.	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.	REMARKS.
<b>III.—FACULTY OF LAW.</b>						
1. CIVIL LAW	£ s. d. 250 0 0	£ s. d. 284 8 0	£ s. d. 484 8 0	None	£	Average expenditure of Professor for current foreign literature of Roman Law, about 40l a year; for prizes, in addition to grant (5l.) from University chest, 74. 10s.
2. LAW OF SCOTLAND.	100 0 0	718 5 0	818 5 0	Two assistants for conduct of examination during both winter and summer sessions	50	
3. CONVEYANCING	105 0 0	457 16 0	562 16 0	4	40	The number of students enrolled was 124. Of these, nine students having already attended two sessions were entitled to free tickets, and free tickets were given to six students who were clerks in the professors' new chambers. The number of students paying fees, therefore, was only 109. The assistants are employed solely in assisting in examining written papers. Their stipend is paid by an annual University grant of 40l., and not by the Professors.
4. PUBLIC LAW AND THE LAW OF NATURE AND NATIONS	250 0 0	37 16 0	Averages about 300l.			The Chair is not, and could not under any circumstances be made self-supporting with the present endowment. It has consequently to be maintained by the Professor, in place of the Professor being maintained by it.
5. CONSTITUTIONAL LAW AND HISTORY	Annually, 150l paid by Exchequer	44 0 0	314 4 0			There is also a share of the Baxter Endowment, estimated at 20l.
6. MEDICAL JURISPRUDENCE						[See under 11. FACULTY OF MEDICINE.]
<b>IV.—FACULTY OF MEDICINE.</b>						
1. ANATOMY	None Deduct expenses.	£ s. d. 2,000 0 0 895 0 0	£ s. d. 1,605 0 0	3 Demonstrators 2 Assistant Demonstrators 1 Mechanical Assistant 1 Porter 1 Charwoman Other expenses of Chair.	£ 605 180 Total 685	To meet the annual expenses of the Chair of Anatomy, 290l is allowed to the Professor from the General Fund of the University; the balance of 395l is paid by the Professor out of the fees. The total emoluments of the Chair, as derived from fees, are reduced, therefore, by this sum of 395l.
2. CHEMISTRY	200 0 0	1,416 9 0	1,616 9 0	2*	200 from University Fund. 100 contributed by the Professor	* Besides the two regular assistants, a Senior Student receives a scholarship of about 30l per annum, temable for one year, on condition that he assists in teaching the junior students in the Laboratory. † This sum varies from year to year. 165l is the sum spent this year.
3. MATERIA MEDICAL	100 a year	*674 0 0	774 0 0	1	50	When the Professor commences classes for the practical instruction of students in the New College Buildings, he will require the services of a highly qualified assistant, a junior assistant, and a laboratory servant, the salaries of whom can scarcely be less than 250l. It is submitted that these salaries should be paid from the General University Fund, or some special endowment; for the annual charges for other objects in teaching practically, will be so large as to absorb a large proportion of the fee which the University may sanction. * The average fees for some years past have been under 600l.

Chair	Endowment.	Actual Fees received in, 1874-75	Total of Emoluments	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.	REMARKS
4. INSTITUTE OF MEDICINE OR PHYSIOLOGY.	150l from Commissioners for Professor. 100l from Commissioners for assistant. 50l from University for expenses.	1,052 2 0	1,202 2 0	1 demonstrator	100 140 40l from Professor	As the Professor pays from his fees 40l to increase the salary of his assistant, and about 30l to cover working expenses, his net income is 1,132s 2s, as nearly as can be calculated for this year (not yet concluded)
5. PRACTICE OF PHYSIC.	100 0 0 (see note under Remarks)	360 0 0	Gross of the Chairs from all sources, 566 4 0 No account kept of all deductions, but the Museum for course of Medical Psychology has been formed wholly at the cost of the Professors	Three for the three classes.	50	1 Strictly the sum under "Endowment" is the equivalent for the examination fees taken from the Professor when the University was re-organized. At present it may be considered as a salary for doing the work of an examiner for degrees, so that there is no endowment. 2 The sums received for the different classes are the gross amounts. The cost of the Medical Psychology Course is borne entirely by the Professor, being a voluntary class.
SHARE OF CHAIR OF CLINICAL MEDICINE (Winter and Summer Courses).	Nil	180 12 0	See note 2, under Remarks			
SHARE OF CHAIR OF MEDICAL PSYCHOLOGY AND CLINIC OF MENTAL DISEASES. Add "Endowment."	Nil	75 12 0	See note 2, under Remarks			
		566 4 0				
6. SURGERY	100 0 0	Winter Class—541 0 0 Summer <sup>1</sup> Operative Class—60 0 0	701 0 0	1 paid assistant	50l paid from University fund.	Winter Class Surgery—I have replied to the queries <sup>1</sup> as put in Schedule. They seem only to refer to the gross amount of fees and endowment, but there are many expenses connected with carrying on the class, which should be deducted, probably amounting to 100l for subjects, museum expenses, instruments, apparatus, &c. <sup>2</sup> Summer Class Operative Surgery.—The sum of 60l mentioned under the above head, is the gross amount of fees. But as it is necessary to limit the number of pupils, owing to the state of the present University accommodation, and as the expenses for material and instruments are very considerable, the fees never remunerate for teaching the class as at present conducted.
7. MIDWIFERY AND THE DISEASES OF WOMEN AND CHILDREN.	100 0 0 Equivalent for examining fees.	Winter session—366 9 0 Summer session—58 14 0 Fees for clinical teaching—78 9 0	513 3 0		50	
8. GENERAL PATHOLOGY, INCLUDING MORBID ANATOMY.	100 0 0	613 8 0	713 8 0	1	50	
9. CLINICAL MEDICINE.	[See under 5]	FRACTION OF PHYSIC, and under 11.				
10. CLINICAL SURGERY.	100 0 0	689 17 0	789 17 0			
11. MEDICAL JURISPRUDENCE Share of Chair of Clinical Medicine.	100 0 0	546 0 0 181 0 0	646 0 0 181 0 0	1 The house physician of the hospital.	50 None.	The real want as to the Chair of Medical Jurisprudence is of decent emolument for an assistant, who should give his whole time to the Laboratory, and enable students to practise analyses in reference to questions of Medical Jurisprudence, and more especially still, of public health, such as water analysis, &c. It is needless to say that the present pay of the assistant is incompatible with this.

Chair.	Endowment	Actual Fees received in 1874-75.			Total of Emoluments.	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.	REMARKS.
		£ s. d.	£ s. d.	£ s. d.				
12. BOTANY		200 0 0	1,270 0 0	1,470 0 0		Four, besides the Curator of the Botanic Gardens and three or four gardeners.	100l. of which 50l. is paid by the University. Each student pays 5s to the Curator of the Garden; this amounted in 1874 to nearly 90l. This fee to the Curator ought to be paid by Government and not by students.	The emoluments of the Chair of Botany vary much. During the last 30 years the number of students has varied from 160 to 354. The fees for the courses are given in an appended printed notice. See ¶.
13. NATURAL HISTORY.		195 15 2½	For 1875 1,250 11 0	—	1		30	There is no record of the amount of fees received in 1874; Professor Curas having lectured for Professor Wyville Thomson. This summer Professor Huxley conducts the class. The amount of fees received this summer is exceptionally large, the number of students being greatly in excess of the usual number.
14. MEDICAL PSYCHOLOGY WITH PRACTICAL INSTRUCTION IN MENTAL DISEASES.			[See under 5. PRACTICE OF PHYSIC.]					

See para. 57, at 409

## II.—SCHEDULE OF LECTURES AND LABORATORY INSTRUCTION.

Chair	Lectures per Week.		Lectures per Session.		Laboratory Work.		REMARKS.
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	

## I. FACULTY OF ARTS.

1. HUMANITY.	15* every session, and 4 additional every alternate session	None.	300 or 380	None.	—	—	* Of these lectures or class meetings for oral examinations, the assistant has five each week. The Professor has thus 10 weekly every session, and 14 every alternate session.
2. GREEK.	Two lectures per week in third or private class; one lecture per week in second class; lectures or compositions in first class occasional, teaching, five hours a week in each class; nine hours per week of tutorial work.	—	About 80, teaching hours, inclusive of lectures, about 300. About 170 of tutorial work.	—	—	—	
3. MATHEMATICS.	13	5 Tutorial only.	About 280	—	—	—	
4. LOGIC AND METAPHYSICS.	5	—	105	—	—	—	

Chair.	Lectures per Week.		Lectures per Session.		Laboratory Work.		Remarks	
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.		
5. MORAL PHILOSOPHY.	5	—	About 25	—	—	—	Of the five lectures per week.— Three are formal lectures; Two are in the form of oral examinations, and conversational expositions.	
6. NATURAL PHILOSOPHY.	5 to ordinary class. 3 to advanced class Total 8	—	110 64 174	—	23 weeks. 25 hours per week	12 weeks 25 hours per week.	Summer lectures (about 60 per annum) have this year, for the first time, been undertaken by the Professor at the urgent request of the Medical Faculty. It is probable that this may become a permanent institution, if so, the short period of each year which the Professor has hitherto been able to devote to original work will be very seriously encroached upon.	
7. RHETORIC AND ENGLISH LITERATURE.	5	—	100, or just over.	—	—	—	—	
8. PRACTICAL ASTRONOMY. [See Remarks with regard to this Chair under Schedule of Payments, p. 54.]								
9. AGRICULTURE AND RURAL ECONOMY.	5	None.	90 to 100	None.	None.	None.	None	
10. MUSIC	It has been found, in some years' experience of an Art Professorship, that formal lectures are of far less educational value than individual teaching. Recently, therefore, this class has, separately and individually, received practical and theoretical instruction, and thus the progress of each student is constantly gauged and observed. It is impossible that any course of lectures can make a musician, in the artistic sense of the word. A musical student must himself work, with frequent assistance and examination of his work. The principles of Harmony being, like those of Acoustics, based on laws of nature, Music is in one sense a Science as well as an Art. But the subject comes more strictly under the domain and province of Art, as in the case of other Fine Arts. The sympathy and interest of the greatest musicians have ever been with the artistic rather than with the scientific aspect of this study. Whilst leaning to the former of these aspects, the present teaching of this Chair aims at combining Art with Science, Practice with Theory.		15 hours are given weekly to the class, each student receiving an hour, as examination of prepared work, practical or theoretical.		A choral class, consisting of about 150 Matriculated Students, has been established in connexion with the Chair (so far as its being trained and conducted by the Professor as voluntary extra work), entitled "The University Musical Society." This meets in the music class room every week or oftener for practice of vocal music, and as evidence of progress a public concert is given in March		Performances on the class room organ by the Professor are given generally on alternate weeks. To these students are admitted by public notice at the College gate, on presentation of Matriculation ticket The privilege has also been extended to unmatriculated persons, of whom a certain number are admitted on personal written application. The conferring of Degrees in Music is urgently advocated. The University of Edinburgh is the only one possessing a Chair of Music which does not give Bachelors' and Doctors' degrees in that Faculty.	
11. SANSKRIT AND COMPARATIVE PHILOLOGY.	—	—	—	—	—	—	—	
12. ENGINEERING (CIVIL AND MECHANICAL)	5	5	100	About 12	In a separate class mechanical drawing is taught five days per week for 3 hours each day	The students at the conclusion of the short course of lectures are taken for six hours each day during 13 days into the field and taught surveying, levelling, and setting out.	There are three classes conducted by the Professor and his Assistant— 1st The main class, held during the winter session. 2nd. The drawing class, held during the winter session, and chiefly taught by the assistant. 3rd. The summer class of surveying, levelling, and setting out taught by the Professor and his assistant.	
13. GEOLOGY AND MINERALOGY	3	—	60	—	—	32	During the session 1874-75, eight excursions for practical instruction were taken to places of geological interest in the neighbourhood of Edinburgh. At the close of the session, as usual, an excursion of eight days' duration was made. This year the area visited included a traverse of the Highland boundary line from Stonehaven to Aberfoil.	
14. COMMERCIAL AND POLITICAL ECONOMY AND MERCANTILE LAW.	5	None.	About 105	None.	None	None	Two lectures are devoted (per week) to Economics; two to Commercial questions, and one, on alternate weeks, to comments on the fortnightly exercises; the other to subjects of interest at the time in commerce or finance. The lectures are interspersed with questions.	



Chair.	Lectures per Week.		Lectures per Session.		Laboratory Work.		REMARKS.
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	

II. FACULTY OF THEOLOGY.

1. DIVINITY.	10	None.	About 170	None.	None.	None.	There are two classes, a junior and senior.
2. DIVINITY AND CHURCH HISTORY.	5	—	110	—	—	—	
3. BIBLICAL CRITICISM AND BIBLICAL ANTIQUITIES.	4	—	About 90	—	—	—	From November 11 till the end of March is the divinity session. The lectures were sometimes from MS. and sometimes expositions of a text-book, or of Greek Testament, &c., from notes.
4. HEBREW AND ORIENTAL LANGUAGES.	Teach 5 days a week.	Teach 2 days a week.	An introductory lecture or two.	None.	None.	None.	

III. FACULTY OF LAW.

1. CIVIL LAW.	5	5	90	46	—	—	"Lectures" include examinations, of which there are eight in winter and six in summer. The course is continuous, the audience the same, and the fee (bl. fr.) covers both sessions.
2. LAW OF SCOTLAND.	—	—	94 meetings for lecture or examination.	46 meetings for lecture or examination.	—	—	
3. CONVEYANCING.	—	None.	90	None.	—	—	65 of the 90 lectures entered were lectures of one hour each. Eight were written examinations of one hour and one half each. Attended almost exclusively by students for the first and the higher class of agents, who have, for the most part, already graduated in Arts, either here or in England.
4. PUBLIC LAW, AND THE LAW OF NATIONS AND NATIONS.	—	—	60 to 90 are given; the number requisite under the Commission being only 40.	—	—	—	
5. CONSTITUTIONAL LAW AND HISTORY.	—	4 regular and a 5th lecture or examination occasionally	—	40	—	—	
6. MEDICAL JURISPRUDENCE.	—	—	—	—	—	—	

IV. FACULTY OF MEDICINE.

1. ANATOMY. Systematic Lectures and Demonstrations.	5	5	100	80	Dissecting room open daily from 9 to 4, from Oct. 1st to April 15th.	Dissecting room open daily from 9 to 5, from May 1st to July 30th.	In conjunction with the Systematic Lectures at Tutorial Demonstrations on Osteology, four days a week for three months from 9 to 10. Also about 20 Demonstrations on Microscopic Anatomy, from 2 to 3.30 p.m. The Professor is engaged during the whole day at the College. The number of Students enrolled in the Class of Anatomy during the incumbency of the present Professor has varied during the Winter Sessions from a minimum of 256 to a maximum of 465, during the Summer Sessions from 75 to 180.
2. CHEMISTRY.	3	3	100	35	Chemical Laboratory open five days per week from 10 a.m. till 4 p.m.	Chemical Laboratory as in winter.	In the Laboratory students are taught chemical analysis, and the making of chemical preparations, and when sufficiently advanced undertake original researches.
					PRACTICAL CHEMISTRY CLASS.		
					During the months of January, February, and March, five hours per week, about 60 hours per session.	Two classes, each 5 hours per week; about 60 hours per session.	The practical chemistry classes are chiefly attended by medical students who have not sufficient time for a full laboratory course.

Chair.	Lectures per Week.		Lectures per Session.		Laboratory Work.		REMARKS.
	Winter	Summer	Winter	Summer	Winter	Summer.	
3. MATERIA MEDICA.	5		100		None		None practical, except by the Professor and his Assistant, as there is no accommodation for Students. But an extensive Laboratory, for the practical instruction of Students, forms part of the plan of the new College buildings. This instruction will be given probably in summer.
4. INSTITUTE OF MEDICINE OR PHYSIOLOGY.	5	None.	100	None	Two classes of practical physiology. Each class meeting for one hour three times a week during five months.	Four classes of practical physiology. Each class meeting for one hour five times a week during three months.	Also general laboratory instruction in practical physiology.
5. PRACTICE OF PHYSIC.	5 and 1 tutorial examination		100		One hour three days a week.	End	1. Practical instruction at the bedside is meant under head Laboratory Work 2. Besides work, as stated, the Professor has to examine all the written and oral examinations for the pass for degrees in Medicine, and to examine continuously for above six weeks in Clinical Medicine during the summer session.
6. SURGERY.	5 lectures per week. Also occasional meetings and examinations on Saturdays.	Practical class for operations, four meetings per week, one each day	100 lectures at least	48 or 50 meetings, not formal lectures, practical instruction in operative surgery.	*Class for practical bandaging and surgical appliances. Conducted by my assistant, one hour each day, six days per week.	Operative surgery may be considered as corresponding to laboratory instruction	*This class consists of sections of the Class of Surgery, and is open to all students of that class without extra fee.
7. MIDWIFERY AND THE DISEASES OF WOMEN AND CHILDREN.	5		98	25	2 1/2 hours during the latter half of the session, one spent in practical instruction of students by the class assistant	3 1/2 hours of practical instruction by the Professor	Besides giving the five lectures per week during winter, the Professor meets the class for oral examination each Saturday
8. GENERAL PATHOLOGY, INCLUDING MORBID ANATOMY.	5	None this summer	100	None this summer	Daily.	None this summer	
9. CLINICAL MEDICINE.	2	1	25	12	2 hours Clinical teaching daily.	2 hours Clinical teaching daily.	
10. CLINICAL SURGERY	2	2	About 140	About 24			
11. MEDICAL JURISPRUDENCE AND POLICE, OR PUBLIC HEALTH Chair of Clinical Medicine.	2	5	40	60			The laboratory is open all the year for students to work in at voluntary work. The daily work at the hospital, four days a week, may be regarded as the laboratory work in reference to Clinical medicine.

Chair.	Lectures per Week.		Lectures per Session.		Laboratory Work.		REMARKS.
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	
12. BOTANY.	Occasional courses of popular lectures amounting to 30 or 40.	Lectures 5, of 1 hour each. Demonstrations 2, of 1 hour each. Weekly excursions on Saturdays with demonstration. Time occupied each day from 5 to 10 or 12 hours.	See reply in previous winter column.	Lectures 60 to 65. Demonstrations, 30 to 35. 12 excursions on Saturdays, with demonstrations, from 2nd week of May till last week of July.	Histological room, herbarium room, and museum open for practical work. Garden and houses also open.	Special histological classes conducted by the Professor of Botany and his assistants, four days a week, from 1st May to the end of July.	There is a great want of accommodation for students, both as regards the lecture-room and the practical working room. There is no facility for carrying on proper laboratory work, more especially in the department of physiological botany. Rooms and apparatus are urgently required. The University has supplied 12 microscopes for the class, while I have supplied 60.
<i>Statistics of the Botanical Class for 1874.</i>							
Number of pupils, 354; of these 308 were medical students, 9 science students, 4 pharmaceutical students, and 33 general students. Students of first year, 225; advanced students, 129. Pupils of the class of Vegetable Histology, 51. Number of lectures and examinations, 60; practical demonstrations, 30; histological demonstrations, 30; competitive examinations, 8; excursions, 12.							
The following were the excursions:—1. Gorebridge and Arnisdon. 2. Kinghorn and Burntisland. 3. Currie and Slateford. 4. Dirlston and North Berwick. 5. Broonlee and Dalplinton. 6. Lumthgow. 7. Beattock and Moffat. 8. Springfield and Ladybank. 9. East Linton and Tynninghame. 10. Bridge of Allan and Stirling. 11. Murthly. 12. Inverran, Ben Vorlich, Loch Lomond.							
Number of species of plants collected during the excursions.—Phanerogamous plants, 635; ferns and their allies, 41; other cryptogams, 64. Total, 740.							
Number of miles travelled by railway, steamboat, and walking, 961. The number of students who attended the excursions was 228; and the number at each excursion varied from 15 to 133. Total expense of the trips, 31. 7s.							
13. NATURAL HISTORY.	—	5	—	From 50 to 60	—	—	*The laboratory is open daily from 10-4 this summer. Owing to the want of accommodation the number of students attending is limited to 20. Dissection of typical examples of the several groups of the animal kingdom is carried on under the direction of Professor Huxley.
14. MEDICAL PSYCHOLOGY AND CLINIC OF MENTAL DISEASES.	—	—	—	48	—	1 to 2 hours at an asylum weekly.	—

For parts.  
52-4.

IV.—NUMBER OF STUDENTS attending the several COURSES in the UNIVERSITY OF EDINBURGH.

Royal Commission on Scientific Instruction  
and Advancement of Science,  
6, Old Palace Yard, London, S.W.  
May 11th, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to favour the Commissioners by stating the numbers of Matriculated Students at the University of Edinburgh in 1871-72, 1872-3, 1873-4.

Also the numbers studying in the Medical and Engineering Schools in each year from 1867-68 to 1873-74, both inclusive.

I have, &c.

J. NORMAN LOCKYER,

The Principal of The University of Edinburgh. Secretary.

NUMBERS OF Students Matriculated at the University of Edinburgh for the years 1871-72, 1872-73, and 1873-74.

1871-72	-	-	-	1,854
1872-73	-	-	-	1,906
1873-74	-	-	-	1,930

NUMBERS OF Medical Students in the University of Edinburgh in each year from 1867-68 to 1873-74, both years inclusive, and numbers attending the Class of Engineering in said University in each year since 1863, being the date of Foundation of the Chair, to 1873-74, both years inclusive.

Year.	No. of Medical Students.	No. of Engineering Students.
1867-68	445	—
1868-69	516	29
1869-70	596	47
1870-71	678	55
1871-72	725	45
1872-73	782	52
1873-74	839	50

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S.W.  
April 17th, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to favour the Commissioners with a Statement of the number

University of Edinburgh,  
May 14th, 1875.

SIR, In reply to your letter dated 11th instant, I have the honour to forward the annexed table containing the statistics required by his Grace the Duke of Devonshire.

I have, &c.

A. GRANT,  
Principal.

J. Norman Lockyer, Esq.

of Students attending the University Course during the past Session in the different Faculties of the University of Edinburgh. The Commissioners are desirous of having as detailed a Statement as possible

I have, &c  
The Principal of J. NORMAN LOCKYER,  
The University of Edinburgh. Secretary.

University of Edinburgh,  
22nd April, 1875

SIR, In compliance with the request contained in your letter, dated 17th instant, I have the honour to state the following particulars for the information of His Grace the Duke of Devonshire and the Commissioners on Scientific Instruction:—

The Winter Session 1874-75 in the University of Edinburgh was closed yesterday. During the Session the number of Students attending the University Course in the different Faculties has been as follows:

1. In the Faculty of Arts	-	-	778
2. In the Faculty of Medicine	-	-	743
3. In the Faculty of Law	-	-	310
4. In the Faculty of Divinity	-	-	66

1897

The Summer Session of the University will open on the 3rd May, when an additional number of Students will join the University. During the last three years the numbers of Students newly joining the different Faculties of the University in the Summer Session have been as follows:

Summer Session.	Faculties of			Total.
	Medicine.	Arts	Law.	
1872	99	8	9	106
1873	117	6	7	130
1874	128	8	8	144
Totals	334	22	24	380
Average	111	7	8	126

Owing to the fact that Professor Huxley is to lecture on Natural History in this University during the ensuing Summer Session, it is expected that the number of new Students will be above the average. But, taking merely the average, the number of Students attending the University of Edinburgh during the Academical Year 1874-75 may be set down as,

During Winter Session (actual)	-	-	1897
During Summer Session (estimate)	-	-	126
Total	-	-	2023

I have, &c.  
J. Norman Lockyer, Esq., A. GRANT,  
Commission on Scientific Instruction. Principal

no. 55. V.—STATEMENT of the FEES payable by Students attending the Courses at the University of Edinburgh.

Royal Commission on Scientific Instruction and the Advancement of Science.  
6, Old Palace Yard, S W.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to state, for the information of the Commissioners, the amount, on an average, of the fees payable by Students per annum at the University of Edinburgh.

I have, &c.  
To the Principal of J. NORMAN LOCKYER,  
The University of Edinburgh. Secretary

University of Edinburgh,  
5th May, 1875.

SIR, IN reference to your letter dated 28th April (which absence from Edinburgh has prevented me from replying to sooner), I beg to enclose excerpts from the University Calendar [marked A & B] which show the fees charged for each Class in the different Faculties.

It will be seen that the fee for each Class, or Course of Lectures, in Medicine is four guineas, for each Class in the Faculty of Arts, three guineas, with the exception of Sanskrit, Geology, Agriculture, and Engineering, which are charged four guineas each, for each class in the Faculty of Theology, two guineas; while the fees in the Faculty of Law vary from five to three guineas, according to the length of the respective courses.

I also enclose excerpts (marked C & D) which show the minimum cost of a full Medical Education in the University, and the incidence of that cost on each year of the Student's attendance.

With regard to the Faculties of Arts, Law, and Theology, perhaps, it may be roughly estimated that each Student attends two Classes on an average per annum. I beg, however, to point out, for the information of His Grace the Duke of Devonshire, that the Class fees of Students do not form any contribution towards the expenses of the University, as they go in each case entirely to the Professor who teaches the class.

The Matriculation fees mentioned in excerpt B are the only contribution made by Students towards the University expenses.

Each Student Matriculates, not once for all, but each year while he attends the University, and he pays the Matriculation fee which entitles him during that year to be a "civis" of the University. In the last published accounts of the University's Income the Matriculation Fees are stated for the year as 1,841l.

I have, &c.  
J. Norman Lockyer, Esqre A. GRANT,  
Principal

(A.)

Programme of Classes.  
SUMMER SESSION.

Classes.	Professors.	Class Fee
Engineering, Surveying, Levelling, &c.	Prof. Jenkin	2 3
Sanskrit	Prof. Aufrecht	3 3
Hindustani, &c.	Prof. Loston	2 2
Civil Law	Prof. Muirhead	5 5*
Scots Law	Prof. Macpherson	5 5*
Constitutional Law and History	Prof. Mackay	3 3
Medical Jurisprudence	Prof. MacLagan	4 4
Botany	Prof. Balfour	4 4
Botanical Demonstration—Monday, Wednesday, and Friday		4 4†
Vegetable Histology—Tuesday and Thursday		
Anatomical Demonstration	Prof. Turner.	
Practical Anatomy		2 2
Clinical Surgery—Monday and Thursday.	Prof. Lister	3 3
Clinical Medicine—Monday and Thursday, Tuesday and Friday	Prof. Laycock and Prof. Sanders	3 3
Natural History	Prof. Thomson	4 4
Practical Physiology	Prof. Rutherford	3 3
Medical Psychology and Mental Diseases—Monday, Tuesday, and Thursday	Prof. Laycock	2 2
Medical Psychology and Mental Diseases with Practical Instruction at an Asylum		3 3
Operative Surgery	Prof. Spence	2 2
Practical Pathology	Prof. Sanders	2 2

Summer Tutorial Classes in the Faculty of Arts, in Latin, Greek, and Mathematics, will be opened for Students who have attended a Winter Course on these subjects. These Classes will meet five days in each week, commencing on 2nd May, and closing on 21st July. Fee for each Class, 2s. 2s., payable to the Class Tutor.

\* Inclusive of Winter Session.  
† Besides the Garden fee of 4s.

WINTER SESSION  
Faculty of Arts, or Literature and Philosophy

Classes	Professors	Class Fees
First Humanity	Prof. Sellar	2 4
Second Humanity		3 3
Third Humanity		3 3
First Greek	Prof. Blackie	3 3
Second Greek		3 3
First Mathematical	Prof. Kelland	3 3
Second Mathematical		3 3
Third Mathematical		3 3
Logic	Prof. Fraser	3 3
Metaphysics		3 3
Moral Philosophy	Prof. Calderwood	3 3
Political Economy—Tues- day and Friday	Prof. Hodgson	3 3
Natural Philosophy	Prof. Tait	3 3
(Advanced Class)		3 3
Rhetoric and English Lite- rature	Prof. Masson	3 3
Practical Astronomy	Prof. Smyth	3 3
Agriculture	Prof. Wilson	4 4
Sanskrit and Comparative Philology	Prof. Aufrecht	4 4
Theory of Music	Prof. Dakeley	3 3
Engineering	Prof. Jenkin	4 4
Mechanical Drawing		3 3
Geology and Mineralogy	Prof. Geikie	3 3

Faculty of Theology.

Divinity—Junior Class	Prof. Crawford	2 2
Do. Senior Class		2 2
Divine and Church History	Prof. Stevenson	2 2
Biblical Criticism	Prof. Charteris	2 2
Do. Junior Division		2 2
Do. Senior Division		2 2
Tuesday and Thursday		2 2
Hebrew—Junior Class	Prof. Lison	2 2
Do. and Arabic Ad- vanced Class		2 2
Hindustani		2 2
Do.		2 2

(B.)

Faculty of Law.

Civil Law	Prof. Muirhead	5 5†
Law of Scotland	Prof. Macpherson	3 5†
Public Law	Prof. Lorimer	3 3
Conveyancing	Prof. Tytler	4 4
Constitutional Law and His- tory	Prof. Mackay	3 3
Medical Jurisprudence	Prof. MacLagan	4 4

Faculty of Medicine.

Materna Medica	Prof. Christison	4 4
Chemistry	Prof. Crum Brown	4 4
Surgery	Prof. Spence	4 4
Institutes of Medicine	Prof. Rutherford	4 4
Midwifery and Diseases of Women and Children.	Prof. Simpson	4 4
Clinical Surgery—Monday and Thursday.	Prof. Lister	4 4
Clinical Medicine—Monday Thursday, Tuesday, and Friday.	Professors Laycock, MacLagan, and Sand- ers.	4 4
Anatomy	Prof. Turner	4 4
Natural History	Prof. Thomson	4 4
Practise of Physic	Prof. Laycock	4 4
General Pathology	Prof. Sanders	4 4
Anatomical Demonstrations	Prof. Turner	2 2
Botany	Prof. Balfour	—

Royal Infirmary

Royal Infirmary at Noon, Daily—Perpetual Ticket, 10l;  
Annual Ticket, 5l 5s.; Half-yearly Ticket, 3l 3s. Sepa-  
rate payments of two years entitle the Student to a Perpetual  
Ticket.

† Fee, 2l 2s to those who have previously attended the Logic Class.  
‡ Two Courses of three months each.  
§ This includes the Summer Session. Second Year's Course, 3l 3s.

Matriculation Fees.

	£	s.	d.
For the Academical Year	1	0	0
For the Summer Session only	0	10	0

All Students are required to Matriculate at the Regis-  
trar's Office, in the University, before entering any of the  
Classes.

Class Sessions.

There are Two Seasons of the Classes in each year,

I The Summer Session, which opens in the beginning  
of May and ends with July.

II The Winter Session, which opens in the beginning  
of November, and ends with April, during which the Classes  
in all the four Faculties are assembled.

The order of attendance at the Classes in the Faculty of  
Arts is referred to in the statement relative to the Curricu-  
lum prefixed to the Synopses of the Classes in that Faculty,  
and is given at length in the Regulations for Graduation  
in Arts, &c.

In the Faculty of Medicine, besides the Regulations for  
Graduation, there is a Vidimus of the minimum cost of  
attendance, with the order of study recommended for  
Graduation, appended to the Synopses of the Classes in  
the Faculty of Medicine.

In the Faculties of Law and Divinity, the order of study  
is given in the Regulations for Graduation in these Facul-  
ties, to be found at a subsequent part of the Calendar.

During Summer and Winter, the following means are  
afforded for Practical Instruction—

Dissecting Rooms open daily, under the superintendence  
of Professor Turner, assisted by J. A. Russell, M.B., D. J.  
Cunningham, M.B., and A. H. Young.

Chemical Laboratories open daily, under the superinten-  
dence of the Professor, assisted by K. A. Lettis, Ph.D., and  
A. P. Atkin, D.Sc.

Physiological Laboratory open daily, under the superin-  
tendence of Dr. Rutherford, assisted by Wm. Stirling.

Physical Laboratory, and Medical Jurisprudence Labo-  
ratory, open daily from 10 to 3, under superintendence of  
Professors Tait and MacLagan.

Royal Botanic Garden, Herbarium, and Museum, open  
daily, during summer, from 6 a.m. to 6 p.m.

Natural History Museum, in the Museum of Science  
and Art, Argyll Square, is accessible to the Students  
attending the Natural History Class.

(C.)

Minimum cost of attending the Medical Classes, with the  
Order of Study.

Whilst there is no authorised order of study, the usual  
Course is given below: Preliminary Examination in Arts  
to be taken in the month of March or October, before  
entering Medical Classes. By order of the General Medical  
Council, all Medical Students require to be registered as  
such within fifteen days after the commencement of the  
Session. Students are recommended to commence their  
Medical Studies by attending the Summer Session.

First Summer Session

	£	s.	d.
Preliminary Exam- ination Fee	0	10	0
Matriculation Fee	0	10	0
Botany (besides gar- den fee, 5s)	4	4	0
Natural History	4	4	0
	29	8	0

Second Summer Session.

	£	s.	d.
Botany or Natural History, if not at- tended previously.	3	8	0
Practical Chemistry	3	8	0
Examination in Botany, Natural History, and Chem- istry, in October following	5	5	0
	23	8	0

First Winter Session.

	£	s.	d.
Matriculation (for whole year)	1	0	0
Anatomy	4	4	0
Practical Anatomy	3	8	0
Chemistry	4	4	0
Hospital	5	5	0
(Perpetual Ticket, 10l.)			
	21	16	0

Second Winter Session.

	£	s.	d.
Matriculation	1	0	0
Institutes of Medi- cine	4	4	0
Surgery	3	8	0
Hospital	5	5	0
Examination in Botany, Natural History, and Chem- istry, in April, if not previously passed.			

(D.)

Third Summer Session.		Fourth Summer Session.	
£	s. d.	£	s. d.
Practical Pharmacy	2 2 0	Medical Jurisprudence	4 4 0
Dispensary	2 2 0	Hospital, and Clinical Lectures.	4 4 0
Hospital	2 4 0		
			£4 4 0
		Fourth Winter Session.	
		£	s. d.
		Matriculation	1 0 0
		Practise of Medicine	4 4 0
		Midwifery	4 4 0
		Practical Midwifery	1 4 0
		Clinical Medicine	4 4 0
		Vaccination	1 1 0
		Hospital.	1 1 0
			£15 17 0
		Fifth Summer Session.	
		£	s. d.
		Hospital	1 1 0
		Final Examination for M.B. and C.M.	10 10 0
		Total Minimum Expenses for M.B. and C.M.	104 18 0
			£419 18 0

Only one Course of Instruction on each subject is here stated, that being the minimum.

Fees for Degrees

	£	s.	d.
Examination in Botany, Chemistry, Chemical Testing, and Natural History	5	5	0
Examination in Anatomy, Physiology, Materna Medica, and Pathology	5	5	0
Final Examination in Surgery, Midwifery, Practise of Physic, Clinical Medicine, Clinical Surgery, Medical Jurisprudence, and Prescriptions, during last Summer Session	5	5	0
Total Fees for M.B. Diploma	15	15	0
Additional Fee for C.M. Diploma	5	5	0
Additional Fee for M.D. Diploma	5	5	0
Government Stamp-Duty (for M.D. only)	10	0	0

Note.—Total Fees and Stamp for graduating as M.D. only, by Regulations for Students commencing before February 1861, 25l.  
The Fees for Examinations must be paid eight days before the dates thereof and the Fees for Degrees of C.M. and M.D., and Stamp-Duty for the latter, must be paid on or before the 15th day of July in the year of Graduation.

para. 62. VI.—THE PROPOSED NEW BUILDINGS FOR THE UNIVERSITY OF EDINBURGH.

My Lord MARQUESS, 23rd March 1875  
I AM requested by Mr. Lyon Playfair to furnish your Lordship with information relative to the proposed New Buildings for the University of Edinburgh  
The particulars are as follows:  
The site for the new Medical School and Hall of the University, in immediate proximity to the New Royal Infirmary of Edinburgh, has been purchased for a sum which, with law expenses, amounts to about 33,000l. About 1,000l. will have to be paid to redeem a servitude existing over part of the ground  
The Buildings themselves, which are being designed in the plainest style, are roughly estimated to cost 76,000l.  
The internal fittings are roughly estimated at 20,000l.  
The total cost of the New Buildings with Architect's fee may then be set down as not less than 135,000l.  
Besides this expense, about 20,000l. will be required for adapting the old Medical Class-rooms in the present College for the use of Professors in Arts, &c.; total 155,000l.  
Towards this there have been subscribed altogether about 75,000l. The subscription fund is nearly exhausted, but, perhaps, by great exertions, some 10,000l. more may be raised  
I am, &c.  
The Most Hon. A. GRANT, Principal.  
The Marquess of Lansdowne.

UNIVERSITY OF EDINBURGH BUILDINGS EXTENSION SCHEME.

Appeal for 100,000l.  
Of which already subscribed 75,000l.

ACTING COMMITTEE

- The Right Hon. the Lord Provost  
Principal Sir Alexander Grant, Bart., LL.D.  
Professor Sir Robert Christison, Bart., D.C.L.  
James Cowan, Esq., M.P.  
E. L. I. Blyth, Esq., C.E.  
T. J. Boyd, Esq.  
Professor Crum Brown  
John Christison, Esq., W.S.  
John Clapperton, Esq.  
George Harrison, Esq.  
Charles Jenner, Esq.  
R. Bruce Johnston, Esq., W.S.  
Professor Muirhead.  
T. G. Murray, Esq., W.S.  
R. M. Smith, Esq.  
Professor Tait.  
Professor Turner.  
Professor Wilson  
Principal Sir Alexander Grant, Bart., Convener.  
Samuel Hay, Esq., Union Bank of Scotland, Edinburgh.  
James Norwell, Esq., Secretary, Union Bank of Scotland, Edinburgh.  
Hon. Treasurers,  
Professor Wilson,  
John Christison, Esq., W.S.,  
R. Bruce Johnston, Esq., W.S.,  
Hon. Secretaries,

LONDON COMMITTEE

- The Right Hon. Lyon Playfair, C.B., M.P.  
F. Bennoch, Esq., 80, Wood Street, City  
G. M. Birdwood, Esq., M.D., India Museum  
Alexander Halley, Esq., M.D.  
H. B. Mun, Esq., 34, Clement's Lane, Lombard Street.  
Richard Davy, Esq., F.R.C.S.  
Dyce Duckworth, Esq., M.D., 11, Grafton Street, Piccadilly.  
F. Churchill, Esq., M.D.  
The Rev. Cosmo R. Gordon, D.D.  
H. M. Matheson, Esq., 3, Lombard Street.  
Macrae Muir, Esq., M.A., Barrister-at-Law  
Charles Murchison, Esq., M.D.  
E. H. Sieveling, Esq., M.D.  
Philip Vanderbyl, Esq., Cannon Street.  
Edward Wyld, Esq., Holland Park  
Dyce Duckworth, Esq., M.D., 11, Grafton Street, Piccadilly.  
G. M. Birdwood, Esq., M.D., India Museum.  
Hon. Secretaries,

SUMMARY OF PROPOSALS.

- 1st. To purchase the sites of Park Place and Teviot Row. (This has been already effected at a cost of about 33,000l.)
- 2nd. To erect in the immediate vicinity of the New Royal Infirmary, complete Class-rooms; Theatres, Laboratories, and Museums, with the latest scientific improvements, for the Medical Faculty of the University of Edinburgh
- 3rd. To reorganize the existing Class-rooms of the College, and to improve them in direct adaptation to the wants of the several Professors in the Faculties of Arts, Law, and Theology
- 4th. To provide increased and more convenient accommodation for the University Library
- 5th. To erect an University Hall for the conferring of Degrees, the holding of Examinations, and for all public Academical Ceremonials
- 6th. To improve to some extent the north front of the College building

Statement and Appeal

One hundred years ago an appeal was made to the public on behalf of the University of Edinburgh. The number of students was then stated as "between six and seven hundred," the inadequacy of the Collegiate buildings to the use and importance of the University was pointed out, and it was declared that while in Edinburgh great improvements were going forward on all hands, "the University fabric alone" remained "in such a neglected state as to be generally counted a dishonour to the city of Edinburgh, and to this part of the Kingdom."  
The result of that appeal was a liberal public subscription, opened in March 1788, which, with the aid of Government, provided the handsome edifice now existing. That building for a long period amply sufficed for all the teaching

purposes of the University. But the lapse of a century has produced great changes. During that period the population of the Metropolis has been more than trebled; increased facilities for travelling have brought the University within easy reach of all parts of the country; the advantages of an University education have become much more appreciated; the Advancement of Science has widely extended the field of academic teaching, and the renown alike of Teachers and Graduates, whose names will ever be associated with the University of Edinburgh, has increased its fame and reputation throughout the world.

Thus, the buildings of the University again prove to be wholly inadequate to its necessities. The inadequacy is felt in various ways.

The number of Students attending the University in 1768 was "betwixt six and seven hundred," and the number of Professors was 21. In the present session (1874-5) the number of Students is between 1,900 and 2,000, and that of the Professors is 35. The class-room accommodation has thus become wholly insufficient. The Students at present attending the Chemistry, Anatomy, and Natural History Classes number about 300 in each case. The lecture-rooms are consequently much overcrowded, and great personal discomfort is thus occasioned to both the teachers and the taught.

But apart from the present buildings being insufficient as regards the number of students in attendance, the nature of the modern system of teaching in several branches has rendered the existing accommodation altogether unsuitable.

Since the present University buildings were erected, the whole subject of Practical Chemistry has been added to the Course of Study. Within the last 10 years large and commodious Laboratories have been provided in connexion with many of the European Universities, and it would be most unfortunate if the University of Edinburgh, which was the first British School to introduce practical instruction in Chemistry into the medical curriculum, were not enabled to carry on satisfactorily this important branch of medical and scientific training.

Again, the instruction formerly given in Anatomy consisted almost entirely of lectures and demonstrations delivered in the class-room. The changes in medical education during the last 30 years render it necessary that each Student should now pursue for himself the study of Practical Anatomy. The rooms at present in use were not constructed for that purpose, and are lamentably inadequate for the work to be done in them.

But besides the Departments of Chemistry and Anatomy, increased accommodation, in the form of laboratories and rooms suited for microscopic and other practical investigation and instruction, is required for the Chairs of Materia Medica, the Institutes of Medicine, Natural History, and Pathology. Nor is it less urgent that much additional accommodation for the apparatus and the physical laboratory of the Chair of Natural Philosophy should be provided.

There have been recently instituted in the University of Edinburgh, by the liberality of the late Sir David Baxter, of the Merchant Company of Edinburgh, and of the late Sir Roderick Murchison, Chairs of Engineering, Political Economy, and Geology respectively, and by the munificence of Mr. H. G. Watson and Miss Watson, arrangements have been made for establishing a Chair of Fine Art in honour of the late Sir John Watson Gordon, their brother. For none of the classes thus created is there suitable accommodation within the present University buildings, and should the much-needed additional Chairs of Universal History, of Modern Languages, &c., be hereafter erected, the absolute insufficiency of the present class-rooms would of course be increasingly felt.

Collateral with the want of teaching accommodation there is also the disadvantage of restriction upon the natural growth of the Museums of the University. That of Anatomy, for instance, has by the accumulations of years so outgrown the space allotted to it that the Students cannot be freely admitted, and it is to a great extent rendered unavailable for teaching purposes.

The University Library, which yearly accumulates a large number of valuable books, and which is continually receiving, by gift and otherwise, accessions of literary treasures, is fast outgrowing the limits assigned to it.

Nor is it only in its teaching and scientific operations that the University is hampered by the present inadequacy of its buildings. All who are interested in the University must feel it to be unfortunate, if not disastrous, that it possesses no Hall of Assembly in which Degrees may be conferred, the University Council convened, and the installations of Chancellors and Rectors and other academical ceremonies conducted. It is not only inconvenient but also unworthy of the Metropolitan University to be constrained to hire the Music Hall or other common Assembly-Room for such purposes, whilst other Universities possess

handsome halls. That about to be erected in Glasgow is estimated at a cost of not less than 55,000*l.*

On the occasion of the late Scott centenary banquet (9th August 1871), the Earl of Dalhousie made a spirited appeal to supply, in connexion with the name of Sir Walter Scott, this great want of the University of Edinburgh. A subscription for a "Scott Hall" was opened, and had good prospect of success; but the committee in charge thought it right to advise its discontinuance for the time, lest it should be found to interfere with that which must be a paramount object with all well-wishers to the University—namely, the provision of more suitable accommodation for its various educational departments.

It is now resolved to make the most strenuous efforts for effecting the improvements thus indicated as essential.

After a full consideration of all the circumstances, it has been concluded that the best arrangement will be to devote the existing University buildings to the service of the Faculties of Arts, Divinity, and Law, and to transfer the Medical School to a new building which will at once afford sufficient accommodation for Lecture-rooms, Museums, Laboratories, and other apartments for practical work.

The site in view, which contains an area of 80,000 square feet, is that occupied by Park Place and a portion of Teviot Row adjacent to the New Royal Infirmary in course of erection. The new buildings will be such as to enable the University to reorganize, not only the Departments of Anatomy and Chemistry, but all the separate Departments of Medical Teaching, on a scale suited to the present advanced state of Science, and to the numbers of students now attending the classes.

The close proximity of the Infirmary will be a great advantage to the medical students, and the removal of this department from the present University building will liberate for the use of Professors of other Faculties a number of class rooms, which, together with all the class-rooms of the College, should now be improved in ventilation and in other respects.

If it be desired that the University of Edinburgh should continue to hold its present high position, measures of the nature indicated have now become an absolute necessity; for this University cannot be expected to maintain its reputation if it is excelled by other Universities in the material appliances of teaching.

By the munificent liberality, for the most part, of the west of Scotland, the University of Glasgow has recently been furnished with a complete equipment of academical buildings. The private contributions for this purpose amounted, on 27th April last, to 149,277*l.* 16*s.* 2*d.* Unless this University can now extend its fabric, it will not only be debarred from anticipating that steady increase in the number of its students, which it might otherwise naturally expect, but it is obvious that it may even cease to occupy its present high place among the educational institutions of the country. It need hardly be said that such a result is to be deprecated. The interests and well-being of the city of Edinburgh, and indeed of all Scotland, are closely bound up with those of the Metropolitan University.

On these grounds, and because the University has no funds to meet the emergency which has arisen, it is now determined to renew the appeal which was made so effectually to the public a hundred years ago. The reputation which the University has earned by the teaching of such men as Muir, Dugald Stewart, Black, Chalmers, Gregory, Leslie, Forbes, Hamilton, Goodier, Syme, and Simpson, and by the education within its walls of such men as Macintosh, Walter Scott, Charles Bell, Liston, Abercrombie, Brougham, Jeffrey, Horner, and Brewster, has hitherto been most worthily maintained. It is the success of the University which has rendered its building extension necessary, and it is hoped that all those who are interested in a continuance of its fame will liberally respond to this appeal.

It is proposed to make the provision of an University Hall dependent on the amount that may be subscribed being sufficient for all purposes, and the contributions will, in the first instance, be devoted to supplying what has become absolutely necessary for the University as a Teaching and Scientific Institution.

Looking to the probable cost of the admirable site selected, and of the required buildings with their outfit, including incidental expenses, the Committee find it necessary to appeal to the general public for contributions to the extent of not less than 100,000*l.*

The amount received will be applied in such manner as may be determined by the General Committee, or by any Acting Committee to be appointed by them.

It is hoped that Her Majesty's Government, which largely contributed to the splendid new buildings of the University of Glasgow, will not fail to give adequate assistance to

private efforts for placing the Metropolitan University of Scotland on such a footing as is necessary to preserve it in its present state of efficiency, and enable it to keep pace with other Universities in the march of improvement.

The foregoing Statement and Appeal were framed during the lifetime of that generous friend of the University, the late Sir David Baxter, Bart., and the Committee were encouraged to venture upon the extensive plan of improvements above indicated by his counsel and co-operation, and by the hope that he would liberally assist in carrying it out. That hope has been amply realized, Sir David having bequeathed the sum of 20,000*l*. for the extension of the buildings of the University, or for the purchase of land to form a site. This circumstance, together with the encouraging public support already promised, has led the Committee to submit the accompanying definite "Summary of Proposals," which also include the improvement of the north front of the existing building.

The scheme embodied in the foregoing statement and appeal was inaugurated at a public meeting held in Edinburgh, on 6th April 1874, at which the Right Hon the Lord Provost presided, and the speakers were His Grace the Duke of Buccleuch, the Right Hon Lyon Playfair, M P., the Right Hon the Lord Justice-General, Chancellor of the University, Mr Charles Cowan of Logan House, Mr Campbell-Swinton of Kimmerghame, Mr Duncan M'Laren, M P., the Rev Dr Macgregor, Mr John Marshall, advocate, the Rev Dr James Taylor, Provost Swan, Kirkcaldy, and the Right Rev. Bishop Cotterill.

The National importance of the University of Edinburgh, and the strong claims of the scheme for its extension to the support of all who are interested in a continuance of its fame and reputation, were ably demonstrated by the speech of the Right Hon. Lyon Playfair. Copies of a full report of the proceedings at the meeting can be obtained on application to any of the Honorary Secretaries.

## APPENDIX IV.

## PAPERS RELATING TO THE UNIVERSITY OF GLASGOW.

o para. 88.

## L.—PROPOSED REGULATIONS for the SCIENCE DEGREE.

[EXTRACTED from the GLASGOW UNIVERSITY CALENDAR for 1874-75, pp 85-90.]

*Bachelor of Science*

The Senate, with the approval of the University Court, have resolved to take the necessary steps to establish the Degree of Bachelor of Science, with three alternative courses of study. Students will be admitted to examination, provisionally, in November 1875. The Courses of Study in the several Departments will be as follows:—

## A. IN BIOLOGICAL SCIENCE—Any four of these five

1. Chemistry.
2. Anatomy.
3. Physiology.
4. Zoology (including Comparative Anatomy)
5. Botany.

And any four of the Classes in the Arts Curriculum \*

## B. IN GEOLOGICAL SCIENCE :

1. Geology.
2. Chemistry
3. Zoology (including Comparative Anatomy).
4. Higher Natural Philosophy.

And any four of the Classes in the Arts Curriculum : provided always that, in the event of a student taking Geodesy in conjunction with any University Class of not less than 25 lectures, he shall be allowed to dispense with one of the Arts Classes.

## C. IN ENGINEERING SCIENCE .

1. Mathematics (1 or 2)
2. Natural Philosophy (1 or 2).
3. Inorganic Chemistry (1)
4. Geology (1).
5. Civil Engineering (2).

And any two of the Classes in the Arts Curriculum except Mathematics and Natural Philosophy : provided always that, in the event of a student taking Geodesy in conjunction with the practical course in Civil Engineering, or any other University Class of not less than 25 lectures, he shall be allowed to dispense with one of the Arts Classes

The following are the General Regulations proposed for the Degree of Bachelor of Science.

1. The examinations in those subjects which are taken from the Curriculum of Arts shall be the same, and subject to the same regulations, as the examination in those subjects for the Degree of M.A.

2. No student may present himself for examination in any subject without having attended a class on that subject in an University ; but students may present themselves for examination in any one or more of the subjects so soon as they have attended the requisite classes. No student shall

\* *i. e.*, Attendance for one session on any four of the following seven Classes—*viz.*, Latin, Greek, Logic, Moral Philosophy, English Literature, Mathematics, Natural Philosophy

be admitted to a Degree in Science unless he shall have given attendance in this University during the last two sessions of his course, nor unless he has attended the half at least of his course in this University

3. No special certificate shall be given to students who have passed examinations in subjects for the Degree in Science, but a certified list of successful candidates shall be published after each examination, and shall be copied into a book kept for the purpose by the Registrar. Both copies of the list shall be signed by the examiners.

4. The fee for the Degree in Science shall be 3*l* 3*s*, it being provided that if any candidate shall present himself for examination in the different subjects at different periods, he shall pay 1*l* 1*s*. in each session in which he is examined, till he has paid 3*l* 3*s*

5. Students who commenced their course for a certificate in Engineering Science before Session 1871-72, may be granted a Degree on examination in all the appointed subjects without attendance on any class but those requisite for the Certificate in Engineering Science.

6. Examinations for the Degree of M.A. will not be held as available for the Degree of B.Sc., unless passed by the student as a candidate for that degree; but examinations for the Degree of M.A., passed previously to 1st January 1874, will be accepted for the Degree of B.Sc., on the candidate paying the fees for examination for that degree, over and above any fees he may have paid as a candidate for the Degree of M.A.

7. Honours in the subjects taken from the Faculty of Arts shall be given to Graduates in Science only on the same curriculum and examination as to Graduates in Arts.

A. In session 1875-76, the subjects of examination in the department of Biological Science shall be as follows:—

*In Physiology*—A general knowledge of the subject as treated, *e.g.*, in Huxley's *Elementary Manual*, and special knowledge of some part of the subject, to be announced from time to time in the Calendar. The special subject for next year to be the General Functions of the Nervous System, including the Brain and Spinal Cord

*In Anatomy*—A general knowledge of Descriptive Anatomy and Histology, and a more detailed knowledge of certain parts of the subject, to be announced from time to time. The special subjects for next year to be—(1) The Skeleton (2) The Joints. (3) The Muscles. The Terminology will be that of *Human Anatomy*.

*In Zoology and Comparative Anatomy*—A general knowledge of the principles of Zoological Classification, with a more detailed knowledge of certain parts of the subject, to be announced from time to time. The special subjects for next year to be—the Nervous System as a guide to Classification; the Placental Mammalia and the Mollusca.

*In Botany*—Morphology (Organography), Physiology, and Systematic Botany, the last restricted to the general principles of classification, and to British Natural Orders. The candidate may be asked to describe plants set before him, and refer them to their proper place in the Vegetable Kingdom. (Text-Book recommended, Henfrey's *Elementary Course of Botany*, Masters' Edition)



*In Chemistry.*—General Principles of Organic Chemistry; Classification of Organic Substances, and Chemistry of Blood, Bile, and Urine.

B. The subjects of examination in the Department of Geological Science shall be as follows:—

*In Chemistry.*—The Fundamental Principles of the Science; the Chemistry of Rock Formations and Mineralogy.

*In Geology.*—Lithology and Stratigraphy; Palaeontology, and the conditions on which Climatal Changes depend. As special subjects for next year:—Denudation, atmospheric and marine; the composition and origin of Coal and Ironstone; Marine Currents; the varieties of Igneous Rocks found associated with the Carboniferous Strata in Scotland.

*In Zoology.*—Principles of Classification, and a more detailed knowledge of certain parts of the subject to be announced from time to time. The special subjects for next year to be—Climatal Influence on the Distribution of Animals; the Structure and Affinities of the Brachopoda.

*In Natural Philosophy.*—Students will be required to show equal proficiency to that which is required for the Degree of M.A.

C. The subjects in the Department of Engineering Science shall be as follows:—

*In Mathematics.*—The subjects of the Senior Mathematical Class.

*In Natural Philosophy.*—Thomson and Tait's *Elementary Treatise of Natural Philosophy*; portions of Maxwell or Balfour Stewart on *Heat*; Central Forces. Candidates may profess higher subjects.

*In Civil Engineering.*—The subjects mentioned in the Calendar at pp 43 and 44, for the two Courses of the Professor of Engineering.

*In Geodesy.*—Theory of Geodesical Instruments; Methods of Determining Local Time; Longitudes, Latitudes, and Azimuths; Measurement of Base Lines; Principles of Triangulation; Measurement of Arcs of the Meridian.

*In Chemistry.*—The Fundamental Principles of the Science; the Chemistry of Iron, Copper, Lead, Tin and Zinc; of Building Materials; of Water and Atmosphere, &c.

*In Geology.*—Lithology, Stratigraphy; Geology as applied to Mining, and Geological Surveying.

*In Chemistry and Geology* the examination may be conducted, in whole or in part, at the discretion of the Examiners, by reference to specimens, or (in Geology) by excursions in the field.

See para. 80. II.—STATEMENT of the TOTAL EMOLUMENTS of the PROFESSORS and ASSISTANTS in the UNIVERSITY OF GLASGOW; and SCHEDULE of LECTURES and LABORATORY INSTRUCTION.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, London, S.W., May 31st, 1875.

SIR,

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to inform you that the Commissioners, with a view of making their Report on the Universities of Scotland as complete as possible, and, as far as may be, similar, in the character of the information it affords, to the Report already issued on the English Colleges, are desirous of including a Statement of the Total Emoluments of the Professors and Assistants in the various Faculties.

With this view, the accompanying Schedules have been drawn up, and I am to ask you to be so good as to further the Inquiries entrusted to the Commission by affording the required information in as complete a form as possible, together with any remarks you may be pleased to make.

I am to add, that as the Report is now nearly ready for presentation to Her Majesty, the Commissioners would be glad to receive the Schedules at as early a date as practicable.

I have the honour to be, &c.

J. NORMAN LOCKYER,  
Secretary.

The Principal of  
The University of Glasgow.

Glasgow University, June 13th, 1875.

SIR,

IN the absence of the Principal, I enclose a statement of the Professors and Assistants in the various Faculties of this University. As the Winter Session closed in April, and only a few of the Classes meet in summer, it has been found impossible, partly owing to the absence of some of the Professors, to make the Return quite complete.

In the second return (Schedules of Lectures, &c.), the numbers given include all Class meetings, whether for lectures strictly so called, or for examinations, or other class work. In some of the Classes, instruction is conveyed almost entirely by means of lectures (examinations being only occasional), in others, the greater part of the time is occupied with the examination, chiefly oral but also in writing, of the Students in certain prescribed tasks. In the Humanity and Greek Classes, for example, three of the four hours of daily meeting are spent in this way, and only one in lectures and probations, delivered by the Professor.

I have the honour to be, &c.,

DUNCAN H. WRIB,  
Clerk of Senate.

J. Norman Lockyer, Esq.  
Secretary to the Royal Commission on  
Scientific Instruction.

I.—SCHEDULE OF PAYMENTS.

Subjects.	Endowments.	Fees or Share of Fees (Average for 8 Years)	Total of Emoluments.	Number of Assistants or Demonstrators.	Aggregate Stipend of Assistants and Demonstrators.
	£ s. d.	£ s. d.	£ s. d.		
Logic and Metaphysics.	280 11 2	560 0 0	*840 11 2	—	—
Moral Philosophy and Political Economy.	301 2 3	350 0 0	*651 2 3	—	—
Natural Philosophy.	316 11 3	- - -	* - -	† An assistant under Ordinance, and a Demonstrator in Experimental Physics.	Salary of Assistant 100l.
Greek.	292 4 6	872 11 0	*1,164 15 6	One assistant	100l.
Humanity.	289 8 11	1,000 0 0	*1,289 8 11	One assistant	100l. (increased by Professor to 250l.).

\* A residence is attached to these Chairs.

† By the liberality of Mrs. Arnott (widow of the late Dr. Neill Arnott) and of Professor Sir William Thomson, a Demonstratorship in Experimental Physics has just been founded (March 1875), and endowed with a capital sum of 3,000l.

Subjects.	Endowments.			Fees or Share of Fees (Average for 3 Years).			Total of Emoluments.			Number of Assistants or Demonstrators.	Aggregate Suspend of Assistants and Demonstrators.
	£	s	d.	£	s	d.	£	s	d.		
Mathematics.	312	0	0	820	0	0	*1,132	0	0	One assistant	100 <sup>l</sup> (increased by Professor)
Astronomy.	300	0	0	3	10	0	*303	10	0	One assistant	100 <sup>l</sup>
Civil Engineering and Mechanics.	475	0	0	179	8	0	654	8	0	One assistant	50 <sup>l</sup> (paid by Professor).
English Literature.	200	0	0	380	0	0	580	0	0	—	—
Divinity.	438	13	7	118	0	0	*556	13	7	—	—
Oriental Languages.	300	0	0	149	0	0	*449	0	0	—	—
Ecclesiastical History.	341	15	7	77	0	0	*418	15	7	—	—
Biblical Criticism.	315	0	0	62	0	0	377	0	0	—	—
Law.	310	0	0	340	0	0	*650	0	0	—	—
Conveyancing.	100	0	0	213	0	0	313	0	0	—	—
Medicine.	270	0	0	—	—	—	*1,081	13	0	One assistant	(Paid by Professor.)
Anatomy.	250	0	0	781	13	0	—	—	—	Demonstrator and assistants	200 <sup>l</sup> for assistants and class expenses.
Natural History.	210	0	0	230	0	0	440	0	0	One assistant in Geology.	(Paid by Professor.)
Surgery.	100	0	0	524	5	0	624	5	0	—	—
Midwifery.	100	0	0	215	19	4	315	19	4	—	—
Chemistry.	200	0	0	640	0	0	840	0	0	Two assistants	200 <sup>l</sup> .
Botany.	230	0	0	300	0	0	530	0	0	—	—
Materia Medica.	100	0	0	264	11	4	364	11	4	One assistant	25 <sup>l</sup> (increased by Professor to 46 <sup>l</sup> ).
Institutes of Medicine.	150	0	0	—	—	—	—	—	—	†Assistant	Paid by Professor.
Forensic Medicine.	100	0	0	200	0	0	300	0	0	One assistant	25 <sup>l</sup> (increased by Professor).
Clinical Surgery.	100	0	0	104	9	6	204	9	6	—	—
Clinical Medicine.	100	0	0	97	2	6	197	2	6	—	—
Waltonian Lecturer on the Eye.	105	5	0	—	—	—	—	—	—	—	—

\* A residence is attached to these Chairs.

† There has been, for some years also a Lecturer on Pathology in connexion with this Chair

II.—SCHEDULE OF LECTURES AND LABORATORY INSTRUCTION.

Subjects.	Lectures per Week.		Lectures per Session.		Laboratory Work.	
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.
Humanity	20	—	500	—	—	—
Greek	20	—	500	—	—	—
Logic and Metaphysics	10	—	250	—	—	—
Moral Philosophy and Political Economy.	10	—	250	—	—	—
English Literature	5	—	80	—	—	—
Mathematics	20	—	500	—	—	—
Natural Philosophy	10	—	250	—	Daily from 9 a.m. to 4 p.m.	—
Astronomy	1	—	20	—	—	—
Civil Engineering and Mechanics, &c.	10	—	250	—	Two or more days each week.	—
Divinity	5	—	125	—	—	—
Oriental Languages	15	—	375	—	—	—
Church History	5	—	125	—	—	—
Biblical Criticism	5	—	125	—	—	—
Law	9	—	225	—	—	—
Conveyancing	5	—	125	—	—	—
Anatomy	15	7	300	—	Daily from 9 a.m. to 4 p.m.	Daily from 7 a.m. to 2 p.m.
Chemistry	10	—	250	—	Daily from 10 a.m. to 4 p.m.	Daily from 10 a.m. to 4 p.m.
Botany	—	5	—	60	—	Demonstration at the Botanic Garden, one hour daily.
Physiology	5	3	125	40	—	—
Natural History	5	5	60	60	—	—
Surgery	5	2	110	40	—	—
Materia Medica	5	3	110	40	—	—
Practice of Medicine	5	2	175	—	—	—
Forensic Medicine	5	—	110	—	—	—
Midwifery	5	—	110	—	—	—
Clinical Surgery	2	2	50	25	—	—
Clinical Medicine	2	2	50	25	—	—

See para. 92. III.—NUMBER OF STUDENTS at the UNIVERSITY OF GLASGOW.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S W.,  
April 17th, 1875

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to favour the Commissioners with a Statement of the number of Students attending the University Course during the past session in the different Faculties of the University of Glasgow. The Commissioners are desirous of having as detailed a Statement as possible

I have, &c.  
The Principal of J. NORMAN LOCKYER,  
The University of Glasgow. Secretary.

Glasgow University,  
22nd April 1875.

SIR, I AM instructed by the Principal of this University to inform you that the number of Matriculated Students attending the University during the past Session was 1,456, viz—

In the Faculty of Arts -	-	904
In the Faculty of Medicine -	-	339
In the Faculty of Law -	-	153
In the Faculty of Divinity -	-	60
Total -	-	1,456

I am also instructed to forward to you the enclosed copy of the "Class Catalogues" of the University referring to the same Session.

I am, &c.  
THOS. MOIR,  
Registrar.  
To the Secretary,  
Royal Commission on  
Scientific Instruction, &c.

IV.—FEES PAYABLE BY STUDENTS at the UNIVERSITY OF GLASGOW.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, S W.,  
April 28th, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to state, for the information of the Commissioners, the amount, on an average, of the fees payable by Students per annum at the University of Glasgow.

I have, &c.  
To the Principal of J. NORMAN LOCKYER,  
The University of Glasgow. Secretary.

University of Glasgow,  
May 3rd, 1875

SIR, I AM instructed by the Principal to inform you that each Student attending this University pays annually a Matriculation fee of 1*l.*, and also a Class fee to each Professor whose Lectures he takes out. The fee for each Course is 3*l.* 6*s.*, with the following exceptions, viz., Natural Philosophy, Scots Law, Civil Law, Conveyancing, 4*l.* 4*s.* each; Astronomy, 1*l.* 1*s.*; Political Economy, 1*l.* 1*l.* 6*s.*; Metaphysics, 1*l.* 1*l.* 6*s.*

Many of the Students attend two Classes each Session, others a greater number, but some take only one Class.

I am, &c.  
THOS. MOIR,  
Registrar.

## APPENDIX V.

## PAPERS RELATING TO THE UNIVERSITY OF ST. ANDREW'S.

See para. 126. I.—INCOME of the UNIVERSITY OF ST. ANDREW'S

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S W.,  
April 28th, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to state, for the information of the Commissioners, the amount of the income of the United College of St. Salvador and St. Leonard in the University of St. Andrew's

I have, &c.  
The Principal of the United J. NORMAN LOCKYER,  
College of St. Salvador Secretary  
and St. Leonard, University  
of St. Andrew's

St Andrew's,  
30th April 1875.

SIR, I AM directed by the Principal of the United College in the University of St. Andrew's to acknowledge the receipt of your letter, of date 28th ult., requesting him to state, for the information of the Commission, the amount of the income of the United College of St. Salvador and St. Leonard

In compliance with said request I have now to mention that the income of the United College available for the salaries and incomes of the Principal and eight Professors in the College, after payment of public and parochial burdens on the college lands, permanent charges and expenses, amounts, on an average of the past three years, to 1,950*l.* 1*l.* 1*s.*

The Professor of Chemistry in the United College does not participate in the above income. He receives a salary of 90*l.* per annum from the proceeds of a bequest by the late Dr. Gray, the net amount of which, after defraying other charges, does not admit of any greater payment being made to the Professor.

I have, &c.  
J. Norman Lockyer, Esq., STUART GRACE,  
Secretary, Royal Commission Secretary, United College  
on Scientific Instruction and of St. Andrew's  
and the Advancement of Science

SIR, I AM directed by the Principal of St. Andrew's,  
6th May 1875  
in the University of St. Andrew's, to acknowledge the receipt

of your letter of date 28th ult., requesting him to state for the information of the Commission the amount of the income of St. Mary's College.

In compliance with said request, I have now to mention that the Revenue of St. Mary's College available for payment of the Salaries and Incomes of the Principal, the Professor of Divinity and Biblical Criticism, and the Professor of Hebrew in the College, after deduction of public and parochial burdens on the College Lands, permanent charges and expenses, amounts, on an average of the past three years, to 720*l.* 8*s.* 3*d.*

The Professor of Divinity and Church History in St. Mary's College does not participate in the above income.

I have, &c.  
J. Norman Lockyer, Esq., STUART GRACE,  
Secretary, Royal Commission Secretary of St. Mary's  
on Scientific Instruction and College.  
and the Advancement of Science.

II.—STATEMENT of the TOTAL EMOLUMENTS of the PROFESSORS and ASSISTANTS in the UNIVERSITY OF ST. ANDREW'S; and SCHEDULE of LECTURES and LABORATORY INSTRUCTION.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S W.,  
May 31st, 1875.

SIR, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to inform you that the Commissioners, with a view of making their Report on the Universities of Scotland as complete as possible, and, as far as may be, similar, in the character of the information it affords, to the Report already issued on the English Colleges, are desirous of including a Statement of the total Emoluments of the Professors and Assistants in the various Faculties.

With this view, the accompanying Schedules have been drawn up, and I am to ask you to be so good as to further the Inquiries entrusted to the Commission

by affording the required information in as complete a form as possible, together with any remarks you may be pleased to make.

I am to add, that, as the Report is now nearly ready for presentation to Her Majesty, the Commissioners would be glad to receive the Schedules at as early a date as practicable.

I have the honour to be, &c.

J. NORMAN LOCKYER,  
Secretary.

The Principal of  
The University of St. Andrew's.

University, St Andrew's,  
June 10th, 1875.

SIR, I AM directed to acknowledge the receipt of your letter of the 31st ultimo, addressed to the Principal of the University, and to enclose, for the information of your Commissioners, a "Schedule of the Lectures and Laboratory Instruction," and a "Schedule of Payments," as requested by you.

I have, &c.

J. Norman Lockyer, Esq.,  
Secretary to the Commission on  
Scientific Instruction

ROBERT WALKER,  
Registrar.

I.—SCHEDULE OF PAYMENTS.

Subjects.	Endowments		Fees, or Share of Fees	Total of Emoluments	Number of Assistants or Demonstrators	Aggregate Stipend of Assistants and Demonstrators
	From College property	Parliamentary vote.				
<b>I.—UNITED COLLEGE</b>						
Principal	£ 307 10 7	£ 240 0 0	none.	£ 547 10 7	—	—
Humanity Professor	195 4 7	120 0 0	152 5 0	467 9 7	—	—
Greek "	215 4 7	100 0 0	155 8 0	470 12 7	—	—
Mathematics "	306 4 7	109 0 0	155 8 0	470 12 7	1	100 0 0
Logic and English Literature Professor	215 4 7	150 0 0	113 11 6	478 16 1	—	—
Moral Philosophy Professor	215 4 7	150 0 0	64 1 0	429 5 7	—	—
Natural Philosophy "	215 4 7	150 0 0	80 17 0	446 1 7	—	—
Chemistry "	*90 0 0	125 0 0	95 0 6	310 0 6	—	—
Medicine "	194 8 11	100 0 0	{ None exacted by present Professor }	294 8 11	—	—
Natural History "	194 8 11	100 0 0	{ None exacted by late Professor }	294 8 11	—	—
<b>II.—ST. MARY'S COLLEGE.</b>						
Principal and Systematic Theological Professor	†218 6 1	243 0 0	40 5 0	501 11 1	—	—
Biblical Criticism Professor	327 9 2	87 0 0	21 17 6	426 6 8	—	—
Ecclesiastical History Professor	nil.	†422 1 8	23 5 6	445 7 2	—	—
Hebrew Professor	174 12 10	211 1 8	30 19 6	416 14 0	—	—

\* From Dr. Gray's Mortification † The Principal of St Mary's College has an official residence  
† This includes a share of the revenues of the Deanery of the Chapel Royal, which the University Commission estimated would yield 334l per annum.

II.—SCHEDULE OF LECTURES AND LABORATORY INSTRUCTION.

Subjects	Lectures per week.	Lectures per session.	Laboratory work.
<b>I.—UNITED COLLEGE.</b>			
Principal	—	occasional.	—
Humanity Professor	15	345	—
Greek "	15	345	—
Mathematics "	18	299	—
Logic and English Literature Professor	8	184	—
Moral Philosophy and Political Economy Prof	7	150	—
Natural Philosophy "	7	168	—
Chemistry Professor	7	161	—
Medicine "	8	69	—
Natural History Professor	5	115	—
<b>II.—ST. MARY'S COLLEGE</b>			
Principal and Systematic Theology Professor.	9	162	—
Biblical Criticism Professor	5	90	—
Ecclesiastical History "	5	90	—
Hebrew Professor	10	180	—

past Session in the different Faculties of the University of St Andrew's. The Commissioners are desirous of having as detailed a Statement as possible

I have, &c.

The Principal of J. NORMAN LOCKYER,  
The University of St Andrew's. Secretary.

University, St. Andrew's,  
April 22nd, 1875

SIR, IN reply to your letter of the 17th inst. I beg to state that the number of Students attending the Classes in the Faculty of Arts during Session 1874-75 has been 118 This Faculty includes the following Classes in Mathematical and Physical Science, viz, Mathematics, Natural Philosophy, and Chemistry. The number attending the Faculty of Theology has been 23

I enclose a printed list, from which the Commissioners will see the number of Students attending the respective Classes.

I have, &c.

J. C. SHAIRF,  
Principal of the United College

J. Norman Lockyer, Esq.

Number of Matriculated Students (Session 1874-75) at the United College - 118  
Number of Matriculated Students at St. Mary's College - 23

Total at the University - 141

[Extracted from Lists for 1874-75.]

III.—NUMBER OF STUDENTS attending the UNIVERSITY OF ST. ANDREW'S.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, London, S W.,  
April 17th, 1875.

SIR,

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to favour the Commissioners with a Statement of the number of Students attending the University Course during the

IV.—FEES payable by STUDENTS at the UNIVERSITY OF ST. ANDREW'S. See para.

Royal Commission on Scientific Instruction and the Advancement of Science,  
6, Old Palace Yard, S W.,  
April 23th, 1875.

SIR,

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to

state, for the information of the Commissioners, the amount, on an average, of the fees payable by Students per annum at the University of St. Andrew's

To the Principal of J. NORMAN LOCKYER,  
The University of St. Andrew's. Secretary

SIR,  
UNIVERSITY, ST. ANDREW'S,  
May 5th, 1875.  
IN reply to your letter of the 28th April, addressed to the Principal, I am directed to inform you that Students attending the United College pay a Matriculation Fee of 1l. on entering, and a few of 3s. for each Class they may

attend during the Session. Should they attend three Classes, which is the average number, in that case the annual payment made by each Student amounts to 10l. 9s. In the event of their proceeding to Graduation in Arts a further fee of 1l. 1s. is payable for each of the three Departments of Examination.

Students of St. Mary's College pay a Matriculation Fee of 1l., and a Fee of 2l. 2s. for each of the Classes they attend, which is in general three in number.

I have, &c.,  
Norman Lockyer, Esq., ROBERT WALKER,  
London. Registrar.

## APPENDIX VI.

## PAPERS RELATING TO THE UNIVERSITY OF ABERDEEN.

See para. 148. I. CORRESPONDENCE BETWEEN HER MAJESTY'S COMMISSIONERS AND THE PRINCIPAL OF THE UNIVERSITY OF ABERDEEN.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S.W.,  
February 17th, 1872.

SIR,  
I AM directed by the Duke of Devonshire, the Chairman of this Commission, to acquaint you that Evidence on the subject of Scientific Instruction in the Scottish Universities is now being taken, and I am to ask you if you are desirous that any witnesses should be examined with reference to the Scientific Instruction given in the University of Aberdeen, and the Statement which you have already been so good as to forward to the Commission. In the event of this being the case, I am to request you to be so good as to favour me with the names of the witnesses whom you would propose, and to state if either Wednesday or Friday next week would be convenient for taking the evidence, of which a *précis* should be at once forwarded, in order that it may be printed and circulated among the Commissioners prior to the day of meeting.

Minutes of  
Evidence,  
Vol. II,  
Appendix V.,  
p. 7.

The Principal of  
The University of Aberdeen

UNIVERSITY OF ABERDEEN,  
Feb. 23rd, 1872.  
SIR,  
I HAVE communicated the contents of your letter to the Professors of the University. I regret to say that, at this busy season of the year, it would be extremely inconvenient, if not impossible, for any of them to leave their Academic duties for the purpose of going to London.

At the same time I have to observe, that if a *précis* of the examination to which, in the event of their going there they would be subjected, or any series of queries, should be sent by the Commission, either to the University or to the Professors separately, any information that is desired will be gladly furnished.

May I venture respectfully to express an earnest hope that if any practical steps for the Advancement of Science should result from the labours of the Commission, the deficiencies in appliances for Scientific Instruction, particularly as to means of illustration, which this and other Universities labour under, may be borne in mind.

I have, &c.,  
(Signed) P. C. CAMPBELL,  
Principal.

J. N. Lockyer, Esq.  
6, Old Palace Yard, London, S.W.,  
March 2nd, 1872.

SIR,  
I HAVE laid your letter of the 23rd of February before this Commission, and I am directed by the Chairman to ask when it would be convenient for any of the Scientific Professors to appear before the Commissioners with a view of giving evidence on the deficiencies in appliances for Scientific Instruction referred to in your letter, as the Commissioners can only Report on what may be given in Evidence before them.

I have, &c.,  
J. NORMAN LOCKYER,  
Secretary

The Principal of  
The University of Aberdeen  
UNIVERSITY OF ABERDEEN,  
March 4th, 1872.  
SIR,  
I HAVE had the honour to receive your letter of the 2nd inst., and will communicate on the subject of it with the Professors.

I fear, however, that it will scarcely be possible for them formally to come to a decision on it before the next meeting of the Senatus, which is to be on the 9th inst.,—Saturday next.

In the meantime, I should be much obliged by your telling me how long the Commission is to sit, and what is the latest period at which evidence will be received.

I have, &c.,  
(Signed) P. C. CAMPBELL,  
Principal.  
J. Norman Lockyer, Esq.,  
6, Old Palace Yard, London, S.W.,  
March 23rd, 1872.

SIR,  
I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask whether it would be convenient for any of the Scientific Professors to appear before the Commissioners on either the 12th or 19th of April, for the purpose of giving Evidence on Scientific Instruction in the University of Aberdeen?

I have, &c.,  
The Principal of J. NORMAN LOCKYER,  
The University of Aberdeen. Secretary.

The University, Aberdeen,  
March 28th, 1872.  
SIR,  
REFERRING to your letter of the 23rd inst., addressed to the Principal of this University, I trust that I may, in the absence of the Principal from ill health, be permitted to say that I shall lay your letter before the Senatus Academicus at its first meeting on the 5th of April next, after which I shall be able to give you a definite answer.

I am, &c.,  
(Signed) WM. MILLIGAN,  
Secretary of the University,  
Royal Commission on Scientific Instruction.

The University, Aberdeen,  
April 8th, 1872.  
SIR,  
REFERRING to your letter to the Principal of this University of date 23rd March 1872, I am instructed by the Senatus Academicus to say that, on consideration of the subject therein referred to, the Senatus is of opinion that it has nothing special to communicate to the Commission.

I am, &c.,  
(Signed) WM. MILLIGAN,  
Sec. of Senatus.  
The Secretary of  
The Royal Commission on  
Scientific Instruction.

II. NUMBER OF STUDENTS attending the UNIVERSITY OF ABERDEEN.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, London, S.W.

APRIL 17th, 1875.  
SIR,  
I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to favour the Commissioners with a Statement of the number of Students attending the University Course during the past Session in the different Faculties of the University of Aberdeen. The Commissioners are desirous of having as detailed a Statement as possible.

I have, &c.,  
The Principal of J. NORMAN LOCKYER,  
The University of Aberdeen. Secretary.

Rosemount, Sidmouth, Devon,  
April 26th, 1875.  
SIR,  
IN reply to your letter of 17th inst., I have the honour to state that the number of Students attending the Un-

iversity Courses during the past Session (1874-75) was as follows.—

In the Faculty of Arts	336
"    "    Divinity	36
"    "    Law	14
"    "    Medicine	227
	<hr/>
Students in both Arts and Medicine	8
in both Divinity and Medicine	2
	<hr/>
10	
Total number of Students	603

I regret that absence from home has prevented me from making an earlier reply

I have, &c.  
P C CAMPBELL,  
Principal of the University  
The Royal Commission  
on Scientific Instruction, &c.  
of Aberdeen.

III. FEES payable by STUDENTS at the UNIVERSITY OF ABERDEEN.

Royal Commission on Scientific Instruction  
and the Advancement of Science,  
6, Old Palace Yard, S.W.  
April 28th, 1875

SIR,

I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to state, for the information of the Commissioners, the amount, on an average, of the fees payable by Students per annum at the University of Aberdeen

I have, &c.  
J. NORMAN LOCKYER,  
Secretary.

Rosemount, Sidmouth,  
May 1st, 1875.

SIR,  
IN answer to your letter of the 28th ult., I beg leave to state that the amount, on the average, of the fees payable by the Students per annum at the University of Aberdeen is as follows—

In the Faculty of Arts	£	s	d.
"    "    Divinity	7	12	0
"    "    Law	5	13	4
"    "    Medicine	5	4	0
	12	0	6

These are the average sums paid yearly by the Students following the courses requisite in each Faculty, but as many Students attend more than the requisite number of Classes, their expenditure is in such cases higher than the above.

The fee for each Class or Course of Lectures is generally 3l 3s.; for Second Classes and Summer Courses generally 2l 2s., in some cases 1l 1s. In Anatomy—Second Course, 3l 3s., Third Course, 1l 1s.

The average yearly payment stated above includes in each case the annual Matriculation Fee of 1l (which comprises Library and all incidental expenses), as well as fees to Professors. Additional payments have to be made at Examination for Degrees, in Arts, 3l 3s.; in Divinity (B D), 3l. 3s., in Medicine (M B), 15l 16s., (C M), 5l. 5s., on promotion from M B. to M D., 5l. 5s., in addition to the stamp duty on Diploma. The Degrees of D D and LL.D. are Honorary, and no charge is made for them.

A considerable number of Students in the Medical Faculty attend this University only during the last two years of the Curriculum, having studied at other Medical Schools, and some Students, having no views to Graduation, attend Special Lectures in the Faculties of Arts or of Medicine, paying the usual fees to the Professors whose lectures they attend

I do not understand it to be the wish of the Commissioners to know the gross Revenue of the University and its Officials, arising from payments by the Students. But although your letter does not appear to imply this, I should endeavour to prepare a statement on the subject, if desired, and if you would be so good as to let me know the number of years over which you would wish the average to be taken.

I have, &c.  
P C CAMPBELL,  
Principal of the University  
of Aberdeen  
J. Norman Lockyer, Esq., Secretary,  
Royal Commission, on Scientific Instruction

APPENDIX VII.

PAPERS RELATING TO THE QUEEN'S UNIVERSITY AND THE QUEEN'S COLLEGES IN IRELAND.

I EXTRACTS FROM THE CIVIL SERVICE ESTIMATES FOR THE FINANCIAL YEAR 1875-76.

The Queen's University in Ireland

A.—SALARIES	£	1,261
B.—EXAMINERS' STIPENDS	£	1,260
C.—EXAMINERS' EXPENSES	£	735
D.—MEDALS AND PRIZES	£	749
E.—INCIDENTALS	£	265
	£	<hr/>
	£	4,273

DETAILS OF THE ABOVE

A.—SALARIES	SALARY OF OFFICE			1875-76.
	Minimum	Annual Increment	Maximum	
Secretary*	£ 500	£ 20	£ 600	£ 600
Assistant Secretary†	150	20	330	330
Clerk‡	90	10	180	170
Clerk of Convocation	-	-	-	100
Writers	-	-	-	40
Office Cleaners§	-	-	-	11
Editing Calendar	-	-	-	50
				<hr/>
Total for Salaries				£1,261

\* This Officer receives also 300l. per Annum as Assistant Examiner in Dublin for the Civil Service Commissioners. Class II., Vote 11.

† This Officer received also 13 guineas in 1874, as Assistant Examiner in Dublin for the Civil Service Commissioners. Class II., Vote 11.

‡ This Officer received also 13 guineas in 1874 as Assistant Examiner in Dublin for the Civil Service Commissioners. Class II., Vote 11.

§ A portion of the Stipend of the Office Cleaners, amounting to 2l., is paid by the Civil Service Commissioners. Class II., Vote 11.

B.—EXAMINERS' STIPENDS.

Three Examiners in Greek, two at 18l, one at 20l	£	56
Ditto ditto Latin ditto ditto	£	56
Ditto ditto Mathematics ditto ditto	£	56
Ditto ditto Natural Philosophy, two at 18l, one at 20l.	£	56
Five Examiners in History, English Literature, Logic, and Metaphysics, four at 18l, one at 20l.	£	92
Three Examiners in Chemistry, two at 18l, one at 20l.	£	56
Ditto ditto Natural History, two at 18l, one at 20l.	£	56
Ditto ditto Modern Languages, two at 18l, one at 20l.	£	56
Ditto ditto Anatomy and Physiology, two at 18l, one at 20l.	£	56
Ditto ditto Civil Engineering, at 20l each	£	60
Ditto ditto Law ditto	£	60
Ditto ditto Political Economy ditto	£	60
One Examiner in Medicine	£	100
Ditto ditto Surgery, &c.	£	100
Ditto ditto Midwifery, &c.	£	75
Ditto ditto Medical Jurisprudence	£	75
Ditto ditto Materia Medica	£	75
Contingent Examiners	£	100
Superintendents of Examinations	£	15
	£	<hr/>
	£	1,260

ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION, ETC:

**D.—MEDALS AND PRIZES: £**

16 Medals at 5l. 5s. for First Class at Degree Examination	- 84
17 Prizes at 15l and one at 10l for Degree Examinations	- 265
13 Prizes at 10l for First Class at previous University Examination	- 130
22 Prizes at 10l and three at 5l for Second Class at Degree Examination	- 235
7 Prizes at 5l for Second Class at Degree Examination at previous University Examination	- 35
	<u>£749</u>

**E.—INCIDENTAL EXPENSES: £268**

Advertisements, Senators' Expenses, Extra Attendance at Examinations, at Meetings of the University, and at Meetings of Convocation, and Sundries -

Return of the Number of Students in the several Faculties or Departments at Queen's College, Belfast, during the Session 1873-74.

In Arts	-	-	-	118
" Civil Engineering	-	-	-	20
" Law	-	-	-	26
" Medicine	-	-	-	206
Not pursuing any Special Course or Faculty	-	-	-	13
				<u>382</u>
Attending in two Departments	-	-	-	7
				<u>Total number of separate Students 375</u>

(Signed) **RD. OULTON, B D., Registrar,**  
May, 1875. Queen's College, Belfast.

The Distribution of the Students attending Queen's College, Cork, among the several Faculties, during the Session 1873-74, is shown in the following Table -

	Matriculated Students.	Non-Matriculated Students.	Total.
Faculty of Arts	58	6	64
" Law	7	—	7
" Medicine	154	16	170
" Engineering	18	—	18
Total	238	22	260*

\* Of this number, 10 Students entered for, and attended Lectures in, two Faculties.

Sir, Queen's College, Galway, May 14th, 1875.  
I beg to send you, for the information of his Grace the Duke of Devonshire and the Commissioners of Scientific Instruction, the number of Students in the several Faculties at the Queen's College, Galway, during the Session 1873-74.

I have, &c,  
**EDWARD BERWICK, President.**

Return showing the Number of Students in the several Faculties at Queen's College, Galway, during the Session 1873-74

	Members of the University of Ireland.	Presbyterian.	Roman Catholic.	Other Denominations.	Total.
Faculty of Arts	7	21	26	1	55
" Law	1	8	5	—	9
" Medicine	21	15	45	4	85
Department of Engineering	6	2	2	—	10
Occasional Students	—	1	1	—	2
Non-Matriculated	2	—	3	1	6
Totals	37	42	80	6	165
Of these nine attended in two Faculties, viz -	2	4	3	—	9
Total of separate individuals.	35	38	77	6	156

Queen's College, Galway, **EDWARD BERWICK,**  
May 14th, 1875. President.

NUMBER OF STUDENTS (Matriculated and Non-Matriculated) attending the QUEEN'S COLLEGES IN IRELAND, in the Session 1874-5

[Received in reply to telegrams]

	Matriculated.	Non-Matriculated.	Total.
Belfast	345	47	392
Cork	226	23	249
Galway	148	6	154

The Queen's Colleges, Ireland.

A.—IN AID OF THE EXPENSES OF QUEEN'S COLLEGE, BELFAST	-	1,000
B.—IN AID OF THE EXPENSES OF QUEEN'S COLLEGE, CORK	-	1,000
C.—IN AID OF THE EXPENSES OF QUEEN'S COLLEGE, GALWAY	-	1,000
D.—IN AID OF THE AUGMENTATION OF THE SALARIES OF THE PROFESSORS OF THE ABOVE-NAMED COLLEGES	-	1,176
		<u>£4,176</u>

The Sum of 21,000l. per annum is charged upon the Consolidated Fund for Salaries of Professors and Officers, and Allowances for Scholars and Prizes, pursuant to 8 & 9 Vict. c 66. s 12.

See para. 210. II. NUMBER OF STUDENTS attending the QUEEN'S COLLEGES IN IRELAND

6, Old Palace Yard, London, S W.  
May 12th 1875.

Sir, I AM directed by the Duke of Devonshire, the Chairman of this Commission, to ask you to be so good as to state, for the information of the Commissioners, the number of Students in the several Faculties at Queen's College {Belfast, } during the Session 1873-4.  
{Cork, }  
{Galway, }

I have, &c,  
**J NORMAN LOCKYER,**  
Secretary.

The President of  
Queen's College, Belfast,  
" " Cork,  
" " Galway.

Sir, Queen's College, Belfast, May 14th, 1875.  
I HAVE the honour of sending to you herewith, in compliance with your communication to me of the 12th inst, a return of the number of Students who attended this College during the Session 1873-74, classified departmentally

It will be observed by a comparison with my Report for 1872-73, of which I have the honour of sending a copy by post to his Grace the Duke of Devonshire, that in the Session 1873-74 there was an increase of 24 Students here I also take the liberty of sending to his Grace the Duke of Devonshire a copy of the Report of the Queen's University for 1875

My Report for the year ending in October last (1874), is nearly printed, and will be presented to Parliament immediately after Whitsuntide.

I am happy to say that during the current Session an increase again appears, as 392 Students are at present in attendance

I have, &c,  
**P. SHULDEAN HENRY,**  
President.

LONDON:

Printed by GEORGE E. EYER and WILLIAM SPOTTISWOODS,  
Printers to the Queen's Most Excellent Majesty  
For Her Majesty's Stationery Office.

V125

# EIGHTH REPORT

OF THE

ROYAL COMMISSION



ON

## SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

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Presented to both Houses of Parliament by Command of Her Majesty.

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LONDON:  
PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,  
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY,  
FOR HER MAJESTY'S STATIONERY OFFICE.

1875.

[C.—1298.] Price 7d.



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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

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VICTORIA R.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting :

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said Willham, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE  
ADVANCEMENT OF SCIENCE.

---

*VICTORIA R.*

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts; Savilian Professor of Geometry in Our University of Oxford, Greeting :

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased :

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,  
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,  
To be a Commissioner for inquiring into  
Scientific Instruction and the Advancement of Science.

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# EIGHTH REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

We, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty, in conclusion of the Inquiry entrusted to us, the following Report on the Advancement of Science and on the Relations of Government to Science.

In the course of our Investigations into the Proceedings and Management of the Universities, Colleges, Museums, and other Institutions, which exist wholly or in part for Scientific Purposes, considerations bearing on the Relations of the Government to Science, and on the Advancement of Scientific Research, necessarily came under our notice to a certain extent; they were, consequently, referred to in an incidental manner in the Reports already submitted to Your Majesty, which, however, were mainly concerned with Scientific Instruction. The present Report will address itself directly to the Relations of Government to Science, and to the Advancement of Scientific Research; and our Inquiry divides itself into the following branches:—

- (1.) The Scientific Work carried on by Departments of the Government.
- (2.) The Assistance at present given by the State towards the promotion of Scientific Research.
- (3.) The Assistance which it is desirable the State should give towards that object.
- (4.) The Central Organization which is best calculated to enable the Government to determine its action in all questions affecting Science.

## I.—The Scientific Work carried on by Departments of the Government.

The principal branches of Scientific Work conducted by Officers of the Imperial Government, and the Departments by which they are administered, are as follows:—

Topographical Survey [Treasury (Office of Works)].

Hydrographical Survey [Admiralty].

Geological Survey [Privy Council].

Astronomical Observations:

Greenwich and the Cape of Good Hope [Admiralty].

Edinburgh [Treasury (Office of Works)].

Meteorological Observations:

Greenwich [Admiralty].

Edinburgh [Treasury (Office of Works)].

The Meteorological Office.

[The Meteorological Office is not administered by any Public Department, but is directed by a Committee, which, although appointed by the Royal Society, is independent of that body.]

Botany.—Royal Gardens, Kew; Botanic Garden, Edinburgh; Botanic Gardens, Dublin [Treasury (Office of Works)].

The Chemical Department of the War Office.

The Standards Department of the Board of Trade.

Analogous work is carried on in some of the Colonies and Foreign Possessions by Departments of their respective Governments.

In one case, that of the Royal Observatory, Greenwich, the work is examined into and reported on to the Admiralty by a Board of Visitors composed of men of Science.

Some branches of the work dealt with, from the accident of their origin and from other causes, are less entirely devoted to the direct necessities of the State than others; whilst it will be seen that there are certain lines of investigation of no less importance to the State than those for which provision has already been made, which the State has not as yet undertaken.

The Imperial Investigations enumerated, with the exception of the very special work of

the Chemical Department of the War Office and the Standards Department of the Board of Trade, generally extend over large areas or long periods of time, and consequently are of such a nature that the State could not safely intrust them to the action of Individuals or Societies, even if these were willing to undertake them!

When Scientific questions arise on which the Departments are not supposed to possess the requisite theoretical or practical information, Special Committees are appointed or the advice of individuals presumed to be specially qualified is obtained, either directly or through the Royal, the Geographical, or some other Learned Society.

The following is a Statement showing the annual charges borne by Imperial Funds, at the present time, to defray the expenses of such of these various investigations as appear separately in the Estimates for the year 1874-75.

	£
Appendix I. Topographical Survey, (excluding Military pay of men employed).	132,000
Hydrographical Survey	121,055
Geological Survey	22,920
Astronomy	9,703
Meteorology	12,082
Botany, including the maintenance of Botanical Gardens as places of Public Recreation	21,470
Standards Department of the Board of Trade	2,063

In addition to these recurring charges, sums are voted from time to time for various Expeditions and for Experiments incidental to the Services of the various Departments, such as the Investigations concerning the Causes and Processes of Disease carried on under the Direction of the Lords of the Privy Council, and the various Experimental Researches carried on for the Army and Navy.

We have not considered it necessary to take Evidence regarding the detailed work of the Public Departments, but have thought it sufficient to collect the general opinion of those who are connected with, or well-informed concerning, the Scientific Work carried on by those Departments.

In the case of the Meteorological Office, however, both on account of its recent establishment and the circumstance that it is not directly responsible to any Public Department, we have felt it our duty to take Evidence at some length, both as regards its Scientific and Financial Administration.

#### *Evidence as to the Insufficiency of the present Organization.*

The Evidence which we have taken, as to the sufficiency or insufficiency of the work done for the Advancement of Science, including that of the Government Departments, is very copious. A large portion of it is contained in the volumes already published, and it will have been seen that there is a general concurrence of opinion, that, even in the interests of the Departments themselves, more ought to be done by the Government in the way of Investigation, particularly in respect of those Sciences the Practical Application of which has been developed, or the scope of which has been enlarged by Discovery, within recent years.

These opinions are entertained alike by persons engaged in Scientific Work under the various Departments of the Government, and by Scientific Men having no official connexion with the State.

The following are extracts from the Evidence on this branch of the subject.

Qu. 12,564. Sir Henry Rawlinson, a member of the Indian Council, states that in that Council they perpetually have references before them which they are unable to deal with. He adds:

Qu. 12,565. \* \* \* "We have, for instance, Sir William Baker, upon the Council, and General Strachey and Colonel Strange both attached to the Office; yet, notwithstanding their valuable aid, there are many subjects referred to us with which we are quite incompetent to deal."

He then refers to the following subjects among others:—The Manufacture of Iron and Steel in India; the Efflorescence of Soda on Irrigated Land; the Fermentation of Beer, "which may involve a loss of 200,000*l.* or 300,000*l.* a year to the British Government;" the question of Drought arising from the Destruction of Forests; the Construction of Harbours and of other Hydraulic Works; the Founding of Brass Guns; Tidal Observations; the Publication of Works on the Flora and Fauna of India; Geological and Trigonometrical Surveys; Sea Dredging; and Observatories.

He points out that many of these questions are practical and economical, but that still there is a scientific element in almost all of them, and he adds—

"References on all these subjects are constantly coming home, and we have no means of answering them in our own body, while it is very unsatisfactory to be obliged to send out for gratuitous information. We do sometimes, it is true, apply to individuals and sometimes to societies, but in very many cases, I am afraid, the questions are shelved, because there is no competent and authoritative body to refer to." Qu. 12,565.

Captain Douglas Galton, of the Office of Your Majesty's Works and Public Buildings, thinks that, as a rule:

"\* \* \* "Our statesmen do not appreciate properly the value of scientific advice or scientific inquiry, and that they are very much fonder of experiments made upon a large scale with no defined system, than they are of experiments which have been brought out as the result of a carefully studied previous inquiry. I think that an enormous amount of money was wasted in the case of the inquiry into armour plates, both for ships and forts. In that case the Government appointed a partly scientific committee, but it was mixed up with other persons who were not scientific, and instead of commencing a series of experiments upon a small and clearly defined scale, from which they could have drawn conclusions for making their larger experiments, they began by firing at any plates that were offered to them which had no relation one to another, either in their relations to the guns or to the form of backing, or in any other way, and consequently it was difficult to draw useful calculations from them." Qu. 12,966.

Mr. Froude, who was a prominent member of the late Committee on Naval Designs, and who is now devoting his whole time without remuneration to the investigation of the proper forms of ships of war, states that if, at an earlier time, a laboratory had existed, and proper experiments had been made, enormous sums would have been saved which have been expended in the actual construction of ships, or, as he terms it, "experiments on the scale of 12 inches to a foot;" and that definite results would have been arrived at with less loss of time.

"I think any experiment almost on the sailing or rolling properties of a big ship, when tried in a big ship to begin with, is a waste of money. The cost of construction of a big ship as an instrument of investigation is enormous; and if it is tried with a view to the application of a new principle, there must be the risk that the experiment will be to some extent wasted. Being an experiment, the very fact that it is an experiment implies that it may not turn out as it is expected, and a failure in so costly a piece of apparatus as a new complete ship is inevitably a very costly failure. So far as it is possible to arrive at a proper understanding of such subjects by small-scale trials, it is of the utmost importance, economically, that that method should be adopted, and I think that that has not been sufficiently adopted." Qu. 11,344.

It will be seen from the Evidence of General Strachey, which we quote in a subsequent part of this Report, that he also disapproves of the mode in which Government is at present advised on questions of Science, especially on the ground of the absence of scientific training in the political and official classes of this country.

Sir Wm. Thomson has given us the following Evidence:

"\* \* \* "With a vast amount of mechanical work which is necessarily undertaken by the Government, and which is continually in hand, questions involving scientific difficulties of a novel character frequently occur; questions requiring accurate knowledge of scientific truth hitherto undeveloped are occurring every day. In both respects the Government is at present insufficiently advised, and the result is undoubtedly that mechanical works are sometimes not done as well as they might be done, that great mistakes are sometimes made; and, again, a very serious and perhaps even a more serious evil of the present system, in which there is not sufficient scientific advice for the Government, is the undertaking of works which ought never to be undertaken." Qu. 10,675.

"Are you able to point out any instances which you have in your mind of mistakes which you think have occurred from the want of good advice on the part of the Government?—One great mistake undoubtedly was the construction of the "Captain," and I believe that a permanent scientific council advising the Government would have made it impossible to commit such a mistake. They would, in the very beginning, have relieved the Government from all that pressure of ignorant public opinion which the Government could not possibly, in the present state of things, withstand." Qu. 10,676.

The present system of Special Committees is objected to by Sir William Thomson, and by other competent Witnesses.

Sir William Thomson thinks "that a single body would be better than a number of small Committees for advising the Government on the great variety of questions which from time to time would be likely to arise." Qu. 10,677.

Admiral Richards, late Hydrographer of the Admiralty, is of opinion that:

"The members of such committees must be selected more or less to fulfil certain political conditions, and that, as a rule, they would come new to the subject that they were going to consider, and I do not believe that the Commission which sat on the Naval Designs the other day was a very successful one. I do not know that any great advantages have arisen or are likely to arise from it." Qu. 11,589.

Mr. Froude, in reply to the remark: "You do not consider Committees of that kind to be a very satisfactory way of proceeding?" thus states his objection to the present system:

"I do not think so, because they have to find out the dream and the interpretation both, which is always a difficulty. They have to feel their way to a *locus standi*, which would already be possessed by a Council habitually operating with reference to the subject." Qu. 11,293.

Additional examples of these defects are given, not only by these Witnesses, but also by others, whom we shall quote in that part of our Report which deals with the proposed remedies.

*Evidence as to the Insufficiency of the present Appliances for Investigation*

Our attention has been especially directed to the want of Laboratories for the use of the officials charged with Scientific Investigations urgently required for the economical management of the Public Departments.

Qu. 11,923. Mr. Anderson, the Superintendent of Machinery at Woolwich, who has been responsible for the expenditure of "very nearly 3,000,000*l.* of public money," points out that there are no means at the disposal of State servants to enable them to investigate questions on which large expenditure depends. With special regard to his own Department, he states :

Qu. 11,929. "There is a very great deal which I should like to see taken in hand systematically. \* \* \* There is much that we are in the dark about ; we are groping in the dark in almost everything at present."

Qu. 11,930. "Although we know a very great deal with regard to iron, cast, wrought, and in the condition of steel, there is yet very much which we do not know, and I am persuaded that if we could with certainty treat ordinary cast iron in the way that we sometimes do, nearly by chance, we would do away with three-fourths, or a very large proportion of the wrought iron which is now used in this country, and we should use cast iron. A great deal of the cast iron of commerce is not much above five tons per square inch in tenacity, but we can, by trying, get it up to 15 tons, although some of the reasons that determine that high character are obscure and it is very difficult to see what they are. I should like that the subject of cast iron should be thoroughly exhausted, and at the same time I should like to see the physical properties of iron thoroughly exhausted." \* \* \* \*

He next refers to another question of great importance to almost all the Public Departments :

Qu. 11,931. \* \* \* "There is another very important subject which I might mention to the Commission. Some 20 years ago we were using 10 or 12 pounds of coal per horse-power per hour, and the majority of engines still require six pounds, but by the improvements that have taken place we are now down to two pounds. There is a little engine at work now in the London district which is working at 1½ pounds. There is a great gulf yet between getting steam-engines that will work at 1½ pounds per horse-power per hour, and the point where we are now ; I mean getting that done practically ; but I believe that if the right man, or two men, were told off to thoroughly investigate this subject, and not to stop working until they had brought it to a practical shape, we could in 10 years from this time get down to one pound per horse-power per hour. I see that there are very many leakages or loss in steam-engines in the very best way that we make them at present. The knowledge that was gained by Joule's experiments a few years ago seems to me to have been of immense value. Those experiments that he carried out for himself were the sort of thing which I think the Government should have done for the sake of the country. He did more to make engineers thoroughly dissatisfied with their present knowledge with regard to what they can do with steam than anything which had been done before. I believe that what Mr. Joule did will do more for this country than even what James Watt did. The part that James Watt took was very great, and the world gives him full credit for it, but the world is scarcely willing to give credit to Joule for what he will do ; but he has made all engineers dissatisfied. They know that the best steam engine is not doing one-sixth of the work which it ought to do and can do. That is a sad state of matters to be in when we know that we are so far wrong, but yet no one will go to the trouble of going to the end of the question so as to improve the steam engine as it might be done ; in fact, it will cost a great deal of trouble and a great deal of expense, I have no doubt."

Qu. 11,933. With regard to the question whether it is "desirable that the Government should establish any Laboratories for carrying on those investigations," he thus stated his opinion :

"I should like to see a grand laboratory fitted with everything that would go towards the investigation of such matters, and at the same time a testing apparatus for getting at the physical facts as well. To get up the proper plant would be very expensive, but still I should like the nation to have it, so that any public department could go to this same laboratory and ask them for assistance to investigate any doubtful point. \* \* \* In the Government service everybody who gets any work to do worth mentioning is overpowered with work—either they get too much or too little to do—and the investigator should not be bothered with such miscellaneous work. For example, take my own case, I may have 50 subjects in a day many times. Yesterday I had well on to 50 subjects to take up, and go into them all as well as I could, and I did not get over my work to write the paper which now lies before your Grace until 9 o'clock last night. A man is not in a position to pursue investigations when he is overworked in that way."

Mr. Anderson's Evidence finds a parallel in that given by Mr. E. J. Reed, M.P., late Chief Constructor of the Navy.

Qu. 12,706. "I think that there are many branches of science remaining undeveloped at present, the development of which would be of great advantage to the country. I base that opinion partly upon the experience which I acquired at the Admiralty, in which I continually found that great and important questions were undeveloped for the want of organisation and of the means of developing them."

Qu. 12,707. \* \* \* "Mr. Froude in his evidence before this Commission stated that he had in hand a series of experiments for the Admiralty, having for their primary object the determination of the relations between form, speed, and resistance in ships, and, as he justly observed, this inquiry collaterally raises some other questions ; but there is one subject related to that which Mr. Froude has under consideration, but which has not been developed at all yet, and it is one upon which very important financial questions hang ; I refer to the dependence of the form of ships upon the weight of the materials composing their hulls. It will be obvious to the Commission that if you are going to build a ship for high speed of the thinnest steel, you can afford to prolong the ends of the vessel at either end, and give them extreme fineness in a manner and to a degree which would be preposterous, and I may even say monstrous, in the case of a ship which had to be built with very thickly-armoured sides. In this country the earlier ironclads were made of a form involving very long and fine lines, in fact a form analogous to that of mercantile steamships, and the consequence was that although in the 'Minotaur' type of ship armour and backing equivalent only to that used in the first instance in the



'Warrior' was employed, yet we got a ship 400 feet long, costing nearly half a million sterling. The impropriety of that course impressed itself upon my mind, and I believe it was more for that reason than for any other that I ventured to propose to the Admiralty a great change in that respect, and placed before them the design for the 'Bellerophon' as an example of a vessel which should be as fast as those long ships, and more effectually armoured, and much more handy, carrying at least as efficient an armament, and yet should cost about 100,000*l.* less. That policy was sanctioned by his Grace the Duke of Somerset; the 'Bellerophon' was built, and I believe long before she was finished the principle obtained so much favour that the idea of building another of the extremely long vessels never entered anybody's mind, and it was stated by the late First Lord of the Admiralty, Mr. Childers, in Parliament, officially, that by adopting that modification of form at least a million sterling had been saved to the country in the course of a very short time. But I wish to impress upon the Commission, if I may be allowed to do so, that that economy resulted from a mere tentative and limited application of a scientific principle, which has never been developed, and which the organisation of the Admiralty furnishes no means for developing. I indicated the nature of this investigation in a paper laid before the Royal Society some two or three years ago, but as the solution of it involves high mathematics on the one hand, and elaborate experimental investigations upon the other, it has never been taken up and dealt with in any sufficient way."

"A second illustration which I should like to give is this: the present condition of the marine steam-engine and boiler is very unsatisfactory. It is unsatisfactory to such an extent that I believe if the manufacture of iron and steel were improved with reference to its use in the construction of engines and boilers, and if improved material were applied by improved methods, a saving of one half of the present weight would be attained, and when I say one half I know that I am speaking greatly within the limits which some persons who have thought very much about this question would be prepared to express. Of course, if that be so, if we are carrying about in our mercantile and other steamships twice the weight which is essential for the production of the power, that is so much taken off either from the further power and speed which might be obtained, or from the freightage and commercial value of the vessel. I may mention that in the manufacture of shafts, for instance, of the marine engine and of stern posts, and other large forgings for ships, the method of production is comparatively rude, and it very much needs development. I for one feel the necessity of great improvement in these respects, because I know that at the present moment the successful production of those enormous forgings rests a great deal more upon the skill of a workman than upon the application of any science whatever to them. So much has the subject been neglected, that, at this moment, I have the responsibility of seeing some very large forgings indeed made for certain ships, and the most effectual manner in which I can give effect to my responsibility is that of selecting the very best working smith that I can find, and putting him into the manufactory where those things are being made, for him to do the best that his experience enables him to do, in order to see them properly constructed. I believe that if a regular independent scientific investigation were applied to a manufacture of that nature, enormous advantage would at once result."

Qu. 12,708.

The Standards Department of the Board of Trade is another Department requiring advice in varied scientific subjects. The Warden of the Standards (Mr. Chisholm) states:

"There is no scientific authority to which I am entitled to appeal. It happens at the present time that I have the advantage of appealing to my former colleagues in the Standards Commission, to the Astronomer Royal and to Professor Miller, and I get a great deal of assistance from them in that way, especially from Professor Miller. In fact I could hardly have 'executed the scientific duties' of my department without having assistance of that kind, but such aid has been obtained merely in consequence of my relations with them as a colleague. I am in no wise authorised to call upon them or upon any other scientific authority for information or assistance. I may here particularly refer to one subject which is mentioned in my paper, the preparation of new standard trial plates for coin. I actually required scientific information upon that point, and I could only apply to the Astronomer Royal, but his time was taken up so much that after some time he declined interfering in the matter, so that I have been obliged to act in the matter without having any scientific authority to aid me, although it is a very responsible duty cast upon me by law."

Qu. 11,666.

Sir William Thomson, in reference to the subject of Standards, says:

"The conservancy of weights and measures is a subject involving questions of the most extreme scientific nicety. Faraday made statements showing how completely unknown at present are the properties of matter upon which we depend for a permanent standard of length. One of the very first objects that should be undertaken in connexion with the conservancy of the standards of weight and length is secular experiments, on the dimensions of metals and solids of other classes under various conditions of stress, temperature, and atmosphere. Those would involve scientific experiments of an extremely difficult character, and also operations extending from year to year. There ought to be just now a set of experimental specimens of solids laid up which should be examined every year, or every 10 years, or every 50 years, or every 100 years, the times when observations are to be made from age to age being regulated by the experience of the previous observations. It would be necessary to begin observing every month, then when constancy is attained within the degrees of observable minuteness to observe every year, then every 10 years, then perhaps every 50 years, and then it might be sufficient to look at them every 500 years, and examine whether this copper standard and that brass standard have retained precisely the same length. This would not be a very difficult or expensive thing to institute in such a way as eventually to obtain good results, but it would be an operation of a secular character, which could only be carried out by the Government."

Qu. 10,678.

Dr. Frankland thus refers to the various requirements of Government involving Chemical Investigations:

"The State requires many important investigations to be carried on. Such investigations are being continually conducted in buildings often very ill-adapted for the purpose, and which are fitted up for the purpose at a great cost. The laboratory of the Rivers Commission, for instance, which we have occupied for four years, was constructed in a house in Victoria Street; a rent of 200*l.* a year is paid for it, and it is literally nothing more than a moderate sized room, and two smaller ones, very ill-adapted for the purpose. Consequently, this laboratory is not so efficient as a building erected for the express purpose of conducting such investigations would be."

Qu. 11,065.

In the Evidence which we have taken with regard to Astronomical Physics and Meteorology, the expressions of opinion as to the insufficiency of the means of investigation are so interspersed with suggestions as to the remedies to be applied, that we think it more convenient to refer more particularly to these subjects in the Third Part of this Report.

## II.—The Assistance given by the State towards the Promotion of Scientific Research.

Fourth  
Report.

It may be convenient, for the purposes of this Report, to consider the Assistance given by the State towards Scientific Research as being either Permanent or Occasional.

Our great National Museums (upon which we have already reported) come under the first of these descriptions, and it will have been seen that for the purposes of the Student of the Biological and Geological Sciences, Collections are provided on an extensive scale so that the Student of these branches of Science has advantages similar to those provided for the Student of Art or Literature.

On the other hand, the Student of the Physical Sciences has no such facilities; there are, at the best, for some of these branches of study, Collections of Instruments of a very inadequate kind, and relating for the most part to Applied as distinguished from Theoretical Science.

We have also reported to Your Majesty that the National Collections, so far as they illustrate the Biological and Geological Sciences, are rendered easily accessible to the Students of those Sciences. But the few instruments illustrative of Physical Science in any National Collection are so placed that they can scarcely be used even in the study of the History of Science. Moreover, as a mere collection of instruments, however complete, without working laboratories, is of little use to the Student of the Experimental Sciences, and as there are no Public Laboratories available for the Researches of Private Investigators, it may be said that in many branches of Experimental Science the State affords no permanent material aid to such Investigators.

Assistance of a Permanent Description is also afforded to certain Learned Societies, by providing them with apartments free of rent, or with annual grants of money in lieu of such accommodation; the sum of 500*l.* granted annually to the Royal Geographical Society under certain conditions is an instance of such a grant.

We may regard as a Permanent Aid to Science the grant of 1,000*l.* for Researches carried on by Private Individuals, which is annually voted by Parliament, and administered by a Committee of the Royal Society.

This Grant has rendered such great services to Science, that we desire to give the following Outline of its History.

The first proposal for such a grant was contained in a letter (dated October 24th, 1849) from Earl Russell (then Lord John Russell) to the then President of the Royal Society (the Earl of Rosse), and was to the following effect:

App. XI.  
vol. II. p. 47.

"As there are from time to time scientific discoveries and researches which cost money and assistance the students of science can often but ill afford, I am induced to consult your Lordship, as President of the Royal Society, on the following suggestion—

"I propose that at the close of the year the President and Council should point out to the First Lord of the Treasury a limited number of persons to whom the grant of a reward, or of a sum to defray the cost of experiments, might be of essential service. The whole sum which I could recommend the Crown to grant in the present year is 1,000*l.*, nor can I be certain that my successor would follow the same course; but I should wish to learn whether, in your Lordship's opinion and that of your colleagues, the cause of science would be promoted by such grants."

Lord Rosse, in his reply to the proposal made by Lord John Russell, expressed his personal opinion that the judicious employment of grants in the way proposed "would very materially promote the Advancement of Science;" and of the two alternatives, namely, expending the 1,000*l.* in rewards or appropriating it to the payment of the expenses of experiments, he preferred the latter, indicating his reasons as follows:

App. XI.  
vol. II. p. 47.

"There are often details to be worked out before it is possible to employ usefully newly discovered principles. In many of the sciences reductions are required before observations can be made use of. Both in Science and Art facts technically called constants are the materials of discovery; to determine them accurately is of great importance. Now in all these cases, and in many others, the work to be done is laborious and expensive, and as it adds but little comparatively to the fame of the individual, it especially requires encouragement."

On this correspondence being communicated to the Council of the Royal Society, a Committee was appointed "to consider and report respecting the application of the proposed grant." This Committee agreed to the following Recommendations:

- "First and chiefly—That the grant be awarded in aid of private individual scientific investigation.
- "Secondly. In aid of the calculation and scientific reduction of masses of accumulated observations.
- "Thirdly. In aid of astronomical, meteorological, and other observations, which might be assisted by the purchase and employment of new instruments.
- "Fourthly, and, subordinately to the purposes above named, in aid of such other scientific objects as may from time to time appear to be of sufficient interest, although not coming under any of the foregoing heads."

It was further added--

"That a Committee be appointed, consisting of the whole Council for the time being, ex officio, together with an equal number of Fellows of the Society, chosen by the Council amongst the members most conversant with the business of the Royal Society, or with one or more of the leading departments of Science, or officially connected with the principal scientific bodies of the kingdom; such additional members to be named for a period of three years, subject to the annual revision of the Council, and provision being made for filling up the vacancy occasioned by such additional member becoming a member of Council during his term of service on the said Committee, should such occur."

App. XI.  
vol. II. pp.  
41, 42.

With regard to this Government Grant, Sir Edward Sabine, in his Evidence, says:

"I suppose that the 1,000*l.* in one year was designed as an experiment to try the matter in the first instance. I always understood that Lord Russell contemplated that the sum would be augmented if the plan were found to work well."

Qu. 11,135.

Neither the amount of the Grant, nor the conditions of its administration, have been varied from the time of its commencement. For full details as to its application in successive years, we refer to the Statement presented by Sir E. Sabine, and printed in the Appendix to Vol. II., at pp. 41 to 47. In a later part of this Report, we shall refer to the proposals which have been made to us for increasing the amount and usefulness of the Grant.

The most important instances of the Occasional Assistance given by the State, are Expeditions for Special Researches, and Outfits of Ships, and Apparatus and Grants of Money for such Researches. These contributions are of great value, but they do not appear to be granted or refused on any sufficiently well defined principle.

III.—The Assistance which it is desirable the State should give towards Scientific Research.

We have received strong Evidence that it is the interest and within the proper function of the State to give efficient aid to the Advancement of Knowledge, even in those cases where such knowledge is not directly required for State purposes, and, we may remark, that some of the most decided expressions of opinion to this effect are those of Statesmen, whose views, owing to their official experience and their intimate knowledge of the exigencies of Parliamentary Government, are entitled to great weight on points involving increased grants of public money.

The Evidence of Lord Salisbury is emphatic :

- Qu. 13,555. "Do you hold that the State may legitimately interfere in giving aid to the advancement of science?—I certainly do. It is a very orthodox doctrine to hold, and one which could be supported if necessary by quotations out of Adam Smith, the essence of the doctrine being, that the State is perfectly justified in stimulating that kind of industry which will not find its reward from the preference of individuals, but which is useful to the community at large."
- Qu. 13,556. "The State has already, to a considerable extent, recognized, has it not, that duty; and there are a considerable number of scientific institutions supported more or less by the State?—No doubt the State, in the money that it gives, and has given in past times, to the best Universities, has recognized that duty."
- Qu. 13,557. "There are the Observatory at Greenwich, the British Museum, and Kew Gardens; you would consider those as instances in which the State aids the promotion of science?—They would be all instances in point; and I do not apprehend that as to the abstract doctrine itself there has ever been any serious contest." \* \* \*

Lord Derby's Evidence in favour of State Aid to Science is all the more weighty from the limitations by which he guards it :

- Qu. 13,513. "I think there has been a very general consent amongst a large number of men of science who have been examined before this Commission that in the present state of science there are many branches as to which there is no probability of their being advanced to the degree to which they are capable of being advanced by private effort, and without the assistance of State funds in some shape; what is your Lordship's opinion upon that subject?—I am, as a general rule, very strongly in favour of private effort, and very decidedly against the application of State funds to any purpose that can be accomplished without them; but I think that if there is any exception to that which I venture to call a sound and wholesome rule, it is in the case of scientific research, because the results are not immediate, they are not popular in their character, and they bring absolutely no pecuniary advantage to the person engaged in working them out. A great mathematical or a great astronomical discovery is a benefit to the whole community, and in a certain sense to mankind in general; but it is productive of absolutely no benefit, in a pecuniary point of view, to the person who has given his labour to it."

Sir Stafford Northcote thus states his opinion on the point :

- Qu. 13,623. \* \* \* "The State should do what it can both to promote scientific education and also to assist in the prosecution of scientific experiments and inquiries when they can be best prosecuted by the aid of the State."

On the proposition that it is the duty of the State to encourage Original Research, we might multiply our extracts from the Evidence indefinitely. Dr. Frankland, Sir W. Thomson, Dr. Joule, Mr. Gore, Dr. Carpenter, Professor A. W. Williamson, Mr. Reed, Sir E. Sabine, Dr. Siemens, Dr. Sclater, Mr. Farrer, Admiral Richards, and numerous others, show that the Aid of Government to Scientific Research has been beneficial, so far as it has gone, but that it has been insufficient and should be increased.

We have selected the Evidence of Dr. Frankland and Sir W. Thomson from amongst that given by men of Science.

Dr. Frankland's Evidence is to the following effect :

- Qu. 5883. "Setting aside the interests of science, what would be your expectation under equal circumstances otherwise, in reference to two countries, in one of which scientific research was neglected, whilst in the other it was pursued with considerable vigour, with regard to the progress of the arts and of manufactures?"
- "In my opinion there could not be any doubt but that the nation which neglected science must suffer in the end, because although it could buy scientific inventions from the other country, yet still it would always be behind, as it were, in the market; it would have to follow the lead of the other country, which I imagine would be a commercial disadvantage."
- Qu. 5884. "Might it not also be the case that the appreciation of the commercial value of scientific inventions would be very much more uncertain in the one country than in the other?"
- "Yes. It is also much more difficult to establish manufactures upon new inventions in a country which neglects science, because you cannot have either workpeople or managers competent to conduct those processes which depend upon scientific principles."
- Qu. 5885. "People might pay large sums for what was worthless, and neglect that which was of great value?"
- "They might."

- Qu. 10,736. Sir W. Thomson emphatically asserts that, in his opinion, it is of the most immediate consequence to the honour and welfare of the country that men should be enabled to

live on Scientific Research, and that a definite and secured position should be given to Scientific Workers.

In another part of his Evidence he states :

\* \* \* \* "There are many investigations which can only be done by the nation as a whole ; and viewing the Government in one sense as acting for the nation, as it were a committee of the whole nation, there are very many investigations not merely of importance with reference to promoting the material prosperity of the nation, but valuable to the nation as promoting scientific discoveries, in which the whole nation takes a pleasure, and from which the whole nation derives as great benefit as anything material can possibly produce. Investigations for which a large expenditure of money is necessary, and which must be continued through long periods of years, cannot be undertaken by private individuals. Generally speaking, I believe that if the Government is well advised in respect to science, it will be for the good of the nation that the Government should make it part of its functions to promote experimental investigations in science." Qu. 2,693.

As representing the opinions of public servants occupying high official positions in Government Departments, we may refer to the Evidence of Admiral Richards, late Hydrographer of the Admiralty, and to that of Mr. Farrer, Secretary to the Board of Trade, the latter of whom, in answer to the question—"Have you formed any opinion as to whether further grants ought to be given by the Government for Scientific Research?" says ; Qu. 12,642.

"I can only give an opinion which is of very little value ; but I think there can be no doubt whatever that there are numerous subjects, and always will be numerous subjects, in which private observers are unable to do what is wanted. For the older sciences you have had observatories established at the Government expense, for astronomy, and now, recently, for meteorology ; and those cannot be the only sciences to which assistance ought to be given on the same principle."

#### *Evidence relating to the Establishment of Laboratories.*

We proceed to give extracts from the Evidence placed before us in reference to the need of Laboratories for conducting alike Chemical, Physical, Metallurgical, and Physiological Inquiries, both for Departmental Work, and for the Researches of Private Individuals. Where the Evidence is of a general character, and includes proposals regarding Observatories also, we give it here, although we shall deal with the special question of Physical Observatories separately.

Amongst the witnesses who are in favour of the erection of new Laboratories for Research is Colonel Strange, whose view of the National Requirements in these respects is thus given :—

"Will you be so good as to enumerate the institutions which you think should be under the State?— (1.) an observatory for physics of astronomy ; (2.) an observatory for terrestrial physics, namely, meteorology, magnetism, &c ; (3.) a physical laboratory ; (4.) an extension of the Standards Office ; (5.) a metallurgical laboratory ; (6.) a chemical laboratory ; (7.) an extension of collections of natural history, and an able staff of naturalists ; (8.) a physiological laboratory ; (9.) a museum of machines, scientific instruments, &c. I believe that under one or other of these and existing institutions every requisite investigation will range itself. I have not stopped to inquire whether one or another is more or less important. My aim in the spirit of my postulate No. 2 has been *completeness*. It may be necessary for a manufacturer to prosecute only such particular investigations as promise direct and speedy profit. A great nation must not act in that commercial spirit. All the operations of nature are so intimately interwoven, that it is impossible to say beforehand that a given line of research apparently unproductive may not throw light in unsuspected directions, and so lead to untold and undreamt of treasures." \* \* \* \* Qu. 10,441.

Sir W. Thomson's Evidence is as follows :—

"Are you of opinion that any national institutions supported by the Government are required for the advancement of science?—I think that there ought to be institutions for pure research supported by the Government, and not connected with the Universities. The only suitable place at present for such institutions would be London, or the neighbourhood of London ; in that situation, I believe, very great things could be done by institutions for pure research, at which work of a very great immediate money value would be produced at an extremely moderate cost, and I believe that discoveries redounding to the honour, and credit, and pleasure of this country would infallibly be made" Qu. 10,696.

"Are you able to give any idea as to how many such institutions would be required?—There should be five. One at present exists, namely, the Royal Observatory at Greenwich. Another in my opinion is very much wanted, an observatory for astronomical physics, then again a physical laboratory, and a laboratory for chemical research, and a physiological laboratory are necessary." \* \* \* \* Qu. 10,697.

"Would such a physical laboratory differ in any essential respects from a physical laboratory attached to an University?—Yes ; it would be adapted solely for research, with no provision for pupils except what may be called apprentices, or pupils for research ; no provision for teaching the mere elements of manipulation, but provision for researches directly adapted to increase knowledge, and for making pattern researches for the sake of training research pupils who had already gained experience and proved ability in institutions of instruction." Qu. 10,703.

"Would you leave the researches to be carried on at such a laboratory mainly to the discretion of the person who had charge of it, or would you place it in any degree under the control of the council of which you have been speaking?—I would leave it to the discretion of the person who has charge of it." \* \* \* Qu. 10,704.

- Qu. 10,705. "And that the Government should also be able to command investigation on the advice of the council?—  
Yes."
- Qu. 10,706. "Of course the director would report?—Yes, the director would report on everything, both researches undertaken at his own instigation, and investigations undertaken for the council, or for the Government."
- Qu. 10,707. "And your view of what should be done in the chemical and physiological laboratories would, I presume, be something of the same nature?—Yes, something of the same kind, *mutatis mutandis*."
- Qu. 10,709. "With respect to the apparatus, and the annual supply of apparatus, it is probable, is it not, that the physical laboratories would be the most costly?—Yes, the most costly in apparatus."
- Qu. 10,710. "Some very fine instruments of a costly kind are now required in physiological inquiries, and large pieces of apparatus are sometimes employed, such as the respiration apparatus at Munich, which was put up on the recommendation of Professor Pettenkofer?—Yes, it would be in my opinion necessary not to limit to a fixed endowment the expenditure of any one of those institutions, but to let it be determined (if I may use the expression once more) by natural selection, applications for money to be made to the council to be duly weighed, and the council to apply to the Treasury. That would be much more economical than giving a fixed sum which, being to be spent, might be spent without due regard to economy, or which, on the other hand, might prove to be insufficient for valuable researches, causing the institution thereby to be crippled and to lose efficiency."
- Qu. 10,711. "You would not think it indispensable, would you, that such institutions, if the Government thought fit to establish them, should be in the heart of London, or in any very central situation?—No; it would be much better that they should be in the country in positions conveniently accessible to London. For a physical laboratory quietness of the ground is of immense importance. It would be impossible to make a great deal of the most important scientific investigations in a physical laboratory within 100 yards of any of the great thoroughfares of London, and a much greater distance than 100 yards is quite necessary for many such investigations."
- Qu. 10,712. "You would not institute any regular provision for teaching in those laboratories?—No."
- Qu. 10,713. "But you would allow young men or students who wished to carry out original research to avail themselves of them under the direction of the persons who were in charge of them?—Yes, under the direction, and to some degree under the instruction of the persons in charge; but the instruction should be limited to methods for advancing science. The director of such an institution must not be occupied with lecturing in any other institution, or with lecturing at all. He ought indeed to be prohibited from lecturing, except one or two occasional lectures in the course of a year."
- Qu. 10,714. "You think that the object for which you recommend the establishment of those laboratories could not be accomplished by any other means—~~not~~ by investigations carried on in other laboratories in the country?—Certainly not by any other means."
- Dr. Frankland thus refers to the double function which such Laboratories might perform, and states his view in reference to their management:—
- Qu. 11,064. "Can you make any suggestions as to stimulating original research in this country?— \* \* \* We have in this country a considerable body of investigators who are not engaged in teaching at all, and I think that this is a peculiarly hopeful feature of our case. It shows that the English have not only a taste for research, but that they have a natural talent for it. We have numerous men like Mr. Gassiot, Sir W. Grove, Dr. De La Rue, Mr. Spottiswoode, Mr. Huggins, Mr. Duppa, Mr. Buckton, Mr. Joule, Mr. Lockyer, Mr. Perkin, Mr. Schunck, Colonel Yorke, and others whom I could name, who are not in any way engaged in teaching, and never have been, but who have made important original researches, and have spent a good deal of their time in the working out of new discoveries. Now that method of stimulating research, which I have mentioned to my former examination, would, not of course apply to them. Men of this class are really peculiar to England, for I have never known any such instance in Germany or in France, of men altogether disconnected with teaching taking up research in the way it is done in England. I think that for such men the establishment of national institutions such as those which are recommended by Colonel Strange would be peculiarly useful. In fact, I have heard several of these gentlemen express strong opinions as to the great advantage it would be to them if they could go to some institution of that kind to conduct research, where expensive instruments, which are often required for their experiments, were provided for a number of such investigators, and where appropriate rooms for carrying on these researches could be had. It is exceedingly difficult to carry on chemical research in one's own house, because of the want of proper contrivances for dealing with corrosive gases and vapours; and hence appropriate buildings ought to be provided for carrying on such investigations. I think, therefore, that it would afford a great stimulus to research of this kind if such institutions were provided, and furnished with such instruments as would be generally useful in research, leaving the more special instruments and materials adapted to the particular researches themselves, to be provided by each operator. \* \* \* I have reason to believe that no inconsiderable number of men, more especially of those educated in some of the science schools, would undertake researches if such facilities were afforded them."
- Qu. 11,065. "Would you consider the chief use of such institutions as laboratories to be to enable private inquirers to carry on their researches, or would you propose that any investigations should be carried on there on behalf of the State?—I think that both things might be provided for. The State requires many important investigations to be carried on. \* \* \* That might well form one part of the objects of such a building, but I should think that so far as abstract research, of which we are more especially speaking now, is concerned, the other portion of those objects, namely, the encouragement of original investigation in the case of amateurs would be more important, because the investigations made for the Government are essentially practical investigations; they are not usually of that character which lead to discoveries or to the advancement of science."
- Qu. 11,066. "Would you place these laboratories under a permanent official?—They must of necessity be under the direct and constant superintendence of some one thoroughly conversant with the operations going on in them; and, so far as the conducting of the separate original researches is concerned, I think that it would be very desirable that the admission into such institutions should be granted through some such body as the Research Fund Committee, for instance, of the Council of the Royal Society, or some body of that kind, who would make intelligent and impartial inquiry into the qualifications of the men applying for accommodation."
- Qu. 11,067. "You would not throw upon the director the sole responsibility of deciding who should be admitted and who should not?—I think that would not be desirable."
- Qu. 11,068. "And I understood you to say that you would not think it desirable that the Government should direct any specific original research to be carried on, except with reference to some practical purpose?—Except with regard to subjects about which the Government wished for information, I think it is much better for each

man to devise his own research; he takes much more interest in it, and is much more likely to pursue it with vigour than if it is prescribed for him."

"And do you think it would be requisite that those institutions should be on a large scale?—I think that they ought to be on a fairly large scale even to begin with, because it is always a costly process to rebuild such institutions; and I am inclined to think that they would be rapidly filled. A tolerably large institution of that kind would probably in a very few years be filled with workers." Qu. 11,069.

"You would not recommend, in the first instance, at least, more than the establishment of one for each department of science?—I think not more than that." Qu. 11,070.

"And should it be in London?—Yes, I suppose they must be commenced here, but eventually it would be desirable that the important centres in the provinces should also be furnished with such places." Qu. 11,071.

"Colonel Strange recommended the establishment of four laboratories; should you be disposed to agree with him in that view?—Yes, I think that those would be necessary; perhaps the least essential of them would be the metallurgical one, but certainly the others would be quite essential." Qu. 11,072.

"Could that be combined with the chemical laboratory?—I think the metallurgical one, in the first instance, might be combined with the chemical laboratory, as the processes are similar. There would be the chemical laboratory, the physical laboratory, the physico-astronomical, as we may term it, and the biological. It would be necessary, in connexion with the physico-astronomical observatory, to have the means of performing various chemical experiments and making physical observations. Of course the chemical operations would be quite subsidiary to the cosmical observations there." Qu. 11,073.

Mr. De La Rue expresses himself as follows:—

"Are you of opinion that any new institutions in the way of laboratories should be established by the State?—I hold it to be so important that Chemistry should be extensively cultivated in England, that I would strongly advocate that there should be a State laboratory. That State laboratory should undertake all the chemical work which the Government might require, but at the same time, according to the views which I hold, it ought to be such an establishment as could afford facilities to men who have completed their scientific education, and who might be desirous of continuing original investigations, in which space for working and instruments should be afforded them, and, moreover, if men were not in a position of fortune to continue their researches, in some cases materials and even money might be granted to them on the recommendation of the council. I may state that of my own knowledge I know that chemical science at present is not progressing in England in a satisfactory manner, that we do not make so many original researches as our continental neighbours, particularly the Germans, do. In Germany very great patronage is given to science, magnificent laboratories have been built, and the students, who, after they are sufficiently advanced, are encouraged to make original investigations, contribute at present most largely to scientific Chemistry." Qu. 13,054.

"Do you think that the establishment of those Government laboratories would be likely to give rise to complaints from any existing institutions?—I think not, if those Government establishments were not educational establishments. There would be a natural jealousy on the part of educational establishments if the Government were to undertake to educate students without charge; but what I contemplate is merely that facilities should be given to men who have already been educated, and not to interfere at all with the functions of educational establishments." Qu. 13,063.

"I think that some good might be done by aiding educational establishments; but I believe that the more advantageous course would be for the State to afford facilities in the laboratory which it might require for other purposes." Qu. 13,105.

"Do you think that any other laboratories would be needed?—I attach the greatest importance to a chemical laboratory, because I believe that Chemistry is destined to play a very important part in the advancement of the arts in all civilised countries, but there also ought to be a physical laboratory, very much on the same footing as the chemical laboratory, and in which facilities should be afforded for conducting physical investigations." Qu. 13,057.

"You would give admission to those laboratories on the same principle as to the chemical laboratories?—Yes, to men who could show that they were qualified to make a beneficial use of them." Qu. 13,058.

"You think that any investigations required by the State should also be conducted there?—Yes, they should be conducted in either the chemical or physical laboratory, according to the nature of the investigations. For example, there were a great number of investigations carried on at Woolwich relating to the strength of different alloys whose chemical composition was determined by analysis. Such investigations would be very well conducted in the chemical laboratories." Qu. 13,059.

"Would you transfer the work now done at Woolwich to such a laboratory?—Part of the work, but I would except such special work as could be better done at each of the Government establishments. Special investigations would fall within the duties of the central government laboratory. The testing of the purity of the products to be used in the department, and routine work, would be better conducted in those establishments." Qu. 13,077.

"With respect to the other purpose of the laboratory, do you think that there would be a sufficient number of independent inquirers to occupy an establishment like that?—I think that there would be a great number of men who would be very glad to avail themselves of such opportunities as a laboratory of that kind would afford, and their doing so would not add materially to the cost of the establishment." Qu. 13,078.

Mr. Gore also recommends the establishment of Laboratories:—

"Are there any measures that you can suggest to the Commission which you wish to see adopted in order more effectually to promote this object than is the case at present?—I propose that national laboratories should be established, in which abstract scientific investigation alone should be carried on. I propose that in those laboratories scientific investigators should be wholly employed upon abstract original investigation, and be paid for their labour and be supplied with the necessary means in their respective sciences, leaving each investigator to choose his special subjects of research." Qu. 10,782.

"Perhaps you could explain to the Commission rather more fully what should be the general character of those laboratories?—For making original scientific investigations in the subjects of chemical physics and chemistry. I speak only within the subjects with which I am familiar." Qu. 10,784.

"Do you refer, in this recommendation, to the establishment of a physical laboratory?—If you mean by a physical laboratory one in which the sciences of heat, light, electricity, and magnetism would be investigated, I should mean a physical laboratory." Qu. 10,785.

"And you think that that ought to be distinct from a laboratory for chemical physics and chemistry?—Yes, I think distinct from the laboratory for chemistry only." Qu. 10,786.

Qu. 10,787. "I understand you to recommend that this should be a Government institution supported entirely by Government funds?—Yes, I do recommend that."

We next proceed to refer to the Evidence in which other views are expressed. It will be seen that it is rather in favour of the utilization and extension of existing, than of the establishment of new Laboratories. We shall confine ourselves to extracts from the Evidence of Dr. A. W. Williamson, Dr. Siemens, Dr. Burdon Sanderson, and Lord Salisbury.

Dr. A. W. Williamson—

Qu. 12,696. "A good deal of evidence has been offered to the Commission in favour of establishing and maintaining laboratories of research at the expense of the State, in order to give opportunities to original inquirers to carry on investigations. Have you formed any opinion of the expediency of such arrangements?—I think that to establish a laboratory for research only would be beginning at the club end, and would be decidedly inadvisable. I think that the main thing for research is to give to schools, and especially to the higher schools, proper facilities for it, and to develop them greatly. At the same time, it is quite possible that, in exceptional cases, research might with advantage be carried on in separate places; but I should always view with regret, as a waste of resources, the separation of that higher work of research from the more humble work of teaching, which naturally belongs to it. They help one another, and I think that each would lose from being separated from the other; still, in some cases, it might possibly be advisable."

Dr. Siemens—

Qu. 11,804. "What is your opinion as to the establishment of laboratories at the Government expense?—I would recommend the establishment of observatories but not of laboratories, for the same reason, that in laboratories unconnected with teaching, as have been proposed, using the public conveniences, and public money, there would be a necessity for results which would lead to a certain extent to something approaching charlatanism in the enunciation of those results; and, moreover, I consider that it might lead to disappointment in many, who would believe that they had an equal right with others to take advantage of such establishments."

Qu. 11,805. "Do you consider that laboratories are required in greater numbers, and better equipped than they are at present?—I think so, decidedly."

Qu. 11,806. "But still you would not remedy that defect by establishing Government laboratories?—Not by establishing Government laboratories, but by granting Government aid towards the establishment of laboratories, and chiefly by the endowment of chairs."

Qu. 11,807. "Do you think that laboratories should chiefly exist in connexion with universities or other teaching institutions?—I think so, because we should always look to the coming generation, upon which the future depends chiefly; and a well appointed academical laboratory presents great opportunities for a student, under a great leader, to attain to emmence himself."

Qu. 11,820. "With reference to national physical laboratories, it has been suggested to the Commission by several witnesses that such laboratories might be of use, not so much for the researches to be carried on officially in them, but as giving opportunities to private individuals for carrying on researches in them; has it occurred to you whether, in that point of view, they might be useful or not?—They might be useful in certain cases; but if the Government takes in hand such a thing, there must always be favouritism. It would be impossible to grant such facilities to all applicants, and it would be very difficult for the Government to use such discrimination. Any university or society could do so by granting facilities to men who had given promises of success by reading papers, or by fully explaining their objects in view; but for the Government to use such discretion would be impracticable, I think."

Qu. 11,821. "Then you think that there should be such laboratories that should be available to persons who could not afford, for instance, to have a physical laboratory of their own, but you do not think that such laboratories should be under the control of the Government, or should be Government institutions?—They should be exceptional cases altogether. If, in any existing laboratory, whether Government or otherwise, an instrument existed necessary for certain research, I think that facilities might be given occasionally to an applicant, but I am of opinion that it would not be desirable to establish what might be termed a national workshop of science."

Qu. 11,822. "Is there any such institution in Germany as a physical or other laboratory (apart from astronomical observatories), independent of an university or an educational establishment?—I believe not. There are laboratories connected with Polytechnic or Mining schools, but still they are connected with teaching."

Qu. 11,823. "Has any difficulty been found in affording facilities in those laboratories to original inquirers who may not belong to the school?—It would not be difficult for any one to get access, for instance, to the laboratory of an University. If he entered his name, he would be allowed to go into the laboratory, and, under certain restrictions, imposed by the Professor, carry on his researches."

Qu. 11,824. "Are those laboratories, as established in Germany in connection with the universities and other educational institutions, quite sufficient for all the wants of science and of original investigation in science?—Whether more might be done by increasing their number I am not prepared to say, but still there seems to be no expressed want for additional laboratories."

Qu. 11,825. "At any rate you would not propose to establish laboratories on a different footing?—No."

Dr. Burdon Sanderson—

Qu. 12,302. "Will you proceed to state in what way you consider that money might be applied for the promotion of physiology?—I consider that it might be available for three purposes; namely, for the improvement of laboratories for the providing of instruments and materials for research, and for the remuneration of workers. I will speak first of the spending of money upon the improvement of laboratories. I do not myself see at the present moment that we are in a position to require the expenditure of large sums of money upon the building of large laboratories, for this reason, that if such laboratories were built we should not have workers to work in them; at present we have not men to work in the laboratories that we actually possess. We have men of a certain class, but we have not men of that trained class which we require. I am of opinion that a physiological laboratory to be of any use at all must be in connexion with the great schools of medicine. A physiological laboratory at a distance from such schools would fail for want of people to work in it. Physiology will never flourish, therefore, excepting in connexion with the two arts which are dependent upon it. Just as vegetable physiology will flourish best in connexion with agriculture, so also animal physiology will flourish best in connexion with medicine. I think that grants might be very advan-



tageously given for the improvement of the laboratories now existing. Of course, in the administration of such grants, one would go upon the principle 'to him that hath shall be given,' that is to say, wherever a good laboratory exists, or wherever men are to be found to work a laboratory, and where there are likely to be students to work in it, money should be given to carry out improvements. I would further notice that in physiological researches, the expenditure for materials is usually much greater than for instruments, and consequently money is more wanted for current than initial expenses; for this reason large sums ought not to be expended in the purchase of collections of costly instruments, for if such sums were spent they would probably not be used. It is much better to provide money to assist to meet those heavy expenses which are required for material. To show this it would merely be necessary to refer to some of the physiological researches which are now being carried out, in which a great expenditure is required for material, but no tremendous expense for instruments. Of course I do not mean to say that it is not necessary to spend money on instruments, but any expenditure on a large scale for this object would be very likely wasted. On the whole I believe that money can be more economically spent in sums paid for work done than in any other way, *i.e.*, either in the way of periodical payment to men of acknowledged competency, for the purpose of carrying out inquiries of long duration, or in the form of separate grants for special researches, or in the form of grants for skilled assistants. \* \* \* \* Of course in Germany men who do this work are not paid, and it is very necessary to bear this in mind, but the difference there is that such men have something to look forward to. There are in Germany numerous teaching appointments to which a man can look forward with the certainty that if he works industriously for a certain time, he is sure to get an appointment of some kind afterwards, which will enable him to take the position of a professor. This state of things does not exist in England, and therefore it is more necessary in England to encourage the younger men to engage in research by pecuniary aids than it is in Germany."

Lord Salisbury—

"In speaking of the establishment of laboratories by the State, your Lordship appeared to me rather to refer to chemical laboratories; but it has not escaped your attention, I am sure, that the cost of physical apparatus is so very great as to put physical inquiries really out of the reach of a very large number of persons who probably might be capable of conducting such researches, and in consequence of there being no such assistance assigned to such persons as a State laboratory, in which they could obtain the use of apparatus, and of a really fitting building, constructed with sufficient solidity for the purposes of research, a great many persons are prevented from entering upon researches of that kind by the want of means; and it has been contended that by providing laboratories, at the expense of the State, you would be doing no more for such persons than has been done for learned men by providing them with great public libraries, as you would be only providing them with the opportunities of research, which otherwise they could not have?—My fear would be that there would be a difficulty in providing laboratories in sufficient numbers to satisfy all, as you can provide books at the British Museum to satisfy all, and that the result would be that very often those who are least fitted to obtain any useful result would engross the instruments. For the purpose of really first-rate workers, I think that the Government might very advantageously be liberal; but such liberality I think would best take the form of an increased grant to the Royal Society. But I should be doubtful whether it was possible by any moderate expenditure of funds to provide an expensive class of scientific instruments of all kinds for all the persons who might be inclined to use them."

Qu. 13,590.

*Evidence relating to the Establishment of Physical Observatories.*

On the general question of the Establishment and Maintenance of Physical Observatories, Lord Salisbury agrees that:

\* \* \* "Some of these institutions which have been alluded to in your Grace's question, especially observatories, clearly fall within the duties of the Government; and certainly, from all that one hears, it is probable that their duty in that respect is inadequately performed, and that observatories for a much larger range of observations might with great advantage be multiplied." \* \* \* \*

Qu. 13,575.

Sir George Airy thus states his view on the subject:

"When I began to be an astronomer, such questions as those of the constitution of the sun and the like were not entertained" \* \* \* \*

Qu. 10,481.

"Are you prepared to express an opinion as to whether it is an object which would be a proper one for the Government to take up as a State establishment?—The Government are already pushed very hard in their estimates. The screw is always put upon them, 'Cannot you reduce the estimates a little more?' And then it would always come to a question of extensive feeling in the House of Commons, and of popular feeling out of the House of Commons; and I am confident from what I have seen that those two bodies would not in every case support an extension." \* \* \* \*

Qu. 10,485.

"Should you say that it is an object which is not very likely to be prosecuted with sufficient vigour unless taken up by the Government?—I do not see how it could go on except it were taken up by the Government. I do not believe that it could go on in any other way."

Qu. 10,486.

"It is not likely, you think, to be prosecuted by private individuals, or by other public bodies such as the Universities?—No, I think that their funds are almost all required for other objects, and the difficulty even of getting the business into shape is extremely great." \* \* \* \*

Qu. 10,487.

"Then such observations, in all probability, will either not be made at all or must be taken up by the Government?—That is my view." \* \* \* \*

Qu. 10,488.

Mr. De La Rue's opinion is thus given in reply to question 13,066:

"I think that the time for the State providing means for reducing observations has now come: when the State should take up, besides mathematical astronomy (which deals with the places of the stars and planets, and the moon especially), physical observations, more particularly observations of the sun, which appear to me to bear directly upon meteorological phenomena." \* \* \* \*

Qu. 13,066.

He says further, in regard to observations of this nature, that they necessitate "a certain staff of assistants, and require continuous superintendence, hence it is necessary that an amateur astronomer who undertakes such work should have leisure during

"the day, and that he should be able to pay for duly qualified assistants, and such men have to be highly paid."

Sir W. Thomson points out the importance of multiplying such Observatories :

Qu. 10,658.

\* \* \* "In respect to the observatories, it might be necessary to have several observatories for astronomical physics in this country, if it were only to secure observations of interesting conjunctures, notwithstanding the varieties of the weather, that there may be in different parts of the country; and, again, observatories for astronomical physics ought most certainly to be founded in other parts of the British dominions than England, Ireland, and Scotland; in other latitudes and on the other side of the world."

Dr. Siemens expresses the same view in the following Evidence :

Qu. 11,789.

\* \* \* "An observatory or several observatories should be established for carrying on physical research, research to obtain information on general subjects, such as solar observations, magnetic observations, and other subjects that might be thought desirable to obtain continually information upon." \* \* \* \*

Qu. 11,864.

"I think that almost the only new establishments which you recommend are certain physical observatories? —Yes."

Qu. 11,865.

"What would be the principal object of such observatories?—For the purpose of magnetic observations, solar observations, and other general inquiries into physical phenomena."

Qu. 11,866.

"Do you contemplate the establishment of more than one such observatory?—Probably more than one would be desirable."

Qu. 11,867.

"Do you contemplate the establishment of any such observatories in any of the colonial possessions of the country?—Yes, I think so"

Qu. 11,868.

"Speaking generally, would they be costly establishments to found?—Not very costly, not so costly as astronomical observatories."

Qu. 11,073.

Dr. Frankland has also given Evidence on the importance of promoting the study of Astronomical Physics, pointing out that "It would be necessary, in connexion with the Physico-Astronomical Observatory, to have the means of performing various chemical experiments and making physical observations. Of course the chemical operations would be quite subsidiary to the cosmical observations there."

Qu. 13,067.

Mr. De La Rue, in reference to locality and organization, in answer to the question whether provision for carrying out Observations of this character should be in connexion with the Greenwich Observatory, says :

"In connexion with the Greenwich Observatory, yes, but at the Greenwich Observatory I should say not. I do not think, in the first place, that there is space enough at Greenwich, and the duties of the staff are already so very onerous that it would require a separate establishment for such special work; besides other new buildings it would entail a chemical laboratory, and there is hardly space for those at Greenwich. I believe also that it would cause too divided attention on the part of the Astronomer Royal, if he were called upon to personally superintend investigations in the physics of astronomy, although I think it would be very desirable that any new establishments, if they are to exist, should be affiliated to Greenwich."

Being asked "whether the new establishment should be in the neighbourhood of Greenwich?" he replies ;

Qu. 13,068.

"Not at all necessarily so. In fact Greenwich would not be at all desirable for some class of observations, it is much too near London."

Qu. 13,069.

And in answer to the question "Would you place the proposed new observatory for those purposes in any respect under the control of the Astronomer Royal?"—

"It would be desirable that the State should have to deal only with one astronomer. Possibly by the increase of the claims upon his attention it might be desirable for the Astronomer Royal to have directors under him, so that he should not have to devote so much time to details even of the Greenwich Observatory, but I do not think that the State ought to have to deal with a great number of astronomers, indeed there might be some difficulty in its doing so."

Qu. 13,071.

He says further, "In order to obtain a daily record, I would advise that one or possibly two observatories should be established in India, and one at the Cape of Good Hope." "At the Kew Observatory it was frequently cloudy for several consecutive days."

Admiral Richards says ;

Qu. 11,625.

"If you are going permanently to establish physical observatories, I should prefer to see separate ones. I think that the physical work probably would be better separated from the Royal Observatory."

Qu. 11,626.

"You think that the two classes of observations are so distinct in character as to render that desirable?—Of course there is a certain amount of meteorology that must be observed at the astronomical observatory; but it need not be of any extended character."

Qu. 11,991.

Mr. Spottiswoode's Evidence is as follows :—

"The Observatories which you recommend could, in your opinion, be attached to existing Observatories; an Observatory for Solar Physics, for instance?" "This might be met by an extension of the existing Observatories."

Qu. 11,992.

"Do you think that it would be as useful, if attached to Greenwich, as if a special observatory were established for the purpose?—I have no doubt that if an independent observatory were adapted to that purpose and furnished with adequate instruments, and manned by such a staff as one could wish, more would be done in such an independent observatory, so manned, than by a branch of the Royal Observatory at Greenwich, but, at the same time, that would involve such a much larger expense, that I thought that the question of expense would perhaps outweigh the scientific advantages to be gained by it."

"Do you think that a great deal might be done by making some additions to the present Observatories?"

"A great deal, because in a large observatory there are, not unfrequently, instruments only partially employed. For example, at Greenwich there is a large and very fine instrument suited to the investigation of solar physics, which is, at all events, largely disposable for such observations." Qu. 11,993.

It will be seen that most of the Witnesses dealing with Physico-Astronomical Observations recommend that, whether or not they be placed under the control of the Astronomer Royal, they should certainly be conducted by Special Directors, and be placed by preference in localities which the Witnesses deem to be better adapted to the purpose than Greenwich.

Such is not the opinion of the Astronomer Royal himself. Sir George Airy thus deals with the question specially referring to the difficulty as to space at Greenwich and the mode of management:—

"Do you think it would be practicable to adopt any measures at the present observatory at Greenwich to make observations of that character?—I think it is possible that it might be done, but I am not prepared with a plan at present, and I am very much inclined to think that the difficulties in these matters will be rather in detail than anything else. There is always a difficulty in keeping an observatory of rather an indefinite character in such a state that it will satisfy the public demands." \* \* \* Qu. 10,482.

"It has been found necessary within the last three or four years to extend our grounds at Greenwich." \* \* \* "Judging from what occurred in our case, I do not think that there would be any difficulty in further extension; where it would be in sufficient proximity to the Royal Observatory to be under the same general control." Qu. 10,483.

"If a department of that kind were instituted, do you see any objection to its being placed under the Astronomer Royal, or would it give him too much to do?—It would give him much to do, but a great deal may be effected by organisation, especially with the license to have officers of good position under him; to have lieutenants of a good class." \* \* \* Qu. 10,484.

A Resolution in general accordance with the views expressed by Sir George Airy was transmitted to us in July 1872, by the President and Council of the Royal Astronomical Society. This Resolution is in favour of the extension of the Royal Observatory at Greenwich and other existing Astronomical Observatories, and does not recommend the Establishment of an independent Government Observatory for the cultivation of Astronomical Physics in England. Appendix VII., Vol. II. p. 37.

In connexion with some points on which differences of opinion have been expressed in this Evidence, we give the following extracts from a Paper handed in by Colonel Strange, consisting of questions addressed by him to Professor Sir W. Thomson, Professor Hilgard, the Secretary of the American National Academy of Sciences, and Professor Balfour Stewart, and to M. Faye, the President of the French Academy of Science; and their replies thereto. Appendix ALL., Vol. II. pp. 27-37.

Colonel Strange's questions, and the replies to them, were as follows:—

"(1.) Is the systematic study of the solar constitution likely to throw light on subjects of Terrestrial Physics, such as Meteorology and Magnetism?"

"(2.) What means, at present known to Science, are available for studying the sun?"

"(3.) Do you consider that Photography (one of the assumed means) will suffice for the purpose?"

"(4.) Do you consider that the class of observations (defined in your answer to my question 2) are such as can be efficiently made in an observatory maintained by the State, or that any of them would be better left to the zeal of volunteer astronomers?"

"[Addressed to M. Faye only.]

"(5.) Do you consider that it would be advantageous to carry on Physico-Astronomical researches on an extensive scale, and Meridional observations, in one and the same observatory, under a single director?"

Sir W. Thomson:—

"The subject of investigation in any observatory for Astronomical Physics is so very different from that for which the great Astronomical observatories at present existing were founded, that I believe generally it would not be good economy of resources to attempt to adapt the old observatories to the new investigations. The instruments adapted for accurately determining the positions of the heavenly bodies, which constitute the most important part of the great observatories hitherto established, are scarcely adapted to give any contribution towards Astronomical Physics. New instruments designed for the work of the spectroscope, and new buildings to contain them, are necessary. A chemical laboratory, and an extensive system of galvanic batteries and electro-magnetic apparatus are required for the new kind of Astronomical observatory. I doubt very much whether one man could act effectively as executive chief of an observatory of Astronomical Physics, and at the same time of an observatory of the old kind."

Professor Hilgard:

"(1.) That the systematic study of the sun's constitution is likely to throw light on subjects of terrestrial physics, I would unhesitatingly affirm; yet without expressing the belief that the minor meteoric or magnetic variations are dependent on changes taking place in the sun.

"(2.) The available means for studying the sun at present known to science are, in my apprehension, in addition to observations made with the eye, solar photography, photometric and calorimetric observations, and spectroscopic observations, combined with laboratory experiments necessary for the interpretation of the latter.

"(3.) I do not think that photography alone will suffice for the purpose indicated, since it will give little else than a registration of solar spots, the study of which by means of the spectroscope appears to be also of prime importance.

"(4.) I perceive no difficulty in organizing the several classes of observations above mentioned systematically, so as to be efficiently made in an observatory maintained by the State. Similar considerations to those upon which the maintenance of meteorological and magnetical observations is based, would warrant a provision for systematic observation of the sun.

"The value of the latter, as of the former classes of observations, largely depends upon their regular continuity, which cannot be expected from the zeal of volunteer observers, who must look for their reward to results of immediate interest."

#### Dr. Ba. four Stewart :

"In reply to your first question, I cannot help thinking that a study of the solar constitution is likely to throw light on the subjects of Terrestrial Physics, such as Meteorology and Magnetism. My reasons are :—

"(1.) That I consider the *fact* of a connexion between sun spot activity and disturbances of the earth's magnetism to be very well proved, although we are ignorant of the *nature* of the connexion.

"(2.) The recent researches of Mr. Baxendell, Mr. Stone, Professor C. F. Smyth, and others, render it extremely probable that there is likewise a connexion between the period of solar activity and the meteorology of our globe.

"(3.) The recent researches of Messrs. Warren De La Rue, Stewart, and Loewy, as well as those of Professor Wolf, render it very probable that there is a connexion between the positions of the chief planets and the behaviour of sun spots.

"(4.) The recent observations of Messrs. Browning and others render probable a connexion between the appearance of the planet Jupiter and the state of the solar disc.

"I think that all these, taken together, can leave us in little doubt of our duty with regard to solar observations. If we were not only perfectly sure of a connexion, but likewise knew all about the nature of this connexion, the necessity of studying the sun would yet be as strong as that of recording the positions of the various planets with the view of verifying the law of gravitation. But inasmuch as here the nature of the connexion is unknown, it is of imperious necessity to study the sun with the view of accumulating a sufficient number of good observations which may ultimately enable us to determine the nature of this unknown connexion.

"We ought to remember how greatly the accurate observations of Tycho Brahe contributed to the generalizations of Kepler.

"In reply to your second question, I would enumerate the following means of observation of the sun :—

"(1.) Eye observations through a telescope.

"(2.) Photography.

"(3.) Spectroscopic observations.

"(4.) Actinic observations.

"In reply to your third question, I do not consider Photography sufficient for the purpose. I think that eye observations, more particularly when combined with the spectroscopes, are essential to enable us to know what is going on in the sun from minute to minute, and unless we know this, I do not well see that we are ever likely to arrive at a true theory of solar disturbances, or of the connexion between these and the disturbances of the meteorology and magnetism of the earth. Could we ever have ascertained the velocity of the solar currents without the aid of the spectroscopes?

"As a self-recording instrument for registering the actinic effect of the solar rays has been perfected by Dr. Roscoe, and as it is a point of importance to study the influence of the solar rays upon vegetation, I think that whenever the sun's surface is regularly studied, actinic observations ought, from this cause as well as from their physical importance, to be included among the duties of the observatory.

"In reply to your fourth question, believing that a long continued and systematic series of observations is beyond the means of volunteers, I think that the four kinds of observation of the solar surface which I have specified ought to be made in an observatory maintained by the State. Indeed, for some of them more than one observatory would be requisite, for I think it an object of great importance to obtain a daily record not only of the position but of the area of every group of spots which appears on the surface of the sun. But to obtain this more than one observatory would be necessary, for we must be independent of the influence of weather; and to be so we must have stations so distributed that when it rained at one station it might reasonably be expected to be fair at another.

"I think that the study of the sun ought to be systematically conducted in an institution for the purpose working under Government, and connected with a number of stations sufficient to ensure a good record of what takes place on the solar surface, independent of the influence of weather.

"It appears to me also that such an institution should have a laboratory as well as a workshop connected with it."

#### M. Faye :

"1. L'étude de la constitution physique du soleil ne me paraît pas appelée à répandre de grande lumière sur la Physique Terrestre, c'est-à-dire sur la Météorologie et le Magnétisme. L'action solaire est actuellement caractérisée par une constance bien remarquable, sauf de petites variations accidentelles ou périodiques de peu d'importance. L'étude directe de ces divers sujets de Physique Terrestre suffit amplement. Mais il en est autrement des âges géologiques dont l'histoire me paraît liée intimement à des changements progressifs d'ont on reconnaît la possibilité dans l'activité interne du soleil.

"Toutefois on ne peut nier que les recherches nouvelles qui ont eu pour but de rattacher certaines périodes dans les phénomènes magnétiques aux phénomènes également périodiques du soleil ne méritent intérêt et considération.

"2 Les moyens dont nous disposons aujourd'hui pour l'étude du soleil sont au nombre de huit :—

"1°. Étude des mouvements de la photosphère par les taches et les facules. (Carrington)

"2°. Étude de la constitution chimique de la photosphère et de la chromosphère. Variations, plus ou moins rapides, de cette constitution. Analyse chimique continue de la surface solaire.

"3°. Étude des mouvements de la chromosphère, éruptions, protuberances, etc. Distribution de ces phénomènes selon la latitude.

"4°. Étude des variations périodiques de la surface, par les procédés de Schwabe et ceux de l'Observatoire de Kew,

- " 5°. Étude des éclipses totales, auréole, couronne, etc., au moyen d'expéditions lointaines.  
 " 6°. Études des changements séculaires de l'activité solaire au moyen des données de la géologie.  
 " 7°. Étude analogue du soleil au moyen de l'observation des étoiles variables ou nouvelles.  
 " 8°. Application de la mécanique moderne à l'étude des mouvements internes qu'on peut supposer dans la masse solaire.

" 3. Le moyen le meilleur d'étudier les mouvements des taches et des facules est incontestablement la photographie. C'est surtout par là qu'on peut espérer de rencontrer des phénomènes auxquels s'appliqueront tôt ou tard les lois de la mécanique. Mais ce n'est là qu'une face de la question. La spectroscopie n'est pas moins indispensable. C'est par elle que la physique et la chimie peuvent s'appliquer aux études solaires aussi bien que la mécanique. Réduire cette étude à la photographie ce serait se condamner à ne voir qu'une face de la question. Je ne veux pas que cette opinion puisse être sérieusement soutenue.

" 4. Il suffit d'envisager l'importance du but des études solaires et la variété du moyen d'action que la science moderne nous présente pour penser que le moment est venu de confier les études à un ou plusieurs établissements pourvu de grandes ressources, et pouvant fonctionner avec continuité pendant un laps de temps illimité.

" Sans doute on devra compter sur le concours puissant des volontaires de la science. Mais le concours se présente toujours avec des restrictions quant aux ressources, à la continuité, et à la durée, lesquelles me paraissent peu compatibles avec les résultats à obtenir.

" 5. Je suis d'avis que les études doivent être poursuivies dans des établissements spéciaux; que leur introduction dans les observatoires astronomiques serait nuisible à l'astronomie proprement dite, sans pouvoir donner tous les résultats que procurerait une division bien nette du travail. L'expérience que nous en avons en France me paraît décisive."

#### *Evidence relating to Meteorology.*

For the reasons which have already been stated, we have taken a considerable amount of Evidence with reference to the Meteorological Observations at present carried on in the United Kingdom, whether at the cost of the Government, or of Societies or Private Observers. To some points in this Evidence we think it necessary to call attention: of these the most important are those which relate to the Meteorological Office.

This Office is under the Management of the Meteorological Committee of the Royal Society, the Functions of which are thus described in the Report annually presented to Parliament:—

"The Meteorological Committee consists of Fellows of the Royal Society who were nominated by its President and Council, at the request of the Board of Trade, for the purpose of superintending the Meteorological duties formerly undertaken by a Government Department, under the charge of Admiral FitzRoy. Preface to Report for 1872.

The Committee are credited with a sum of 10,000*l.* voted annually in the Estimates, for the administration of which they are wholly responsible, and over which they are given the entire control

"The Meetings of the Committee are held once a fortnight, or oftener when necessary, when every subject on which action has to be taken by their executive officers receives their careful consideration. The duties of the Committee are onerous, and *entirely gratuitous*; they were accepted, and are very willingly performed by the members, on account of the earnest desire they severally feel for the improvement of Meteorological Science."

The position of the Committee is anomalous. In the words of the Director of the Meteorological Office—

"The Government distinctly disclaims all connexion with us, whilst the Royal Society equally disclaims all control over us, except merely the nomination of the members of the Committee." Qu. 13,867

"As a matter of fact, all that the Royal Society does is to nominate the members of the Committee?— That is all." Qu. 13,868

"Having so done, it ceases to have any control whatever, does it not?—Entirely." Qu. 13,869.

"What is the precise relation between the Office and the Government?—That the Government gives a vote of 10,000*l.* every year, and that it calls for no account of this money, excepting the account annually presented to Parliament." Qu. 13,871.

"Who audits the accounts?—The members of the Committee. There is no formal audit, because, as the Government would not recognize any audit excepting its own, the Committee considered that it was not worth while paying an auditor if such audit would not be recognized, and, as a matter of fact, two of the members take the trouble of auditing the accounts every year." Qu. 13,872.

"What, in your opinion, are the chief advantages and disadvantages of such an arrangement as compared with those of the direct management of the Office by the Government?—The chief advantage is the perfect freedom from political management. The risk in being connected with the Government is that if a new President of the Board of Trade comes, he may reverse the action of the preceding one. The existence of a scientific supervision for the Office is exceedingly important; it acts as an intermediate party between the public and the Office. I may mention a decided disadvantage which results from the Office not being connected with the Government, namely, the loss of *prestige*. The difficulty is, that if we are sending instruments by sea or by railroad, if we do not call them Government instruments we cannot get as much attention paid to them, and it is my opinion that we should get more co-operation from the merchant navy if we were an office of the Board of Trade. We should have more *prestige* as acting directly from the Government." Qu. 13,573.

The following very clear account of the objects which the Meteorological Committee propose to themselves is taken from the Evidence of Major-General Strachey, one of the Members:—

"I would, then, state generally what I understand to be the objects which the Meteorological Committee Qu. 14,212.

Qu. 14,212. has to superintend. These are, first, the collection of meteorological data from ships' logs, with a view to the preparation of maps for the use of sailors, showing the probable, or it may be termed the average, meteorological elements all over the ocean, on the chief line of trade routes, for the several months in the year. Included with these is the investigation of the ocean currents. This branch of duties is carried on under Captain Toynbee. The second branch of the business is the collection and daily publication of meteorological observations made on the British Isles and neighbouring coasts, extending from the coasts of Scandinavia to France, and partly to Spain. Although at the outset of the issue of warnings as to probable bad weather was not contemplated, yet after the Committee had been in operation for a few months it was considered desirable again to undertake this, and in the first year of the Committee's existence the issue of warnings of anticipated stormy weather was resumed. I daresay Mr. Scott has told the Commissioners, that within the last few months there has been a little more detail given in the warnings. Originally they were mere warnings that stormy weather was likely to occur. Now there is a statement also given of the probable direction from which the wind is to come, and whether it will be of extreme force. The third of the objects is the recording at certain specially-organised observatories, seven in number, maintained under the direction of the Committee, of the principal meteorological elements, with self-recording instruments; with the intention of obtaining a continuous record with as great accuracy and precision as possible, and thus of procuring accurate data for the scientific study of meteorology by all persons who are interested in that science. I should add that the Committee has, within the last month or two, from the commencement of this year in fact, begun to print and to issue monthly the detailed observations made at these seven observatories. The Committee also publishes quarterly reports, which contain diagrams embodying the observations at the seven observatories, and an analysis of the weather over the British Isles, of which the details are furnished in the daily reports. There is no doubt that the publication of those quarterly reports is an useful addition to the daily reports, which are extremely voluminous, and not very easy for persons to follow who do not devote themselves to the subject. The last of the specific duties of the Committee is the supply of meteorological instruments for the Royal Navy and Mercantile Marine. Besides various miscellaneous references come from the Board of Trade, to which, of course, the Committee gives such answers as it is capable of doing."

It is admitted that the objects thus described do not exhaust the whole of Meteorology, and that the Committee in their selection of these objects have been, to a great extent, guided by the proceedings of the Meteorological Department of the Board of Trade, which existed prior to, and which has been superseded by the Committee. Thus Major-General Strachey says:—

Qu. 14,215. "The Committee is now in reality doing no more than continuing the exercise of certain functions which had, in the course of time, been thrown upon the Board of Trade by the position which that Department occupies in connexion with the public administration."

Qu. 14,216. "Has the consequence been that the action of the Committee has been from the outset rather in a practical direction than in one of original research or scientific observation, properly so called?—I think distinctly that such is the case, and that it has necessarily followed from the position in which the Committee was placed. If a reference is made to the earlier papers, and to the Report of the gentlemen on whose suggestions the present arrangements originated, there perhaps is an indication that they anticipated something more in the way of scientific research than has actually occurred; but the turn that things have taken seems to me the necessary result of the sort of duties that were put upon the Committee under the essential condition that it had but a limited sum of money to spend."

Qu. 14,217. "Have any results of scientific importance in your opinion been obtained by the action of the Committee?—In the direction of what one may call investigation of an absolutely scientific character, I should say none at all. Of course the observations that are made at the special observatories are valuable scientific information, and so far one has no right to say that scientific results have not been produced; but [I do not think that these can properly be referred to as specific results of anything that the Committee has done. To the best of my belief there has been nothing undertaken in the way of original investigation into the specific physical causes of any of the phenomena which are recorded, nor any original research, properly so called, in relation to any of the several branches of meteorology. The Committee hardly has appliances at its command for any such investigations, and the funds at its disposal being limited, it was hardly possible that it should attempt them. It is also no doubt quite true that the observations which are made at the seven observatories do not include any matters which are of great importance in physical science, and which would properly come within the range of meteorology."

Qu. 14,218. "Are the funds at the disposal of the Committee in your opinion insufficient for doing anything more than has been actually done at present?—I should say distinctly that this is the case. The Committee has always considered that it is bound to attend primarily to the special objects before referred to, which were in a specific manner made over to it, and it finds that after this has been done there is no money left for other things."

Again, the same Witness expresses a decided opinion that the State should do more for the promotion of Meteorological Science than it does at present, but entertains some doubt whether any increased duties could advantageously be allowed to devolve upon a body such as the Meteorological Committee:—

Qu. 14,226. "Can you state the directions in which you think the State should intervene?—This seems to me an extremely difficult question to answer. The fact is that the form in which the State might in a satisfactory way intervene must depend upon the extent to which it is disposed to intervene. If one knew that the Government really desired to assist in the development of scientific meteorology, it would be possible to make a scheme, but I do not see how anybody could make what I may call an abstract plan which should have any real utility in it. My own impression is that so long as there is no greater interest taken in this sort of matter than at present, probably the best thing to do is to leave the expenditure of what money the Government choose to give for the purpose under the control of some such body as our Committee; but I should further say that if the Government is seriously in earnest in taking the matter up, it would then be the proper thing to have a public department that should manage the business. Then again, if there were a public department, it must be a part of an organised system; and in order to secure an efficient public department to supervise such matters, it seems to me that it would be necessary to have some officer connected directly

with the Government, an Under-Secretary of State, or some such person, who should be responsible that the executive scientific staff properly carried out the whole of the operations of their several departments."

"Are you disposed to think that the Meteorological Committee might in any way extend its sphere of action with advantage?—As matters are now I should think it is extremely doubtful. I look upon the Meteorological Committee as being mainly a controlling body to supervise the expenditure of a definite sum of money in a definite way. At all events that practically has been their position. There has been no virtual change from the time that they were started up to the present time." Qu. 14,285.

"Do you think that that money would be spent better in some other way; that is to say, supposing the thing had to be started afresh, are those objects which the Committee at present have to carry out exactly those that you would have given them to carry out?—I should say in general terms that the whole of the objects which the Committee has charge of are reasonable objects. I do not think that there is any one of them that it is not desirable to attend to. As to whether the precise method of dealing with them is the best possible will be a matter of opinion, but I do not think that I could very usefully go into that." Qu. 14,286.

"Does it occur to you that there is anything else which should be added to the functions of the Committee?—My general impression, as I implied before, is that the Committee is a quasifinancial body having certain scientific knowledge. Its duty is not strictly speaking to direct scientific research or scientific operations, but it is to see that a certain sum of money which the Government thinks may reasonably be applied to collecting and publishing meteorological observations, and doing certain other matters, is not unreasonably applied. It exercises a check upon the persons who have actually to carry out those duties, as I understand it; and I do not think myself that, with a body constituted as the Meteorological Committee is, you can expect more from it than that." Qu. 14,287.

"Do you think it would be desirable that the Committee should be entrusted with money to enable it to have any observations collected, scientifically discussed, and turned to scientific use?—I think it would be much better if any such fund were not given to a body like the Committee. If some individual were selected, and the entire responsibility put upon him, I think it would be a much better plan." Qu. 14,288.

"You want to do away with the Committee altogether?—I think so, certainly; supposing always that I am at liberty to replace it according to my own conceptions of what is best." Qu. 14,289.

The same view is expressed by Professor Balfour Stewart—

"Would you organize the Meteorological Committee in any really different form to that which at present obtains?—I should be inclined to dispense with the Meteorological Committee altogether, and substitute a Meteorologist Royal, or whatever his appellation might be, a single official who should be responsible to the Government in the same way as the Astronomer Royal is responsible for his department. I do not see why the one department should be on one footing and the other department on a different footing. I think that there are grave disadvantages with a department administered by an unpaid committee." Qu. 14,035.

"Would you appoint a Meteorologist Royal corresponding with the Astronomer Royal?—Yes, whatever the name might be; I should appoint an official very much corresponding to the Astronomer Royal and responsible to the same extent. A board of visitors would not be objectionable, but the direction of an unpaid committee appears to me to be very objectionable." Qu. 14,036.

The same Witness considers that the subject of Meteorology naturally divides itself into two heads, (1), Physical Meteorology, of which "the object would be to ascertain the Physics of the earth's atmosphere, and perhaps of the earth's ocean," and which must consequently be regarded as a branch of Terrestrial Physics; and (2), Local or Climatic Meteorology, involving a number of Inquiries having special relation to Health, Agriculture, and various Human Interests. The distinction is one which perhaps does not admit of being very closely pressed. For example, it is not clear to which of the two heads the Observations upon Rain-fall should be referred; not to mention that any series of Meteorological Observations, with whatever object undertaken, must have a special value with reference to the Locality at which they are made. Professor Stewart is further of opinion that while Physical Meteorology should receive even larger support from Government than it does at present, Climatic Meteorology might in the main be left to voluntary and local exertions. Qu. 14,031.

"Would you leave the other branch of the subject, climatic meteorology, to individuals and local efforts?—Yes, I think so, possibly supported to some extent by funds from the Government, but I should not put such branches under the superintendence of a central board at the present moment." Qu. 14,037.

And again,—

"Would you leave climatic meteorology altogether to societies and to individual effort?—At the present moment it appears to me to be a matter that might best be left in that position, and that a central authority would do no good in a question of this kind, but rather do harm; in fact, rather tend to depress than to encourage these local efforts. I have no doubt that a great deal might be done by the zeal of local individuals, but if the thing were undertaken in its present state by a central board, which would do little but register a number of observations, I do not think that any good would be done at the present moment be done." Qu. 14,045.

Such aid as Government might give to Climatic Meteorology, should, in the opinion of the Professor, rather take the form of Grants to Societies, than of any extension, in this direction, of the Functions of the Meteorological Office, for the double reason that it would be undesirable to discourage local efforts, and to dissipate the energies of the Meteorological Office by diverting them from Physical Meteorology. Qu. 14,047.

"As far as the money is concerned, I consider that a mere matter of detail, but I should be very strongly against the Meteorological Committee undertaking anything but Physical Meteorology; I think that they Qu. 14,039.

ought to confine their labours to that. If they at present undertake all those branches of meteorology bearing upon the various individual human interests, it appears to me that you will leave them no energy to attack the problems of physical meteorology. I think the great point is to put physical meteorology somewhat more into the position of a branch of physical science; at the present moment it appears to me to occupy a very low position indeed."

It appears that within the last two or three years the Meteorological Committee have made great efforts to extend their work in such directions as might be most likely to help in the promotion of Scientific Meteorology. Thus, they have commenced publishing the individual values derived from their self-recording instruments; and they have undertaken regular Observations upon Atmospheric Electricity. But the efforts of the Committee to extend their operations are limited by insufficiency of funds.

Qu. 14,436. "Is there a want of funds for a more complete treatment of the subject of land meteorology?—A very serious want of funds. As I mentioned before, for any serious discussion like that of the hourly values for all the elements for five years we are not provided with a sufficiency of funds; in fact the amount of our staff for land meteorology would be sufficient to discuss the results for one observatory, but not for seven. It is in that sort of way that the original provision of clerks who were to discuss the work was quite insufficient, the amount of materials being so enormous."

Mr. Scott also informs us that:—

Qu. 13,925. "Arrangements have been concluded between the Meteorological Society and the Meteorological Office, and have come into effect on the 1st January 1875. The principal features of these arrangements are that the Observers belonging to these two organizations are supplied with an uniform schedule for recording their observations, and that the Society undertakes to furnish to the Office monthly returns from certain selected stations for publication with the returns from its own stations, in consideration of a certain payment, which will probably average about 50*l.* per annum."

Supplementary Evidence.

"An invitation has been issued to the Scottish Meteorological Society to co-operate with the Office on similar terms, and the Meteorological Committee are not without some hope that this proposal may be accepted."

Besides the sum of 10,000*l.* which is placed on the Civil Service Estimates and is annually paid to the Meteorological Committee, the Government incurs a certain expenditure on account of Meteorology at the two National Observatories of Greenwich and Edinburgh. This expenditure for the year 1874-75 amounted to 1,221*l.* for Greenwich, and 115*l.* for Edinburgh.

A further small annual payment of 150*l.* is made by the Registrar General for the Reports of Meteorological Observations which are printed in his Monthly Returns. These Reports are supplied by Mr. Glaisher, the observations being made at different stations in various parts of England, by unpaid private observers, whose co-operation Mr. Glaisher has been able to obtain. The Evidence shows that the work is done under regulations which are sufficient to ensure its general accuracy; and it is obvious that the annual payment of 150*l.* hardly covers the expenses incurred, and affords no remuneration for the trouble taken in organizing and controlling the System of Observations.

#### *Evidence relating to Tidal Observations.*

Evidence in reference to Tidal Observations has been placed before us by Dr. Joule and Professor Sir W. Thomson.

Dr. Joule is of opinion that—

Qu. 10,568. "With regard to the sea level and the tides, although the laws with regard to the tides are pretty well known, they ought to be continuously observed, if only for the purpose of registering the changes arising from the alteration of banks, depth of channels, &c. Also with regard to the sea level, there have been reports from time to time with regard to the inroads of the sea on our coasts, but sufficient steps do not appear to have been taken to ascertain the facts in those cases. It seems to me very important to be acquainted with any alterations in the configuration of the earth which may be taking place, however minute those alterations may be."

He thus expresses his views as to the manner in which these Inquiries may be carried on:

Qu. 10,576. "Would that be a work which ought, in your opinion, to be carried on from day to day by a permanent establishment at such places?" "I believe that self-registering apparatus have been devised which would enable the mean sea level to be registered, and the tides to be registered, without very much trouble."

Qu. 10,577. "Is it a sort of work which can be carried on by public officers stationed at any of the ports, or would you require a separate staff?" "Probably it might be carried on by the officers at the stations. I do not think it would be necessary for anyone to be exclusively occupied in such a work."



Sir W. Thomson's Evidence on this point is as follows :

"In addition to those institutions which you have recommended, you consider, do you not, that it would be advisable that the Government should undertake secular observations of the tides?" "Yes, certainly, secular observations of the tides with accurate self-registering tide gauges, with the triple object of investigating the science of the tides, of perfecting our knowledge of the actual phenomena of the tides, both in respect to navigation and as a branch of natural history, and, thirdly, with a view to ascertaining the changes of the sea level from century to century." Qu. 10,715.

"Is anything of the kind done at present?" "There are several tide gauges, some of which have been carried on with great care, others with not sufficient care, and none with any security of permanence." Qu. 10,716.

"Was not it in connexion with the Ordnance Survey of Great Britain?—No sufficient steps have been taken to ascertain whether the sea level is changing relatively to the land in any part of this country." Qu. 10,719.

"Would you think a large number of stations requisite for the observations of the tides to which you have alluded?—Yes, a large number. The phenomena of the tides are of great complexity, but not of baffling complexity, provided that we make the observations at a sufficiently great number of points." Qu. 10,720.

"Would the duties attached to such observations take up the whole time of the persons who had charge of them?—By no means. They could undertake other duties. A tide gauge may be put under the hands of a careful harbour master or officer of the coastguard service at any station, but it must be under inspection to secure accuracy. The most careful and scrupulous of such men cannot make sure that the instrument is giving accurate results; and they cannot, except under instruction and occasional inspection, give out recorded curves, that they can be quite sure of being accurate in all points of scientific nicety; but the inspection that is required to secure accurate results would be a very simple and moderate matter." Qu. 10,721.

The accurate Reduction of Tidal Observations, without which, of course, they are useless, has not hitherto been undertaken by any Department of the State, and we are indebted to the zeal of individuals for the results which have been obtained. The reductions are laborious, and require the employment of paid computers. The following Memorial from the British Association for the Advancement of Science to the Lords Commissioners of the Treasury, put in evidence by Sir William Thomson, shows the difficulty that has been felt in procuring the moderate sum required for the Reductions :—

"MEMORIAL to the Right Honourable the LORDS COMMISSIONERS of HER MAJESTY'S TREASURY.

"The Memorial of the British Association for the Advancement of Science.

Appendix ix.  
Vol. II., p. 32.

"Humbly sheweth,—

"1. That in the year 1867 the British Association appointed a Committee 'for the purpose of promoting the extension, improvement, and harmonic analysis of tidal observations.' From that time until the present, under committees reappointed from year to year, the proposed work has been carried on. The mode of procedure adopted, and the results obtained up to the month of August 1871, are fully stated in the accompanying series of printed reports.

"2. The primary object of this investigation is the advance of tidal science, but the Committee have uniformly kept in view the practical application of their results to Physical Geography, Meteorology, Coast and Harbour Engineering, and Navigation.

"3. A large mass of valuable observations, recorded by self-registering tide gauges during the last 20 years, having been found available, the Committee have applied themselves, in the first place, to the reduction of these observations, and have deferred the object of promoting observations in other localities until the observations already made have been utilized to the utmost.

"4. The work thus undertaken has proved, as was anticipated, most laborious. The calculations have been performed, under the superintendence of Sir William Thomson, by skilled calculators recommended by the Nautical Almanac Office. The funds required to pay the calculators, and to print and prepare tables, forms for calculations, &c. to the amount of 600*l.*, have been granted by the British Association in four successive annual allowances of 100*l.* each, and a sum of 200*l.* voted at the last meeting. The last grant barely sufficed for the work actually in hand, and to secure the continuance of the investigation additional funds are necessary. The Council of the British Association, therefore, directed the Tidal Committee to make an application to the Government for assistance, the amount at present asked for being limited to 150*l.*

"5. It seemed to the Council that after the Association had done so much in the way of actual expenditure of time by the members of its Committee, and had given such a large contribution from its very limited funds, enough had been done to show the object to be one for which assistance may reasonably be expected from Government. On representations made by Colonel Walker, Director of the Trigonometrical Survey of India, the Indian Government has already granted the means of defraying the expense of making tidal observations in India, and applying to them the methods of reduction devised by the Committee of the British Association. The Council hope, therefore, that the Government of this country may be similarly disposed to assist in a matter of national importance.

(Signed) WILLIAM THOMSON,  
President of the British Association."

"May 21, 1872.

The Lords Commissioners of the Treasury did not accede to the Prayer of the Memorial, so that, at present, there is no guarantee that the Observations which have already been accumulated, and those which are still in progress, will ever be adequately discussed and utilized.

*Evidence relating to the Extension of the Government Grant administered by the Royal Society.*

The strong and concurrent Evidence which we have received as to the usefulness of the Government Grant, as at present administered by a Committee of the Royal Society, has led us to inquire whether this Grant might not be advantageously extended; and

the Witnesses whom we have examined on this point are unanimous in expressing the opinion that great benefits might be expected from such an extension.

- Qu. 11,570. Thus, to the Question, "Have you formed any opinion as to whether it would be desirable that the Government Grant of 1,000*l.* a year, placed at the disposal of the Council of the Royal Society, should be increased or not?" Professor Owen replies: "It has been so admirably applied and with such gain to Science, that there cannot be a doubt that it would be a great benefit to Science if it were doubled to begin with."
- Qu. 11,595. Mr. Spottiswoode, the present Treasurer of the Fund, states his opinion that an extension of the Government Grant would be desirable, and expects that the minimum which might be voted every year would increase materially.
- Qu. 12,214. Professor Grant gives his opinion "that it is very desirable that the grant should be enlarged." He also considers that it "would be expedient that wider publicity should be given to the fact of its being generally available to persons engaged in scientific investigations."
- Qu. 13,135. Mr. De La Rue is of opinion "that it is administered exceedingly well and very carefully." He considers that the amount should be increased.
- Qu. 13,590. From the Evidence given on page 13, it appears that Lord Salisbury also is of opinion that the Government Grant might be increased, with the object of affording liberal assistance to "first-rate workers."
- Appendix XIV., Vol. II., p. 67. In a Memorial presented to us by the Royal Society of Edinburgh, it is recommended that a corresponding Grant be placed at the disposal of that Body, for the Promotion of Science in Scotland. The claims of Scientific Workers in Scotland to participate in the Grant equally with those in other parts of the United Kingdom, have been fully recognised, and we think it of importance that there should be but one such Grant for the whole of the United Kingdom and one body responsible for its administration. In the measure hereinafter recommended we have suggested that the Administration of future Grants should be assigned to a Council of Science which should include the Representatives of the Scientific Societies of the United Kingdom.

#### *Evidence as to the Payment of Scientific Workers.*

On this branch of our Inquiry, the Evidence laid before us, both by Statesmen and men of Science, is to the same effect, and in favour of increased State Aid. It has also especially been urged upon us, that to afford, by direct pecuniary aid, the means of livelihood to men of distinction in pure investigation would be a great advantage to science, as competent investigators would thus be enabled and encouraged to pursue a strictly Scientific Career.

- Qu. 13,553. Lord Salisbury is of opinion that the cause of Science is hindered by the want of a sufficient career for scientific men, giving the following statement of his reasons:
- "I am induced to think so, by noticing how very much more rapid the progress of research is where there is a commercial value attached to the results of it, than in other cases. The peculiar stimulus which has been given to electrical research, in the particular direction of those parts of it which concern the telegraph, is a very good instance in point, and the extent to which researches into organic chemistry have almost clustered themselves round the production of coal tar colours is another instance in point. And therefore it is difficult to avoid the conclusion that research is really hindered by the necessity under which those who are most competent to conduct it feel themselves, of providing for their own support by means of the talent and the knowledge which they possess."
- Qu. 13,523. Lord Derby takes the same view:—
- "I think that, in one way or another, where you have a man of very great eminence as a scientific discoverer, it is unquestionably the duty of the State to provide him with means and leisure to carry on his work. Whether that is to be done by giving him an office under the British Museum, or in any similar institution, or whether it is to be done by simply granting him a pension in recognition of eminent scientific service, or in whatever other way it is done, it seems to me to be immaterial, but I certainly consider that it is a very important part of the public duty, to relieve men who have shown an eminent capacity for original discovery and research from the necessity of engaging in a lower kind of work as a means of livelihood." \* \* \* \*
- Qu. 10,736. Sir W. Thomson, in a reply to which we have already referred, stated his opinion on this point as follows:
- "That men should be enabled to live on scientific research is a matter of most immediate consequence to the honour and welfare of this country. At present a man cannot live on scientific research. If he aspires to devote himself to it he must cast about for a means of supporting himself, and the only generally accepted possibility of being able to support himself is by teaching, and to secure even a very small income, barely sufficient to live upon, by teaching, involves the expenditure of almost his whole time upon it in most situations, so that at present it is really only in intervals of hard work in professions that men not of independent means in this country can apply themselves at all to scientific research." \* \* \* \*

Professor Henry, the distinguished Director of the Smithsonian Institution in the United States, who was good enough to appear before us when he was in this country, gave the following emphatic evidence in the same direction:—

“My idea would be that if the funds were sufficient, and men could be found capable of advancing science, they should be consecrated to science, and be provided with the means of living above all care for physical wants, and supplied with all the implements necessary to investigation.” Qu. 1520.

Professor Balfour Stewart, after referring to the instances of wealthy persons who undertake Scientific Research in this country, points out that the number of those so circumstanced is very small in comparison with the number of able men who are willing to give their time and capacities to Observations and Research. He goes on to say that able men, and men competent to conduct research, suffer in this country from not having sufficient means at their disposal to proceed as they would like to do. Qu. 11,419. Qu. 11,420.

“Do you anticipate, then, that if there were any intelligent centre for the distribution of a sufficient fund to persons having the requisite capacities for observation and research, but not having the means, the distribution of such a fund would have any benumbing influence upon original observation and research?”—“No, I should think quite the contrary; it would encourage it very much.” Qu. 11,421.

Mr. Gore also advocates the enlargement of the present system. Qu. 10,902.

“ . . . I should strongly advocate that the present system should be enlarged, so that the investigators should not merely be reimbursed for all that they have expended, but also paid in some measure for their time and labour, because each investigator has to give up a profitable employment in order to find the time.”

He then gives his own personal experience, which probably resembles that of many of those who, without private fortune, engage in pure research.

“I refuse a great many engagements in analyses and other scientific matters for the manufacturers who come to me . . . I gave up some pupils a short time ago to enable me to have more time for original investigation.” Qu. 10,902.

Some of the Witnesses seem to have considered the Pecuniary Aid which they think should be afforded, more in the light of Rewards for work done than as an Aid to work to be done. Thus, Dr. Joule, is of opinion—

“That a small sum of money in recognition of scientific labour would be in many cases, a most useful help as well as a great encouragement, and if the Patent Laws are retained they might be supplemented with provisions to meet the case of those discoveries to which the Patent Laws do not apply.” Qu. 10,654.

Dr. Siemens is of opinion that, the Government might promote original research by liberal grants to the Learned Societies; remarking that this is done now to some extent, but might be done with advantage to a greater extent. Qu. 11,771.

He then suggests that the Government might also encourage Scientific Research “by granting through Societies, rewards for successful results obtained by independent research. In many instances the Patent Law provides for the reward, but in other cases of pure science the Patent Law does not apply, and the results of original research are left unrewarded.” Qu. 11,771

Mr. De La Rue is of opinion that if men are not in a position of fortune to continue their researches, in some cases materials and even money might be granted to them. Qu. 13,054.

Referring to the extent and value of the Original Researches in Chemistry carried on in Germany, he ascribes them “to the care which is given to the cultivation of every branch of science; and moreover to the positions and places at the disposal of the Government which are given from time to time to men who render themselves eminent in Science.” Qu. 13,094. Qu. 13,095.

With regard to the Scale on which such Remuneration or Payments for Maintenance should be made, Lord Salisbury observes:—

“I should say, taking the parallel [that of certain offices in the Church], to which I have already alluded, that an income of about 1,000*l.* or 1,500*l.* a year would be the kind of income which would suffice for the purpose that I have in view.” Qu. 13,569.

And he would also add Provision for Retirement.

With reference to the safeguards against abuse which would be necessary, Lord Salisbury continues:— Qu. 13,568.

“ . . . It would, for their [the investigators] own interest, and to save them from invidious comments, be desirable, to impose upon them the necessity of publishing, either in the form of books or in the form of lectures (but not sufficient in number really to impede their work), an account of the result of their labours during each successive year. Perhaps one or two stated lectures in the course of a year, to be delivered to University students, would be the best means of imposing upon them that test of industry.” Qu. 13,567.

Lord Salisbury further recommends that aid of this kind should be given directly and with as little concealment by ostensible duties of another kind as possible; adding:

Qu. 18,560. \* \* \* "If any money is to be given, as I think it ought to be given, for the purpose of furnishing a career to men who are really engaged in research which is not pecuniarily profitable, I think that it would be far better given directly and openly than given under the form of an office which would practically be a sinecure."

In contrast with this view, that the endowment should be given directly, we think it right to quote the opinion of the late Professor Rankine:—

Qu. 9515. "I think there is no general principle, but every case must be judged of on its own merits. The other thing which is wanted, besides money, is the leisure time of competent persons. It seems to me that it is out of the question for any State to provide or endow such a set of persons, and that it would be impossible for any department of the Government, either to judge who were fit persons, or how they ought to be employed, or what would be a proper remuneration for them. And I believe that if any such system were instituted, it would only lead to abuse. Setting aside such leisure time as men may have who are of independent fortune, and do not require to practise any profession or special occupation, I would say that it appears to me that in order to ensure that other competent persons shall have the requisite leisure, it is desirable that there should be offices with other functions attached to them, but those functions should be of such a nature that the holder of the office may have leisure time for original research." \* \* \*

#### REMARKS ON THE FOREGOING EVIDENCE.

The great advances in Physical Science which have been made in this Country, and within this century, by such men as Dalton, Davy, and Faraday, without aid from the State; the existence of our numerous Learned Societies; and the devotion of some few, rich individuals to the current work of Science; at first sight appear to reduce the limits within which State Aid to Research is required in this country.

But whilst we have reason to be proud of the contributions of some great Englishmen to our Knowledge of the Laws of Nature, it must be admitted that at the present day Scientific Investigation is carried on abroad to an extent and with a completeness of organization to which this country can offer no parallel. The work done in this country by private individuals, although of great value, is small when compared with that which is needed in the interests of Science; and the efforts of the Learned Societies, not excepting the Royal Society, are directed to the Discussion and Publication of the Scientific Facts brought under their notice; these Societies do not consider it any part of their corporate functions to undertake or conduct Research.

It will have been seen, from the extracts from the Evidence, that amongst the Witnesses who have advocated an increase of State Assistance are some who have made great sacrifices in time and money in the cause of Scientific Research.

But whatever may be the disposition of individuals to conduct researches at their own cost, the Advancement of Modern Science requires Investigations and Observations extending over areas so large and periods so long that the means and lives of nations are alone commensurate with them.

Hence, the Progress of Scientific Research must in a great degree depend upon the aid of Governments. As a Nation we ought to take our share of the current Scientific Work of the World; Much of this work has always been voluntarily undertaken by individuals, and it is not desirable that Government should supersede such efforts; but it is bound to assume that large portion of the National Duty which individuals do not attempt to perform, or cannot satisfactorily accomplish.

The following considerations have been suggested to us by the Heads of Evidence relating to (1) Laboratories, (2) Observatories, (3) Meteorology, (4) Tidal Observations, and (5) the Payment of Scientific Workers.

1. The first condition of scientific investigation is that there should be Collections, Laboratories, and Observatories accessible to qualified persons. The evidence has shown that at present, for certain branches, these do not exist or are incomplete.

Moreover there can be no doubt that the Government Service should, to a great extent, contain within itself the means of carrying on Investigations specially connected with the Departments. Even having regard only to the current wants of the State, additional appliances are necessary.

Three distinct ways have been suggested in which the State might assist in providing the Aids to Investigation which are required by private Individuals. It has been proposed: first, that competent Investigators should receive Grants in Money enabling them to provide themselves with means for conducting their Researches; secondly, that Laboratories, designed primarily for the Service of the State, and those of Universities and other similar Institutions receiving Aid from the State, should be placed, under proper conditions, at the disposal of such Inquirers; thirdly, that Laboratories should be erected by the Government specially designed for the use of private Investigators, though, of course, also available for the service of the State. Wherever the first of these methods can be conveniently and economically adopted, we are disposed to consider that it is the simplest and the best; but it must be remembered that for many Researches apparatus of a costly, but durable character, are among the primary requisites; and that to provide these separately for each investigator would involve a large and unnecessary expenditure. It appears to us that the difficulty thus arising might be adequately met by the adoption of the second of the above suggestions. Our attention has, indeed, been called to the inconveniences which might arise from the admission of independent workers into University or State Laboratories. But, notwithstanding this difficulty, we think the experiment is one which ought to be tried, and till it has been tried we should hesitate to recommend the erection by the State, for the especial use of private Investigators, of Laboratories which would certainly be costly, and might possibly be only imperfectly utilized.

2. Upon a Review of the whole of the Evidence relating to the subject of Astronomical Physics, we are of opinion that an Observatory for that branch of Science should be established by the State. In the study of Solar Physics, continuity of the observations is of the greatest importance; and owing to our variable climate, continuous observations of the sun in this country are subject to peculiar difficulties which should be duly considered in the choice of the site for such an Observatory. The neighbourhood of London is less favourable to Physical Observations than many other sites which might be found, and for this reason we should prefer, that a Physical Observatory should be placed elsewhere than at Greenwich. On other grounds, also, we think that the Observatory for Astronomical Physics should be an Institution entirely distinct from any of the National Observatories for Mathematical Astronomy. The subject of Mathematical Astronomy is vast enough to occupy adequately the whole energies of a Director, and it is especially important that Astronomical Physics should have the undivided attention of the Head of an Observatory, because its methods, which are of very recent invention, are as yet incompletely developed, and because, depending, as they do, on a continual comparison of celestial phenomena with the results of experiments in the laboratory, they are entirely different from those of Mathematical Astronomy.

Our opinion as to the desirability of such an Institution is confirmed by the example of Foreign Nations; Observatories for Astronomical Physics being already at work in various parts of Italy, and their immediate erection having been determined on at Berlin and at Paris.

We venture to express the hope that similar Institutions may before long be established in various parts of the British Empire. The regularity of the climatic conditions of India, and the possibility of there obtaining favourable stations at considerable heights, render it especially desirable that arrangements should be made for carrying on Physical Observations of the Sun in that country.

3. With respect to Meteorology we are of opinion that the operations of the Meteorological Office have been attended with great advantage to Science and to the Country. The subject of Meteorology is a very vast one, and any scheme for its proper cultivation or extension must comprise — (1) Arrangements for observing and registering Meteorological Facts; (2) Arrangements for the reduction, discussion, and publication of the Observations; (3) Researches undertaken for the purpose of discovering the Physical Causes of the Phenomena observed. The resources placed at the disposal of the Committee are inadequate to cover the whole of this wide field; and, having due regard to all the circumstances of the case, we believe that in selecting certain parts of it, as the objects of their special attention, they have been guided by a sound discretion.

We are also disposed to consider that although, as we have already said, the Meteorological Committee occupies an anomalous position, no other form of organization could advantageously have been adopted under the actual conditions. We think, however, that if, as we shall herein-after recommend, a Ministry of Science should be established, the Head of the Meteorological Office should be made re-ponsible to the Minister. We fully concur

with the opinion expressed by the Witnesses that many branches of Meteorology can only be effectually promoted by an organization having the support of Government; and we would draw especial attention to the consideration that, if Meteorology is to take rank as a branch of Terrestrial Physics, the observations must be made at stations widely dispersed over all parts of the earth's surface, and those taken by Observers of different Nations must be so arranged as to be comparable with one another. It is obvious that the intervention of Government would greatly facilitate the attainment of both these objects.

We are very unwilling that any Scientific Observations which can adequately be carried on by Individuals, or Associations of Individuals, should be undertaken by a Department of the Government. So far as the local interests connected with Climatic Meteorology suffice to ensure due attention being paid to that branch of science, we should prefer to see it left mainly to Scientific Societies, any assistance the Government might afford being merely subsidiary. That useful results may be obtained by voluntary effort is evident from the work carried on under the direction of Mr. Glaisher, and from the case of the Scottish Meteorological Society, which has succeeded, with very narrow means, in organising a valuable System of Observations on the Meteorology of Scotland. It is, however, important that any Grants for the promotion of Meteorological Observations in aid of voluntary efforts should be made on some systematic principle; and the attainment of this object would be furthered by making them subject to the Control of a Minister, who would be cognizant of all the facts relating to the expenditure of the Government upon Meteorology.

We may point out that the returns furnished by the Scottish Meteorological Society and Mr. Glaisher, are adopted by the Registrars General, and are recognized by Committees of Parliament in discussions affecting the Public Health, the Supply of Water, and other matters of the same kind. The value of Observations undertaken, as in this case, by private Individuals or voluntary Associations, must vary from time to time, according to the efficiency of the persons principally concerned in their superintendence. We feel, therefore, that the question how far it is proper that such Observations should receive official sanction, cannot be decided *a priori*, and must be left to the judgment of the responsible Minister for the time being.

4. With regard to Tidal Observations, it will be seen that, in the opinion of the Witnesses, these have not hitherto been conducted and reduced systematically. Considering the agencies which the Government can employ for the purpose of making these Observations, the importance of providing proper Superintendence for them, and of securing their Reduction, we think it desirable that they should be carried on under Government control. The expense involved would chiefly consist in the Establishment at proper points, and Verification, of Tide Gauges, and in the Reduction of the Observations; these being entrusted to officers of Government already stationed at the ports and on the various coasts of the Empire.

5. The Witnesses have expressed themselves strongly as to the Justice and Policy of Remuneration to Investigators for their Time and Trouble, and the Evidence also shows by implication how great must have been the sacrifices of those who without private fortune have hitherto devoted their great talents and their valuable time to such work without any remuneration whatever.

It has hitherto been a rule in the granting of Government Aid to Scientific Investigators, subject, so far as we have been able to ascertain, to but very few exceptions, that such Aid should be limited to what was necessary to meet the expenditure actually incurred on instruments, materials, and assistance.

To grants made under these conditions we think that considerable extension might be given.

It is hardly necessary to assert the principle that when Scientific Work is undertaken at the request of the Government, the State is not only justified in paying, but is under obligation to pay for what is done on its behalf and for its service. But we desire to express our belief that there are many instances of unremunerative Research in which the benefit conferred on the Nation by those who have voluntarily engaged in it establishes a claim upon the State for compensation for their time and labour. Without such compensation much important work must remain unperformed, because it must be expected that many of the best men will not be in circumstances enabling them to devote long periods of time to unremunerated labour.

It is a matter of course that State Aid shall only be given to Investigators whose capacity and industry have been placed beyond a reasonable doubt.

#### IV.—The Central Organization which is best calculated to enable the Government to determine its action in all Questions affecting Science.

The functions of the Government with regard to science may be summed up under the three following heads:

First. The Treatment of the Scientific Questions incident to the Business of the Public Departments.

Second. The Direction of Scientific Instruction when given under the Superintendence or Control of the State.

Third. The Consideration of all questions involving State Aid towards the Advancement of Science, and of Administrative Questions arising out of such Aid.

It would be difficult to enumerate exhaustively all the various topics comprehended under these three Heads, and it will be sufficient for the purpose of showing how wide is the field of action of the State in regard to Science, if we point out that under one or other of these heads are included all Scientific questions affecting the Army, the Navy, the Public Health, the Mercantile Marine, Public Works, Government Scientific Establishments; the Elementary Instruction in Science under the Department of Education in Primary Schools, in the Science Classes connected with the Science and Art Department, and in Secondary Schools so far as they are subject to Government control; the Aid which is now given, or which it is desirable should be given, to Universities and other Bodies not directly connected with the State, for the Middle and Higher Scientific Instruction, and the Control which the State either does or should exercise over them in virtue of such Aid or otherwise; the Appointments to all Scientific Offices in the gift of the Crown; Grants to Museums and their Control by the State; Aid to Scientific Expeditions of every kind; the Establishment and Direction of State Laboratories and Observatories; Grants in Aid of such Laboratories not under State Direction, and in Aid of Scientific Research; and generally the allotment and control of Public Funds, for similar Purposes. The majority of the Witnesses who have given evidence in relation to this branch of the Inquiry, express dissatisfaction with the manner in which questions under the preceding heads are now determined, and either recommend the Appointment of a Special Minister of Science or of a Minister of Science and Education.

In most cases the Witnesses recommend that such a Minister should, in regard to Science, be advised by a Council. Others, however, are of opinion that the Functions of such a Council might be exercised by an Administrative Staff of the usual kind.

Before continuing our remarks on this subject we beg leave to lay before Your Majesty extracts from the Evidence which has been placed before us regarding the Appointment of a Minister of Science.

##### *Extracts from the Evidence relating to the Appointment of a Minister of Science.*

We have received a large amount of Evidence in favour of the Appointment of a Minister of Science. There has been almost complete unanimity among the Witnesses on this point. We give the following extracts:

Professor Owen:

"I conceive that the recommendation by Bentham in the last century of such a minister can hardly fail to be practically adopted before the close of the present century, and that the necessity of having a minister for such a purpose will be recognised." Qu. 11,537.

Sir W. Thomson:

"Would you contemplate that a new department of the State should be constituted for directing the scientific work of the Government?—It would be quite necessary to have a Minister of Science; it is indeed, I think, generally felt that a minister of science and scientific instruction is a necessity." Qu. 10,747.

"Not a minister of other instruction?—Specially of scientific instruction, and not under any national education board, but a minister of science and scientific instruction. The minister would necessarily be in Parliament and a political man, but it would be very rare that he could also be a scientific man, and perhaps not desirable that he should be a scientific man, but he must have able scientific advisers always at hand." Qu. 10,748.

"Could any such duties be well assigned to any existing department of the State?—I believe not." Qu. 10,749.

"You spoke of the necessity for having a minister of science, do you conceive that it would be requisite to have a cabinet minister for education and a second cabinet minister for science, or would you contemplate that the minister for education should be the minister for science?—I do not wish absolutely to fix it beforehand; on the whole I think, however, that the title of minister of education would not suffice. If there is to be a minister, it must be a minister of science and education. There might be a minister of science and education, with a chief secretary or under minister for national and elementary education, and another for the advancement of science and for the higher scientific instruction. But naturally the minister of education must act for the masses; that must be his great duty, and however much he might wish to act for science, he has still a great duty to the masses. On the whole, I think that it would be preferable to have a distinct minister

of science and scientific instruction. A minister of science and scientific instruction, as a subordinate to a chief minister of science and education, might probably be a very good arrangement."

Qu. 10,764. "The minister of science administers knowledge to the whole country."

Col. Strange :

Qu. 10,980. "It seems to me that in the first place there should be some means of bringing science fully before the nation through Parliament. I know of no means of doing this that is in accordance with our constitutional procedure, except through a minister of state; and therefore assuming science to be a matter of enormous national importance, I think it is essential that it should be all brought under one minister of state, who should be responsible to Parliament for everything which is done in the name of the nation to further science, and who should frame his own estimates and keep them distinct from those of departments which have little or nothing to do with science. \* \* \* \* I think that there should be an estimate for science just as there is an estimate for the army and for the navy." \* \* \*

Qu. 10,982. "What I should be glad to see would be a minister for science, but I daresay that if proper assistance were given to such a minister, he might superintend other departments as well; for instance, as on the continent, he might superintend education and the fine arts. I think it would be preferable that he should be for science only. I think there is quite enough for him to do in England, for it to be done thoroughly; but rather than have no minister I would assign to him also education and the fine arts."

Qu. 10,983. "There would be a difficulty, would there not, in defining the boundaries between the duties of the minister for science and the minister for education?—I think not. I think one would relate to education, which is quite a distinct thing from national research, and I think that they should be kept as distinct as possible. I think one great evil now existing is the mixing up of those two things. Throughout my evidence I have here and there expressed the same opinion that they should be kept distinct, one being the means, the other the end; instruction I conceive to be the mode of growing a certain number of persons fit to investigate."

Mr. De La Rue :

Qu. 13,036 "I think that science ought to be recognized in the ministry by the appointment of a science minister, in order that all matters relating to science might come properly under the cognizance of the Government, and that whenever the Government sought the aid of scientific men it should be through the intervention of the science minister." \* \* \* \*

Mr. John Ball :

Qu. 7222. \* \* \* "If science is to be aided effectually, and at the same time controlled effectually, there should be some permanent officer in the department of the Government that has its relation with science, whose duty it should be and who should be responsible for making himself generally aware of the state of science and the doings of its cultivators, and who should be the proper person to advise the Government, not as to the best mode of deciding a strictly scientific question, but as to where the means for solving it are to be had. I look upon it at present as being a wholly haphazard matter how questions of science or connected with science and affecting the progress of science are decided in the public offices, and I speak from some slight personal acquaintance with the matter during the short time that I was in the public service in Parliament."

Qu. 7233. "You stated, did you not, that you thought it desirable that there should be some permanent official to represent and advise the Government in its relations to science?—Decidedly."

Mr. Gore :

Qu. 10,813. "I think there should be a scientific department of the State, which should have the control of the money expended by the State upon scientific matters."

General Strachey :

Qu. 11,875. "The first conclusion that I arrive at is, that all questions relating to scientific matters that arise in the operations of the Government should be dealt with by one of the chief ministers of the Crown, and the officer at the head of the Education Department seems to be the most suitable of such officers. It has been, I know, suggested by some persons that it would be better if there were a separate department for science. That I venture to doubt." \* \* \*

Qu. 11,876. "Under such an education and science department there would be a natural division of the duties, which would probably lead to the appointment of some permanent officer in the position of an under secretary of state, who would have specific charge of the scientific duties of the department as distinguished from the educational duties, which constitute a distinct branch of administrative work." \* \* \*

Qu. 11,878. "The principal officers in the proposed scientific branch of the department should be, by their scientific qualifications, capable of disposing of the ordinary current business under their charge." \* \* \* \*

Dr. Sclater :

Qu. 12,043. "Do you agree with [Col. Strange's] views as to the creation of a Minister of Science and a Council of Science?—Yes, I agree generally with his views, I think that it would be very desirable for the interest of science."

Qu. 12,044. "Do you think it would be desirable that the existing State scientific institutions should be removed from the control of the Admiralty, the Office of Works, and other departments under which they are now placed?—I think it would be a very great advantage that they should be removed from those departments and placed under one minister."

Qu. 12,045. "Have you any opinion as to whether the work could be done by a minister of education, supposing such a minister were appointed?—I think it would hardly be expected that a minister should be appointed only for science, and as I believe it is the case in continental countries that that department is given to the minister of education, I think that we could not follow a better example here."

Professor Balfour Stewart :

Qu. 11,505. "I think it [the ministry of science] might form a division, perhaps, of the ministry of education."

Mr. Farrer :

Qu. 12,673. "I dislike very much the idea of establishing new departments of the Government. If it were possible that this business could be placed upon the Minister of Education, who is becoming more and more important, I think that would be much better than establishing a separate department for the purpose."



Sir George Airy does not appear to be convinced of the advantages likely to be derived from the creation of a Science Minister, so far as it would affect the Scientific Departments.

"Do you see any inconvenience arising from the several scientific institutions that are more or less connected with the Government being under different departments?—Not that I am aware of." Qu. 10,528

"You are content that the Royal Observatory at Greenwich should remain under the Board of Admiralty. You do not require to have a Minister of Science, or a Minister of Education?—No; we are naturally connected in these respects with the Admiralty." Qu. 10,524

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*The proposal to establish a Council of Science.*

A proposal to establish a Council of Science was brought before the Government by the Royal Society in 1857, upon a Report from the Government Grant Committee of that Society.

The object of the Committee was (Evidence of Sir E. Sabine, qu. 11,117) to determine "whether any measure could be adopted by the Government which would improve the Position of Science or its Cultivators in this Country."

The report, as quoted by Sir E. Sabine (Qu. 11,119), was as follows :

"With regard to the question of which the consideration was referred to the Government Grant Committee on the 11th of July 1856, namely, whether any measures could be adopted by the Government or Parliament that would improve the position of science or its cultivators in this country, the Committee beg leave to recommend the following resolutions.—" Qu. 11,119.

"1. The Committee regard with much satisfaction the steps already taken in the Universities for advancing the study of physical science by including several branches of it in the public examinations, and express their hope that the improvements thus introduced may receive the extension which the interests of science require, and that the public schools may be thereby induced to make physical science an integral part of their course of education.

"2. The Committee recommend that the establishment of classes in metropolitan and provincial schools, where those who have not the means or opportunity of studying at the Universities may be taught the elements of physical science on a systematic plan, be promoted by grants from Government in aid of such funds as may be locally contributed for that purpose.

"3. That the formation of provincial museums and libraries be encouraged in like manner, and that provincial lectures, accompanied by examinations, be established in Great Britain in towns which request this assistance, and engage to provide a part of the expense, such lectures to be in aid of the schools above-mentioned, so that by means of the two combined a sound knowledge of the principles and application of science may be systematically taught.

"4. That duplicate specimens from the British Museum and other institutions, supported at the public expense, be distributed to provincial museums.

"5. That national publications bearing on science be more extensively circulated than they are at present by additional donations to societies and individuals engaged in the cultivation of science.

"6. That the sum placed annually by Parliament at the disposal of Government for the reward of Civil Services, 'useful discoveries in science and attainments in literature and the arts,' be augmented, that the portion to be appropriated to science be defined, and that it be sufficiently large to admit of the grant of annuities of the nature of good service pensions as rewards of eminent scientific merit.

"7. That the sum placed at the disposal of the Royal Society for the advancement of science be not necessarily limited to the annual grant of 1,000*l.*, when on any occasion special reasons may be assigned for an additional sum.

"8. That scientific officers be placed more nearly on a level in respect to salary with such other civil appointments as are objects of ambition to educated men.

"9. The Committee regard with much satisfaction the steps already taken for the concentration of the principal scientific societies in Burlington House, and trust that the period is not far distant in which permanent accommodation will be afforded to the principal scientific societies in buildings to be erected near the same site, and in pursuance of the same general plan.

"10. While it may not be expedient to interfere in any way with the functions confided to the President and Council of the Royal Society in reference to the distribution of the Parliamentary grant, or with the ancient and recognised relations between the Royal Society and the Government, at the same time it appears to the Committee that much benefit would arise from the formal recognition of some board which might advise the Government on all matters connected with science, and especially on the prosecution, reduction, and publication of scientific researches and the amount of Parliamentary or other grants in aid thereof; also on the general principles to be adopted in reference to public scientific appointments; and on the measures necessary for the more general diffusion of a knowledge of physical science among the nation at large; and which might be consulted by the Government on the grants of pensions to the cultivators of science.

"11. Assuming that the above proposal should meet with the approval of Her Majesty's Government, it will be desirable to ascertain what mode of constituting such a board would inspire them with most confidence in its recommendations. Two modes may be suggested in which such a board might be organised. First, the Government might formally recognise the President and Council of the Royal Society as its official adviser, imposing the whole responsibility on that body, and leaving it to them to seek advice when necessary in such quarters as it may best be found, according to the method now pursued in the disposal of the Parliamentary grant of 1000*l.* The second method would be to create an entirely new board, somewhat after the model of the old Board of Longitude, but with improvements. The question as to which alternative shall be adopted is properly a subject for the consideration of the Government.

"12. Such of the above recommendations as involve the expenditure of money, might be eventually carried out by appropriating to this purpose a certain portion of the fees received from the grantees of patents, after

providing for all expenses which ought to be defrayed from that source." The Committee are satisfied that no application of these fees could be devised more appropriate than the devotion of a portion of them to the encouragement of abstract science, to which practical art is under so many and such important obligations."

The proposal to establish a Council of Science has recently been revived by Colonel Strange.

Amongst the Witnesses who recommend the Appointment of a Council, there is a great diversity of opinion as to its Constitution and Limits of Action. As regards its Constitution, it will be seen from the Summary of Evidence which we shall give subsequently, that while some of the Witnesses are in favour of a Council very limited in numbers, others would desire to have it sufficiently numerous to include Representatives of nearly every branch of Science, as well as Men of known Administrative Ability.

In regard to its Limits of Action, the main difference arises on the two questions, whether the Council should or should not have the power of Initiating Inquiries, either directly or by suggestion to the Minister, and whether or not it should itself undertake the actual work of Investigation required for State Purposes.

As to the Mode of Remuneration, the opinions vary between those which advocate annual payments to permanent officials, and those which are in favour of payments for attendance at meetings.

The Opinions of the Witnesses who are opposed to any such Council are based, in the main, upon one or more of the following objections:—

1. That Government can get the best advice without it.
2. That it would be liable to come into collision with Ministers.
3. That it would not work harmoniously with our General System of Administration.

The Evidence of three eminent Statesmen possessing great administrative experience—Lord Derby, Lord Salisbury, and Sir Stafford Northcote,—is in strong contrast (so far as the proposal to establish a Council of Science is concerned) with that which we have received from many persons holding official positions in various Branches of the Public Service. The Opinions of these latter, as to the inefficiency of the Organization of their Respective Services in regard to questions affecting Science, we have already quoted in the First Part of this Report, and it will be seen, from the quotations we are now about to give, that they in general consider the creation of a Council to be the proper Remedy.

*Extracts from the Evidence in favour of the Establishment of a Council of Science.*

We fear that no mere extracts from the Evidence of Colonel Strange would represent in an adequate manner the views which have led him to recommend the formation of a large and highly-paid Council of Science. It would scarcely be fair to him, as the most prominent advocate of the proposed measure, to do otherwise than refer to his Evidence at length, pp. 75 to 92, and 125 to 135, Vol. II. of Evidence.

Sir W. Thomson's Evidence with reference to the Establishment of a Council of Science is as follows:

- 10,677. "Do you think that a single body would be better than a number of small committees for advising the Government on the great variety of questions which from time to time would be likely to arise?—Yes, certainly."
- Qu. 10,678. "The questions which might be referred to such a Council would differ very much from one another, and extend over a wide range, would they not?—Yes, but there would be an unity of design and action, and a multiplicity of knowledge and skill at command, secured by a single council, and those conditions cannot, in my opinion, be secured at all by occasional committees, or committees working separately and independently of each other."
- Qu. 10,679. "A scientific council would relieve the Government of all responsibility in such matters, and would be responsible itself in a general way for all its proceedings to a political chief and to Parliament."
- Qu. 2694. "Have you formed any opinion as to the constitution of such a committee as we have been referring to; how the members of it should be selected?—I have no other opinion than that the men whose advice may be considered as most valuable and useful to the Government ought to be asked, quite independently of their connexion with any institution, whether under the Government or in the universities, or in connexion with any public or private body in the country."
- Qu. 2695. "You would contemplate that committee being formed, by the Government itself, and not that the universities or the scientific societies should have the right of nomination?—Certainly by the Government; but aided by recommendations from the universities and scientific societies, and from this proposed consulting committee after its first constitution."
- Qu. 2868. "Would you have them a permanent body, with, it may be, a certain number of members going out by rotation, or in the event, suppose, of a change of Government, would you throw over the whole body?—A non-political body, I think, would be necessary for good action."
- Qu. 10,691. "Would you leave the selection of each appointment to the Government of the day, or would you allow scientific societies or other bodies to recommend, or would you propose that the Government should be obliged to consult such bodies?—I would prefer that the Minister of Science should have the appointment."

## Dr. Frankland thus deals with Colonel Strange's Proposal.

"Are you acquainted with Colonel Strange's proposal for the establishment of a consultative council of science?—Yes, I have heard from him some of the chief ideas that he entertains on that subject." Qu. 11,082.

"Are you disposed to consider that such a council would be desirable?—I think so. I am not prepared to say that it should be constituted exactly in the way that Colonel Strange mentioned, but a council of that description would be exceedingly desirable, on many grounds, for furnishing the Government with trustworthy scientific opinions in cases requiring them." Qu. 11,083.

"Are you of opinion that the advice of such a council, even on matters to which the larger proportion of the members of the council had not paid special attention, would be valuable?—Yes, I think it would, because those members of the council who were thoroughly acquainted with the subjects would be expressing their opinion to men conversant with scientific methods, and they would be able to convince their colleagues with respect to the opinion that the council generally ought to give upon the matter. It would be a very different thing from that of convincing a parliamentary committee, for instance, upon a scientific point, because all the men upon the council would have received a scientific training, and would understand the bearing of scientific arguments." Qu. 11,086.

"Have you considered at all how such a council could best be appointed, whether would you leave it to the ministers to appoint and select the proper persons to serve on the council?—I should think that it must ultimately fall upon the ministers, but he might be assisted by the presidents of different learned societies or by the council of the Royal Society, in whom I think everyone would have confidence." Qu. 11,087.

## Mr. Farrer suggests the formation of a Council which might be closely connected with the Royal Society.

"Have you any suggestions to offer as to the best modes, as it appears to you, of solving problems which from time to time present themselves?—I think if upon purely scientific questions there were some scientific body of some kind to whom the Government departments could as a matter of course refer for the solution of such questions as this, it would be a great advantage." Qu. 12,634.

"I have looked at the suggestions that have been made by Colonel Strange and others, and I do not think that any Government department or its professional officers would listen to the dictation of any council of purely scientific men; they would probably say, and say with justice, that they knew more about what was wanted than any such council could know. Every now and then in the course of practice in 'those cases' a new scientific question does arise; such, for instance, as the question concerning deviation of the compasses. In such a case as that we required the best scientific assistance we could get; and in the case of sulphur in gas, and water impurities, we now require it." Qu. 12,636.

"I give with great hesitation a suggestion upon a point upon which I really am scarcely competent to suggest anything, namely, whether you had not better make use of what you have at present, namely, the Royal Society or a committee of the Royal Society, rather than attempt to establish any new body. No new body that you could establish would have the prestige, reputation, and influence that the Royal Society has. That is a matter not to be created; it is a matter which has grown with centuries. You have also in the Royal Society itself a scientific public to whose opinion any council or committee appointed by it would or might be made amenable; and my suggestion would be that you should endeavour to create some committee or body out of the Royal Society which should bear a fixed relation to the Government, which should meet regularly, and the members of which should be paid something, as the directors of a joint stock company are paid for their meetings, to whom the Government should have a right to refer, who should feel that they had on the one hand a duty towards the Government, and who on the other hand should be bound to make public all their proceedings, so that they would be responsible to the public scientific opinion of the country. That is the best suggestion that I can make, but, as I say, I am very ignorant upon the subject." Qu. 12,643.

Admiral Richards is of opinion that the appointment of a Minister of Science and of a Council stand and fall together; and thinks "that the one would not be of very much value without the other." Qu. 11,585.

But, as regards the Admiralty, the Department which he knows best, he would prefer that it should be able to decide Scientific Questions within itself. He says:

"I think that the Admiralty requires the aid of such a council less, perhaps, than any other department of the Government, for this reason, that there are not very many questions, purely questions of science, that come under the notice of the Admiralty; and then we have the Astronomer Royal to refer to, who is a host in himself, and if any question arises which we do not refer to the Astronomer Royal, we generally ask the President and Council of the Royal Society, and we have never found any difficulty in getting assistance. The only department of the Admiralty which might require such assistance beyond this, is perhaps the Constructors' Department, in the designs for ships of war. But as regards that, my opinion is that it would be far better to have some scientific designer attached to that department than it would be to refer such questions to a council even." Qu. 11,591.

As to the Admiralty deriving any advantage from the appointment of the proposed Council, he adds: Qu. 11,592.

"There would be this advantage, I think, which they would derive, that they would be freed from the political pressure which is brought frequently to bear upon the Admiralty upon questions of that kind. The whole responsibility of deciding upon a measure would be thrown upon the council."

"Do you think that would be a desirable result?" "I think that it would be desirable in all departments of the Government; it would be very agreeable to the Government of any day, I should think, to escape the responsibility of deciding on scientific questions on which they may not be very intimate, but in which they may be believed to be interested parties." Qu. 11,593.

"Do you think that the work would be better done?" "I think it would. I should say there could be no doubt about that, but unless the Government are prepared to vote a very considerable sum every year for Qu. 11,594.

the advancement of science, which I am quite of opinion that every Government ought to do, I think very little benefit would accrue from having such a council."

Qu. 11,427. Dr. Balfour Stewart is also in favour of a Council :

"You have no apprehension that the Government, if advised by men of the highest scientific capacities, would be likely to operate so as to control science, and to fetter the operations of individuals, or to benumb and discourage Original Research and Observation?"

"I think not. I think that the great desideratum is to put more means at the disposal of private individuals, and, of course, this must be done by some sort of administrative body."

Qu. 11,515. "In what way would the advice of the council be better than that of the individual members of that council, who are the highest authorities on the question under review?—Because I think that science has a number of bearings, and that a question might involve, not one branch of science, but a great many, and you might, for instance, have to call in various men of science of different kinds. In order to answer this question, you might have to call in, not the advice of one member of the council, but the advice of a number. Of course there are a number of questions regarding which some of the members of the council would naturally be silent, but perhaps a good many of them might be interested in answering a particular question, and would give their answer. In a case of that kind I should fancy, however, that it ought to come as from the whole body, because, really, in most questions now-a-days, the question would not involve one particular branch of science only, but it would involve the joint operation of two or three branches of science."

Qu. 11,516. "Take, for instance, such a question as that which has been recently referred to a committee, the efficiency and stability of ships of war, would there be any advantage in referring a question of that kind to the council, rather than to a committee specially appointed, as has been done on the occasion to which I refer?—I think that if there were a council of this kind, the council would have power to associate other people with them in a case of that kind. Science is so ramified, that the council would not be able of themselves to settle all questions; but upon particular questions, such as you name, very likely they would associate other people with them."

Qu. 11,517. "Do you think that they would be more likely to make a judicious selection of the persons to be consulted than the Minister of State would be, without the advice of such a council?—I think so, because a Minister of State is not likely to know the capabilities of various men. There are a number of men known to scientific bodies as profoundly conversant with particular branches of science, but their knowledge of those subjects does not appeal to outsiders, it only appeals to those who are cognizant with that particular subject." \* \* \* \*

Dr. Roscoe is in favour of a Council, and would give a voice in its appointment to the Learned Societies :

Qu. 7436. "Can you make any suggestions as to the mode in which Government aid could be best carried into effect?—I do this with the greatest diffidence; but it appears to me that the system of a consultative council, to advise the executive on matters of scientific instruction, is the true one. I believe it is a work which it is almost impossible that the executive can do properly without advice received in some form, and that appears to me the form in which it is most likely to be productive of the greatest good."

Qu. 7437. "Have you any suggestions to make as to the constitution of such a council?—I should be inclined to think that a council, formed on the same plan as this Commission, so far as regards the class of its members, would be a very proper one to advise the Government."

Qu. 7438. "Would you think it advisable that the Government should name its own consultative council, or that some of the members should be nominated by the societies?—I should provide for a certain number of scientific men being upon the council, and desire that the Government should nominate (for you may trust the Government to do it with fairness), as well as the societies; that is, the lay members should be appointed by Government, and the professional ones by the various scientific societies." \* \* \* \*

Qu. 12,048. Dr. Sclater agrees generally with Colonel Strange's views, and thinks that a Council "would be very desirable for the Interests of Science."

He then proceeds to state his opinion as to its Constitution :

Qu. 12,046. "Have you formed any opinion as to the constitution of a consultative council to assist this minister?—My idea would be that the heads of the different scientific institutions that are put under the control of the department of science and the minister of education might form a consultative body and be called a council of science, and that there might be certain other members added to assist them in deliberation, if it were thought necessary, such as representatives of the College of Physicians, the College of Surgeons, and of the scientific branches of the Army and Navy."

Qu. 12,047. "Colonel Strange's proposed council would consist of 30 members at least; do you think that that would be too numerous a body?—I think that a less numerous body might suffice, because I see that, in many cases, however numerous the body was, it would be necessary to call in special assistance."

Qu. 12,049. "If a council were constituted in the manner that you propose, should you contemplate that, as a rule, they would be capable of giving advice themselves on most questions that would arise, or would they generally find it desirable to call in further assistance?—I think, that in most cases, they would be quite competent to give an opinion to the Government; but that sometimes on particular questions, it would be necessary to go elsewhere for advice, and that, in such cases, there would certainly be somebody in the council who would know exactly where to put his hand upon the right man for the purpose. For instance, a question might arise in some special department of Natural History: in that case, the council would naturally refer to the head of the State Museum of Natural History to know if he could give an opinion himself, and if not to inform them who could give an opinion upon the point. Thus, I think that with the aid of a small council of science of, perhaps, 20 members, every question requiring solution by the Government as regards science might meet with very fair consideration and be very easily settled."

Qu. 12,054. "Have you any misgivings as to whether such a council would command sufficient public confidence amongst men of science?—I have no misgivings at all upon that subject. I should say that they would meet with general support from men of science. Most men of science, I think, see that something of the sort is

imperatively required. All lament the piecemeal way in which scientific subjects are dealt with by Government, in consequence of their being subdivided amongst all these different offices, and of there being nobody to appeal to upon a question of science, and, therefore, I think the proposal to establish such a council would meet with universal acceptance amongst scientific men."

"Then, in the case of investigations which were required to be undertaken, how do you conceive that they would be dealt with?—I should say that the member of the council representing the particular branch of science would be called upon to present a preliminary report of how he proposed to set about any particular investigation. He would say, to do this I shall require the assistance of such and such persons for so many days, or for such and such time, or to send here or to send there, and would bring these requirements in the shape of a preliminary report before the board, and, if this were approved, would carry out the investigation. Then he would present his report upon the result of the investigation, and the council as a body would consider it, and recommend its adoption by the Government or otherwise."

"Then do I understand that you would prefer, as a general rule at least, that the members of the council should themselves carry out such investigations as might be required from time to time, rather than that they should merely indicate to the minister the person, outside the council very probably, who they thought was best competent to carry out the investigation?—I do not think it would be necessary to draw a hard and fast line upon such a question as that. I think that in many cases it would be better that the council, as a whole, should report to the Government on the best way in which any particular scheme might be carried out. I do not think that it would be necessary to introduce a rule that you should invariably go to the member of the council representing that particular science if advice were wanted upon that branch. But the council would naturally turn to the representative of the particular science for an answer; they would naturally look to his advice first."

"I understand you to mean that the duty of the members of the council should be to know where to go in order that particular questions should be answered, whether it were to go outside the council or to go to one member of the body?—Yes, that is my opinion."

His remarks on the question whether there should be on the Council men having Administrative Experience are as follows.

"I think that the heads of great scientific institutions must have administrative experience. If a man has to manage an institution like the Royal Observatory at Greenwich, or the State Museum of Natural History, he must have the command of a great many men under him, and must be acquainted with the business of the institution, and must have gained his administrative experience. He could not fail to be a person of administrative experience."

"But, taking the application of scientific laws to specific departments of the Government, the army and navy, for example, would it not be important that there should likewise be on the council some men of special knowledge of the mode of facilitating the adaptation of scientific laws to those departments?—I think, certainly, that the army and the navy, which are the branches of the service, perhaps, most requiring scientific assistance, should be represented by one or more members at the board, and no doubt the Government would take care to secure a first-rate man for what I should consider a post of the very highest honour."

As to the numbers composing the Council, he considers "that it would not be advisable to have a larger Council than was absolutely necessary," for the reason that a small body of men generally work better and do more work than a large body; at the same time he does not think that 20 would be a very large number.

Dr. Hooker, the President of the Royal Society, gives it as his opinion "That the general proposition, that the Government should be aided by scientific persons, is an excellent one, both with respect to the administration of the existing Government Scientific Institutions, and with respect to the occasional grants which the Government may be called upon to make for scientific objects." Like Dr. Roscoe, he thinks that the Council should not consist exclusively of Scientific men.

Mr. De La Rue thus gives his opinion:

"There ought to be a board of advisers which should consist of men eminent in different departments of science. I can only speak as to those branches of science to which I have paid some attention, and I should put in the first category that there ought to be on the board a chemist of eminence, there ought also to be a physicist, an astronomer, a mathematician, particularly one who has paid attention to the application of mathematics to science, and an engineer or two engineers, one who has given attention to the construction of great works, such as railroads and bridges, that is to say, civil engineering, the other a mechanical engineer. I do not speak of a biologist or a physiologist, because other witnesses are much more competent to speak as to the necessity for such men than I am."

"But do you think that all branches of science ought to be represented on the council?—Undoubtedly."

"Can you give the Commission any idea as to the number which you think it would probably be necessary to provide for?—About 10 or 12 men, I imagine, would sufficiently represent science."

He would give some voice in the selection of the Members to certain Societies, and would not require the Members to "relinquish any other position that they might already hold."

As to the numbers of the Council, he says that "If 12 men were not found to be sufficient to include all branches of knowledge, it would be desirable to increase the number." He proposes "that special advisers might occasionally be called in who would be remunerated according to their attendance."

He considers that the usual permanent staff of a Secretary and Assistant Secretaries, even if they were men of Science, would not be sufficient; urging as a reason that

- Qu. 13,125. "Science is really now so extensive that one could hardly imagine any secretary so to be intimately acquainted with every branch of science as to be able, even with the aid of his assistant secretaries, to advise, or to point out where to obtain specific information on every question which might be brought under consideration. I think, therefore, that there would be a very great advantage for the Science Minister to have a sufficiently numerous Advising Council."

He considers that promptness of action would be promoted by the appointment of a Council:

- Qu. 13,126. "There ought to be a body of men who could be immediately called together, whose time was so far at the disposal of the State that they might be assembled on every occasion and at any time to advise the Science Minister. Then we should get prompt action, instead of questions being allowed to drag over years and years without any practical solution being come to."

- Qu. 13,131. "But even if a Council were appointed, he thinks that such branches of the Government as the Admiralty, the War Office, and the Public Health Office "should be specially "scientific, each in its own department."

- Qu. 13,134. In answer to the question, "Have you no fear that there might be some collision, or, at any rate, considerable friction, between that Council and the Scientific Departments of the Public Service?" he says:

"Probably at first there might be, but ultimately I believe the confidence of those directors of the departments would be gained by the very sound advice which they would receive from a body constituted as I conceive it ought to be."

He does not think the Government Grant Committee could be so modified as to render a Council unnecessary.

- Qu. 13,135. "Supposing 5,000*l.* or 10,000*l.* were given to the Royal Society to aid investigations, I do not think that that in any way ought to weigh in the consideration of the establishment of a science minister whose functions would be altogether larger and much more important. We want science really cared for in England by the State, and we want all State questions relating to science properly considered by a body capable of dealing with them."

Professor F. Jenkin is in favour of an Elective Board:

- Qu. 1658. "I think that the judging of the applications for assistance, applications for the endowment of new chairs, and the application of Government patronage generally as regards science might be managed by the following system. Supposing that instead of the grant being given simply by the Department itself (speaking now of the Committee of the Privy Council) there were a representative board composed of men of science, composed of professors who could advise—I will not say that they should have the power of deciding—I would rather leave that with the Government, but that they should have the power of reporting at any rate upon each of those applications, I think that the Government would get better advice than it can command at present. My idea is that this board should be an elected board, that each of the existing colleges (you could easily choose the colleges and universities) should appoint one member at such a board as that; but however the choice was made, if there were something like a representative board of scientific men to advise the department, even if their recommendations were not necessarily acted upon, but that they were simply a reporting body, I think that the Government would be better able to decide on such subjects than they can now do, and that their decisions would give greater satisfaction."

- Qu. 1659. "I do not know how otherwise the Government is to decide who is really the best man. We cannot have competitive examinations for professorships, I think, and the system of irresponsible testimonials has come to be in a monstrous state. A man really prepares a blue book; every man one has ever spoken to sends for a testimonial, and you get a whole library of those testimonials."

Professor Martin Duncan points out an important way in which the Council could be utilized:

- Qu. 7704. "With reference to any endowment that might be granted by the Government, have you formed any idea as to the control under which the administration of such endowment should be placed?—That is a matter which I have thought over, and I see that it might lead to great difficulties. The Government might wish to nominate a Professor of King's College, and such a professor might be objectionable to the Council of King's College, and I think it would be more satisfactory to scientific men if all those appointments were placed under the care of a board of scientific men of position, and who would be responsible to the Government for their nominations, and for the duties of the professors being well carried out. There would be no difficulty in obtaining such a board, because the presidents and officers of the learned societies, which have charters, would make a sufficiently good board, and a board beyond doubt as regards their scientific acquirements and their desire to uphold science. To leave the matter entirely in the hands of the Government would, perhaps, not lead to very satisfactory results."

- Qu. 11,973. Mr. Spottiswoode considers Colonel Strange's suggestion the most complete and perfect that has yet been made, and states that he has "always looked upon it as an arrangement to the carrying out of which all others should be directed;" at the same time, however,

he considers "the proposal is a large one," and suggests that "it might be worth consideration whether some intermediate scheme for earlier action should be proposed."

His opinion on the Appointment of the Members is thus expressed :

"If any council (without at present going into its constitution) were appointed, in whose hands do you think that appointment should be placed?—I think it clearly should be in the hands of the Minister with whom it would be in direct relation." Qu. 11,974.

"You would leave the choice absolutely to him, and not make the appointments in any respect *ex-officio*?—There might very well be certain *ex-officio* members, such, for instance, as the Astronomer Royal for the time being, the President of the Royal Society for the time being, and perhaps others." Qu. 11,975.

"The greatest importance would attach to the first constitution of the council?—Certainly." Qu. 12,013.

"How would you advise the minister to proceed in order to act wisely in that appointment?—I should suppose that he would obtain advice from the leading men of science of the day, and with their advice it would not be difficult to form, at all events, the elements of such a council, although he might not be able at once to complete a very fully organized body. If those first appointments were made, he would have the full advantage of the advice of those members in completing the entire list." Qu. 12,014.

"If such a consultative council were appointed, you would probably contemplate that it would be mainly composed of persons now to be found on the council of the Royal Society, or on the committee of recommendations of the British Association?—Yes, I should imagine that it would be mainly composed of Fellows of the Royal Society." Qu. 12,038.

"How would it work if there were some arrangement by which the council of the Royal Society should propose a certain number, two or three persons out of whom the Government might select one on any vacancy?—I see no objection whatever to that proposal." Qu. 12,039.

"That would secure, as a general rule, the appointment of persons of the highest scientific qualifications on the council?—I think it would." Qu. 12,040.

Sir Henry Rawlinson thinks that the Council should be merely consultative. He regards the nomination of a Permanent Council of Science as the natural remedy for the "spasmodic" action on the part of the Government, and adds : Qu. 12,562.

"It appears to me that the chief and most important point in this matter has reference to the appointment of a Council, rather than to the nomination of a Minister. I think with a Consultative Council of Science there would be a corresponding uniformity of action." \* \* \* \* \* Qu. 12,552.

"In the Council of India we have no power of initiation. The initiative rests with the Minister, or, practically, with the executive officers, acting, I may say, on the inspiration of the Minister, and the measures are only brought before the Council, in a subsequent stage, for their approval or disapproval." Qu. 12,562.

We have already quoted the Evidence of this Witness as to the difficulties which the Government Departments, and more especially the Indian Council, meet with for want of authoritative Scientific Advice. In answer to question 12,564, he goes on to say :

"I may mention to the Commission, in reference to this subject, that the desirability of such a council is constantly brought to my observation through another channel, namely, through my duties in the Council of India, where we perpetually have references before us, which we are really unable to deal with. These references recall most forcibly to us, and very frequently, the necessity for the existence of such a council as I have proposed." \* \* \* \* \* Qu. 12,564.

"Should you apprehend that a minister would find it a very difficult task to constitute a council in such a manner as to command the confidence both of the public and of scientific persons?—No, I should think not. I should think a minister, with the latitude of selection which he would have in a country like this, would have no difficulty in bringing together a council of 10 or 15 gentlemen whose qualifications and reputation would command the respect of the world, and whose opinion would fortify him in his decisions, and be of great national benefit." Qu. 12,567.

General Strachey has given us some important Evidence as to the Appointment and Functions of a Council of Science :

"The persons who are employed in the public administration are certainly as a class not amongst those who have anything deserving the name of scientific education; therefore, for a long time to come, it is not to be expected that the members of the Government, or their chief subordinates, will have any such general knowledge of science as would enable them at all satisfactorily to deal with the scientific questions which come before them. Therefore, I conclude that it is absolutely essential for the Government, under any circumstances, to get advice from outside; and then comes the question as to how this advice is to be got. If there is no recognised and regularly organised body whose business it is to give advice to the Government on such subjects, then the only thing that a minister can do is to get his information from unrecognised and irresponsible authorities, persons whose opinions, perhaps, may be very valuable, but still persons of whom the public never can have any cognizance; and private advice given in that way seems to me given in the worst possible form. If then, that form of advice is bad, how can you obtain advice of proper intrinsic value on the multifarious subjects on which it is certain to be needed by an administration really striving to advance science to the utmost, and how can you secure its being given under a sufficient sense of responsibility, and in such a way as to carry the greatest weight possible to the mind of the minister who is expected to act upon it? And here I would repeat that any specific proposal to give effect to such an idea must be made to fit into the general form of the administration; and I, therefore, consider that the best course would be to adopt the proposal that has been made by many persons, that there shall be some sort of council constituted to advise the responsible Government department as to its proceedings in connection with science." Qu. 11,879.

This Witness objects to the proposal that the Council should be elected by, or selected mainly from Scientific Bodies, or Educational Establishments, and considers that—

Qu. 11,879. "The only way to lead a Government in the proper course which they should pursue in relation to science is, to give them advisers whom they have agreed to accept, and whom they are, therefore, forced to admit as trustworthy and satisfactory guides. The only way in which that sort of relation between them can be established, I think, is to put a specific responsibility upon the Government to nominate. I think, too, that there would be, under such an arrangement, an action of a similar character in the other direction, and that a person who was specifically nominated by the Government to perform those particular duties would have a much stricter responsibility put upon him, so to act and so to advise the Government as to produce satisfactory results, than if he were merely developed, so to speak, by the operation of some external body."

Qu. 11,882. "I think that in order to put propositions in a practical form and in an acceptable form before the minister, it is desirable that there should be persons in the advising body who have a certain amount of administrative experience. Also, I think that, as society is constituted now, there should be in it persons of what is commonly called superior social position, such persons having certain advantages in getting access to the minister, and in guiding public opinion, which others have not. What should be aimed at, in short, is a practically useful body rather than an eminently theoretical scientific body; and I should say that a body not differing materially from this present Commission has the sort of constitution which would secure the best exercise of the influence which I conceive that this advising body should exercise. I think that all that would be necessary to enable it to do all that could possibly be required of it, would be to entrust it with suitable power, where the occasion required, for making specific references, or for calling into its councils persons specially qualified to advise it, who were not permanently upon the Commission. I think that an arrangement of that sort could be carried out without any particular difficulty."

Qu. 11,883. He thinks that the body should not be very numerous, suggesting nine as a sufficient number; on the ground that the larger the body the more divided is the sense of responsibility, and also on the ground that under certain circumstances the larger the body the less is the weight that is attached to its opinion.

He would give considerable Initiative Powers to the Council :

Qu. 11,885. "Would you propose that this council should initiate proposals itself, as well as consider subjects on which its advice was asked?—Yes, I think so. I think that the greatest freedom of action should be given to the Council; that it should be in a position to make any representation that it thought desirable to the minister on the subject of science." \* \* \* \*

He disapproves of the suggestion that the Council of the Royal Society should perform the Functions of a Council of Science :

Qu. 11,886. "Would such a body as you are proposing supersede the Government Grant Committee?—Yes, certainly; and I would take the opportunity of saying that it is a question that is open, and which I believe has been discussed, whether the Council, for instance, of the Royal Society, with or without any addition, might not be made to perform satisfactorily some or all of the functions which it has been suggested should devolve upon this Commission. But I think not. And the principal reason that I have for thinking that such a body as the Council of the Royal Society is not suitable for the purpose is, that it cannot have that specific responsibility put upon it which should be put upon a body such as I have spoken of, and that it is got together for totally different purposes and objects. The council of the Royal Society has to manage the business of the Royal Society, and is not at all selected to advise the Government on matters connected with the advancement of science, or the application of science in the operations of the public departments."

Qu. 11,887. "And one-half of their number is changed every year?—Yes."

Qu. 11,888. "You could not make the minister responsible for the action of the council of the Royal Society, or of its committee?—Not at all."

Qu. 11,889. "Because the nomination of the council and of the committee is by a body of constituents over whom the minister has no control?—Quite so, the minister would have a perfect right to repudiate any scheme which they put forward, or any advice they gave; I mean that he would be justified in doing so on the ground that he was not responsible for their selection." \* \* \* \*

He is in favour of the advice of the Council being made public, as a rule, but subject to the discretion of the Minister.

Qu. 11,889. "There would be cases, for instance, in which the minister might ask a question as to the relative qualifications of two scientific men for some post, and the commissioners would give an opinion, and their reasons for that opinion, but it would not be right that the grounds on which they formed it should be made public; still, as a rule, the more complete the responsibility put upon everybody connected with the commission for the opinion that he gave on any subject that came before it, the better would it be."

With regard to the Financial Duties of such a Council, he would wish it to prepare estimates with reference to any expenditure they might propose.

Qu. 11,890. "They should place any proposals that they had to make in a definite form before the minister, but I would not hand over any lump sum to them as is done now in the case of the Royal Society. I understand that the Treasury give a thousand pounds a year to the Royal Society, to spend in their own way on scientific objects. I think myself that this system is essentially vicious, to make a homely comparison, it is as though I desired to absolve myself from all responsibility in connection with the suffering and poorer class of the community, by giving the first beggar I met sixpence. The Chancellor of the Exchequer hands over a



thousand pounds to the Royal Society, and thinks that he has done all that is necessary for the promotion of Science."

He does not propose that the Council should supersede the Scientific Branch of any Public Department; but is of opinion that a Council would strengthen the hands of the responsible Chiefs of such Departments :

" I think that the idea of placing such matters as the construction of ships for the Navy, or the form of guns, or of small arms, or of projectiles, and so forth, upon a body of this sort is altogether a mistake; that is not a function that should be put upon such a body; it is not really what is wanted. The departments of the Government that have to carry out those particular duties are responsible for possessing the necessary knowledge, for instance, the department that builds ships has within its own body all the necessary means of acquiring the information requisite for designing proper ships and for building proper ships, or, at all events, if it has not, it ought to have; and if there is a defect in the organization of those bodies, they ought to remedy the defect themselves; they ought to introduce amongst their officers proper people "

Qu. 11,890.

" There is not the slightest reason to doubt that the responsible officers in the Controller's Department knew perfectly well that the " Captain " was not a safe ship, but their opinion was overridden, and if Admiral Robinson and Mr. Reed had had a body of this sort to refer to, if they could have challenged the Admiralty board to take a scientific opinion from this body as to whether their views were right or wrong, great good would have resulted." \* \* \* \* \*

Qu. 11,890.

As regards the special use of the Council in reference to the Administration of India, the evidence of this Witness is so full and so important that we must refer to it in extenso at pages 213 and 214, Vol. II. of Evidence.

Captain Galton would desire to see a Council whose duties should be principally administrative.

" I should not advocate the formation of such a council unless that council could be given duties other than those of a consultative nature. I do not believe in mere consultative councils. If a council is to be appointed, it must be a council for some other objects, and I think there is quite sufficient reason for the appointment of a scientific council or commission, or whatever you like to call it, for certain other purposes, and that when it was constituted for those other purposes, which are practically administrative purposes, the council might be advantageously consulted upon other subjects by the Government."

Qu. 12,980.

" You have pointed out that there are a very considerable number of Institutions connected with Science which are supported by the State; do you consider that there is sufficient system in the present arrangements? — I think that the institutions which are maintained by the State for scientific purposes are maintained upon no principle whatever with regard to their administration. You have got the British Museum under Trustees, you have got South Kensington under the President of the Council, you have Kew under the Office of Works, you have the Botanic Gardens at Edinburgh, I think, under the Queen's Remembrancer; You have the Observatory at Edinburgh as part of the University of Edinburgh, and you have the Observatory at Greenwich under the Admiralty, besides several others. You have every possible variety of jurisdiction, and, consequently, it seems to me that you have a great waste of power; there is the School of Chemistry, and the School of Mines, and the Museum at Edinburgh, all under South Kensington Museum, and the Meteorological Department, which is partly under the Royal Society and partly under the Board of Trade. There is no possibility of getting any correlation between those different scientific bodies, and if you are to get proper unity of administration you must bring them all under one head, or to one focus. I should recommend placing them all under a scientific commission or council, and I should place that council probably under the Privy Council; but I should make it a body for administering all questions connected with all the scientific institutions, or all grants made by the Government for scientific purposes in the country, and I should give to this Council the same status, with regard to its administration, or very much the same, that the Indian Council have." \* \* \* \* \* The parliamentary head of the Department, if he differed from them in opinion as to their recommendations upon the scientific questions connected with those institutions, or any other that might be founded, should record his differences of opinion in a minute." \* \* \* \*

Qu. 12,984.

" Have you considered what would be the best mode of constituting such a council? — I should keep it to as limited a number as would represent sufficiently the different branches of science. I do not think that you could possibly have a smaller number than five or six. I think they would want a secretary, and, of course, they would have to meet tolerably frequently for the administration of these matters."

Qu. 12,988.

The Council, in his opinion, should be nominated by the Minister of the Department, or the Prime Minister.

Qu. 12,989.

He further considers that all questions as to grants of public money for purposes connected with Science should be referred to the Council, instead of being granted or refused " hap-hazard."

Qu. 13,000.

Dr. Siemens would " assemble the Heads of Departments at frequent intervals for the discussion of general questions, and would propose to add to their number such men as the President of the Royal Society, the President of the Institution of Civil Engineers, and at least one Representative of the two great Universities. This Board would decide general questions appertaining to the Advancement of Science."

Qu. 11,796.

He would regard the opportunities of meeting together, thus given to Heads of Departments, as one of the great advantages of such a Council.

Qu. 11,857.

Qu. 11,800. He thinks that the number of the Council should be about 20, and that the greater part  
 Qu. 11,801. of its members, being Heads of Departments, should not receive payment as members  
 Qu. 11,802. of the Council. The four additional members whom he proposes, he considers would  
 Qu. 11,803. probably decline remuneration.

The Functions of the Council of Science, with regard to Research, would, according to this Witness, be very limited :

"Would it be desirable, in your opinion, that this Council, or any scientific Government department, should undertake experimental research?—I think not; my impression is that scientific research should be left as free and open as possible. If gentlemen were specially instructed to make experimental research they would be, I consider, in a somewhat false position. They would be morally obliged to produce results in order to satisfy the public mind that they were doing their duty, and science or scientific research cannot be measured by such a standard of results. I consider that a man should always have some absolute duty to perform, some drudgery work, which might be made as light as possible; but my impression is that he would not be in a satisfactory position, either to himself or as regards the public, if discovery were his only duty."

Qu. 11,846. "Your opinion was that the Government should not direct scientific research, but I think I understood you to say that it was desirable that they should direct inquiries to be made in reference to subjects of direct national importance?—Yes."

Qu. 11,847. "And those you think should be carried out chiefly by commissions in each case appointed for the purpose?—Yes, by commissions appointed for the purpose. I think that there should always be a direct practical object in view."

Qu. 11,851. "If those inquiries were directed by a Government council of the nature of the one which you have sketched, do you think that they would be more likely to be successful than if they were left to make their investigations in a more independent way?—I think I would as much as possible leave investigations in the hands of individuals. I would make inquiries through committees or commissions, because they have the means at their disposal for collecting information which private individuals have not."

Qu. 11,858. There should be a Ministry of Science and Education, which would constitute an im-  
 Qu. 11,860. portant Department of itself, the Minister being the Head of the Council. "There are  
 "Political Men of highly cultivated minds, or even with a great knowledge of Science,  
 "who would be quite capable of taking such a position."

Qu. 11,938. Mr. Anderson appears not to be thoroughly convinced of the advantage of a Council.  
 Qu. 11,939. He thinks there is at present more sound Scientific Knowledge in the Government  
 Departments and at the disposal of the Government than is generally supposed, but that  
 if a Council should be appointed, a small number would be better than a large one. He  
 Qu. 11,941. considers that seven would be sufficient, and admits that without the assistance of some  
 such Council as this, he sees no "symptom at the present time" of the Government  
 causing such inquiries to be made as he thinks desirable.

Professor Jellett thinks that every science should be represented on the Council :

Qu. 12,812. "Supposing there were no person in the council who was qualified to judge; for example, supposing the  
 subject were a medical subject, and you had no medical man upon your council, I think that when you came  
 to discuss the report you would find yourself in some difficulty. You would be almost entirely at the mercy  
 of the irresponsible individual outside who had given the advice."

Qu. 12,815. "Of course I could not carry on the subdivision to any very great length. For example, take the subject  
 that I am myself most conversant with, applied mathematics. I do not want to have a representative of  
 acoustics, or a representative of optics; one representative of applied mathematics would do."

Mr. Milne-Home would have a local Council for the encouragement of Research in  
 Scotland.

Qu. 12,449. "I understand you do contemplate the establishment of a board solely for Scotland?—Yes, for Scotland  
 solely."

Qu. 12,451. "I think that if the board were formed in England, with sub-committees in Ireland and Scotland, it might  
 answer the purpose, but I do not see how it is possible that gentlemen in London, unconnected with Scotland,  
 can have that knowledge which is desirable with regard to individuals applying for grants. If there were no  
 board of that kind, the London board would require to make inquiry through individuals selected by themselves,  
 and who would not have the same responsibility as persons officially appointed."

Appendix  
 XVI.,  
 vol. II., p. 74. Mr. Justice Grove, who was unable to attend before the Commission, has stated  
 his opinion in an interesting letter which we have given in our second volume, Appendix  
 XVI. He is "not very sanguine as to the working of such a Council, but thinks the  
 experiment worth trying."

He fears that "a large or highly paid permanent Scientific Council \* \* \* would lead  
 "to political intriguing for place; and not the best men of science but the ablest men of  
 "the world would succeed," and that "scientific men, moreover, are not, as a body, suited  
 for the work."

He looks upon General Strachey's proposal, "a continuation of the present Com-  
 mission, permanent as a body but changed as to individuals," as the most hopeful.

He sees no reason "why the members should not be paid a reasonable salary for  
 "their time and trouble, but would not put this too high, because, if obtained, it  
 "would lead to the political-interest-making system."

The extracts which follow have more especial reference to the Functions which the  
 various Witnesses propose the Council should fulfil.

The late Professor Phillips :

"I think, first of all, it would deal with all questions such as are now presented to the Government Grant Committee." Qu. 3138.

"And would it aid in directing research?—Yes. The Government Grant Committee has very limited means of maintaining anything of a permanent character, and I think, therefore, that this new board would recommend, in a case of that kind which we are discussing with regard to the formation of special observatories, some grant for the purpose of research requiring many years to be continued, and for which apparently it would be very difficult, or next to impossible, to find any other successful mode at present." Qu. 3139.

"Do you consider that any questions regarding the scientific education of the country would come under such a board?—No doubt they would; there would be, I conceive, a very natural alliance between such a great subject as that and the definite prosecution of physical research, but I have limited my own views in the first instance to subjects connected with the teaching, experimenting, and continually observing of physical phenomena." Qu. 3140.

"If such a board were established and got into full work, do you not think that a large part of the time of the members of the board would be occupied in those duties?—I do, indeed." Qu. 3141.

Sir W. Thomson :

"The main object of such a council would, in my opinion, be to advise the Government on all scientific questions which might come under the attention of the Government, and on all scientific works actually undertaken." Qu. 10,675.

Another object of the council would be to advise the minister of science in all applications for the expenditure of money to promote scientific investigations. Applications are frequently made to the Government of a singular character which could not be classed; some of those applications may be thoroughly deserving of support, and others may be of a most frivolous character. All such applications should be referred to one responsible council. At present the Government must be very much annoyed by occasional applications, and I have no doubt that the want of a permanent responsible and trustworthy adviser or body of advisers, to whom all such applications can be confidently referred, must be seriously felt. I may mention as an instance of applications of that kind, the applications made by the British Association for funds for the late and previous solar eclipses. The testimony of the Royal Society and the British Association to the importance of the object was no doubt in this case accepted immediately by the Government as a sufficient certificate that the object was a suitable one for the expenditure of public money. But there are many other applications even by the British Association itself which the Government feel must be referred to some competent adviser.\* Then there are many applications made altogether by private individuals for assistance in some department of scientific investigation, those would naturally fall to be all summarily rejected at present, but it would be advisable that they should be handed over to a council of responsible advisers, who would take each case on its own merit." Qu. 10,689.

"Would you be so good as to inform us whether you have formed any opinions as to the best system of appointing such a council?—The council ought to represent the different branches of science, and the practical applications of science. Pure mathematics ought to be represented in the council; mixed or applied mathematics according to the old-fashioned nomenclature as generally understood ought also to be represented; chemistry cannot be shut out; physics must of course be represented and ought to be represented separately; astronomy, both what was formerly called physical astronomy and of course the new science of astronomical physics, ought to be represented. I do not believe that astronomy could be properly represented under one head; astronomical physics must, in my opinion, be separately represented. Geology should be separately represented, and also the various branches of natural history; physiology also, and medical practice in general, should be represented. I have spoken of applied mathematics, I meant rather mathematical dynamics than applications to art and mechanical operations. Then practical applications should be represented, mechanics and mechanical engineering, then again civil engineering and geodesy, mining engineering, statistical inquiries, and the scientific branches of Her Majesty's service ought to be thoroughly represented. Engineer and artillery officers and the navy should be represented both in its navigation department and in the department of seamanship, and the department of gunnery. The mercantile interests of the country and the agriculture of the country ought certainly to be represented. The universities ought to be represented simply—the English universities, the Scotch universities, and the Irish universities. Also practical telegraphy, which is a very distinct branch of engineering, civil engineering or mechanical engineering would not sufficiently represent it." Qu. 10,690.

"Do you think that the functions which are proposed to be assigned to the scientific council would not interfere in any way with the existing scientific departments of the Government; for example, the Medical Department of the Privy Council, or some of the other Government scientific departments?—I think it would relieve the departments from pieces of scientific work at present given to them, because there is no other body to whom they can be given, and for which they are by their organisation and *personnel* almost necessarily ill fitted and insufficiently competent." Qu. 10,750.

"You would leave to these departments their administrative functions, but give them the advantage of consulting with the council upon higher questions of science on which they desired information?—Yes, certainly; every question of science that falls under the notice of any department of the Government would naturally be referred to the scientific council." Qu. 10,751.

Captain Galton :

"I should make it [the Council] a body for administering all questions connected with all the scientific institutions, or all grants made by the Government for scientific purposes in the country, and I should give to this council the same status with regard to its administration, or very much the same, that the Indian Council have; that is to say, that the parliamentary head of the department, if he differed from them in opinion as to their recommendations upon the scientific questions connected with those institutions, or any other, that might be founded, should record his differences of opinion in a minute. Of course as he would be finally responsible to Parliament he must have the final power; but I should put the same check over him that is put over the Secretary of State for India, that he must record his differences of opinion, and his objections to their recommendations, or rather his reasons for not adopting the recommendations of this council, in a written" Qu. 12,984.

\* \* As, for example, that for assistance to the Tidal Investigation. See Appendix IX, Vol. II, p. 32.

inute which would be capable of being produced in Parliament if necessary. Of course the remuneration for those scientific gentlemen who would have to give a considerable part of their time to this council, ought to be of a sufficient nature."

- Qu. 12,985. "Would you place the management of all the Government institutions connected with science in the hands of this council?—I should place the administration of it in the same way that the administration comes to the different Government departments now. The officers in charge of the British Museum would report to those gentlemen on all expenditure of money, on changes, and other matters of that sort. All their estimates would come up through this council, and all their expenditure would be sanctioned through it, and any questions arising in their administration, for instance, changes recommended, or new regulations, would be administered by this scientific council, instead of being administered by the separate heads of the departments who now administer them."

Dr. A. W. Williamson :

- Qu. 12,687. "Could you enumerate what you consider would be the principal duties of this council, supposing it to be established?—I should put the specific duty upon them of preparing a complete report of the national resources available for scientific instruction and research, according to the sense of the word public which I am just now describing it, namely, those which are available for that purpose, and not for the promotion of the profit of individuals; and then that such a report should be re-edited annually, so that one should be able, by referring to it, to know what the funds of the institution are, and what they are doing respectively. I think that it would be of immense value that there should be one general source of information upon that point, and then I have no doubt they would be applied to for many improvements, which would be needed in those institutions; and they would have to investigate the question so brought before them or referred to them by the Secretary of State for that department. I should think it likely that it might be found desirable to refer to this council for advice in the selection of committees to investigate practical matters; for instance, the matter of gunnery, or other matters which are not matters of pure science, and that they would be able to recommend the choice of suitable persons for any work of that kind in which scientific principles would have to be applied to some practical purpose. In fact, the number of questions relating to science which come before the Government now, directly or indirectly, are, I suppose, considerable; and from what I have been able to learn of late on that matter, I should think that a good many people must be incidentally employed, to the extent of a great part of their time, by giving advice upon such matters."
- Qu. 12,694. "Then you would not propose that the Government, if it wanted advice upon such subjects, should go to the council of science in order to obtain it?—I conceive that the Government might with advantage go to the council of science in order to find the individuals most competent to advise them upon such a practical point; but I think that the Government ought not to expect advice on such matters from the council itself. I do not see how the council could include matters of that sort with the really important questions of science itself without losing their homogeneity and unity of action. That would include all human activity almost, for scientific principles can be applied to all kinds of doings."

Dr. Roscoe :

- Qu. 7438. "The great duty of such a permanent body would be to lay down some sort of system, according to which Government aid to science must be given, and to prevent (if possible) the expenditure of national moneys upon ill-considered or one-sided schemes. The results of a systematic Government effort is seen in the case of the German universities, in which, for comparatively small amounts of national expenditure, great results are obtained, whilst, I fear, that with us (for want of system) the opposite condition of things more nearly holds good."
- Qu. 7439. "You would not desire that it should consist solely of men of science?—No, certainly not. I am of opinion that the presence of the lay element is essential, because many questions will occur which are not purely scientific, such as the necessity for establishing new colleges, or aiding existing ones, and on these points the opinions of experienced (perhaps local) non-professional men would be of the greatest value."

Mr. De la Rue :

- Qu. 13,091. "Supposing that there had been such a Consultative Council as you propose, would it not have been advantageous to take their advice upon the expediency of such a proceeding?—I think that it would be one of the functions of such a council [undoubtedly to advise the Government upon questions of that nature [the purchase of the College of Chemistry by the Government], and with regard to all other scientific matters, grants of money, or the establishment of fresh teaching establishments."
- Qu. 13,092. "Then one advantage would be that the public would know on whose advice any such step had been taken by the Government?—Yes"

Dr. Siemens :

- Qu. 11,798. "What do you consider would be the principal duties of such a Council?—To name commissioners for special inquiry, to discuss generally the amounts of the grants to be given to learned societies, and to advise the minister with regard to innovations proposed in Government departments. Take, for example, an invention of ordinance; if such a question, after a preliminary examination by the department concerned, were brought before the general body, it could there be discussed for the guidance of the Minister of Science, to ascertain whether such an innovation was based upon sound scientific principles, and what course of experiments should be pursued to lead to the best results. By referring it to the Minister, and having it discussed before such a Council, a great deal of unnecessary expenditure might often be saved where, through the want of sufficient information, the experiments are conducted by the departments in a somewhat unscientific manner. Another duty of the Council would be generally to direct the publication of the scientific information obtained through the different departments."
- Qu. 11,799. "Do you consider that it would be the duty of such a Council to initiate proposals on matters connected with Science, or merely to give advice when asked for?—Only to give advice when asked for, but the departments should be held to communicate with the Minister all important questions brought before them, who, with the advice of the Council, would direct inquiries to be instituted in many cases where the department would have simply rejected the proposal."

Mr. Reed :

" If a department of the Government were contemplated as an advising department only, I believe it would be an impracticability. But it has been suggested to this Commission, I believe, or at any rate I have heard it suggested, that a scientific department might relieve certain existing departments of the State of some of the duties in connection with science and art. If that were so, if a department of the State had positive executive duties to perform, and were to have the promotion of those independent inquiries and the giving of advice to other departments attached to it as a branch of its duty, and not as its primary duty, I am disposed to think that such a department might work exceedingly well." Qu. 12,711.

" Do you think that the other departments would be willing to defer to the opinion of this special department?—I should be afraid that they would be willing to defer a little too often, and that the risk of such a department would be in a branch like the Admiralty, for instance, refusing to do some of the things which it now does, without first referring to this independent department, and that I am afraid would be an obstruction to the executive officers of the Admiralty; and unless the department were exceedingly well worked, it might operate as a disadvantage on the whole." Qu. 12,712.

" I should prefer myself to see a much smaller council with a larger power of reference than Colonel Strange seems to contemplate." Qu. 12,715.

" By a power of reference, you mean that of obtaining advice outside itself?—Yes." Qu. 12,716.

*Extracts from the Evidence against the Appointment of a Council.*

We now proceed to give extracts from the Evidence of those Witnesses who object, on various grounds, to the creation of a Council.

The late Professor Rankine objects to a Permanent Council. He is "afraid of abuses arising if there were a permanent tribunal. I am doubtful how it would work." But he thinks that "if the Council of the British Association or the Council of the Royal Society were selected, there would be as little objection to those bodies as to any body that can be thought of." Qu. 9557. Qu. 9558.

Sir G. Airy thinks a paid Consultative Council could not do very much to assist the Government.

" There have been bodies of that kind from time to time. The Board of Longitude was a very useful body for a time, when the struggle was rising about accepting the theory of gravitation and generally introducing it, especially into the formation of lunar tables for the aid of nautical astronomy, and also the subjects connected with it; and that Board of Longitude undoubtedly did good service for a time, but somehow or other it died away; it became an object of contempt; there appeared no reason for keeping it up at any expense and it was abolished, and nobody seemed to regret it. Then the Admiralty had an institution of three scientific advisers, but I believe the scientific advisers perished in nearly the same way after a time; and I think that so far as the experience of those bodies has gone it supports the idea that it will be better for the Government, when occasion requires it, to get the best advice that it can." Qu. 10,522.

He considers that the Council of the Royal Society would be "the best body to which the Government could have recourse in any matters of that kind." Qu. 10,544.

Professor Owen is in favour of a Minister of Science, with a permanent Under-Secretary and Administrative Staff; but adds,—

" With regard to the Consultative Council, several objections occurred to me in considering that matter. The consultative council would, no doubt, be formed with the full concurrence, and in complete harmony with the views of the Permanent Under-Secretary. You may take it either way; a consultative council, if it were established, would hardly get on with its work, unless it found a permanent officer in harmony with its views. Assuming the Permanent Under-Secretary with a consultative council established, what would be the probability of the Minister going beyond such machinery in reference to any information or advice which he might require with regard to any movement or change in reference to science? I doubt very much whether he would go outside or beyond that body for advice and information. And what do you find? You find, for example, in reference to my own especial science, one Naturalist on the recommended Council. Now there are, and I suppose there always will be, three or more naturalists who might each severally think that they were entitled to a seat and a word on that Council. You would find two naturalists, at least, who are respectively at the head of some public Natural History Establishment; one might have a bias toward zoology, another toward botany, a third, perhaps, toward geology. Supposing a question were to come before the Science Minister with regard to the assignment of Government collections of Natural History made in Government Voyages, where would the determination be?—In all probability with that naturalist who was a member of the consultative council, and such position would give him, in my humble opinion, an undue advantage." \* \* \* Qu. 11,537.

" Supposing that a single naturalist were a member of that council, the question would be whether, in a case of this kind, he would deal quite impartially between Mr. \* \* \* and Mr. \* \* \*, and so on with regard to any other analogous case; it is always uncertain how far social relations of friendship, and intimacy, and so on, might not have their effect in such a question." Qu. 11,538.

He does not approve of the present state of things, but he thinks that a Minister and a permanent Secretary, who could obtain Advice when thought necessary, would be a better remedy than a consultative Council. He adds, "I think that a body, representing a consultative Council, would do its duty much better if selected by the Minister of Science, or the Minister of State for Science, for the special question before him," and also suggests:— Qu. 11,551. Qu. 11,553.

" There would be the power of applying to the councils of the different scientific societies, the council of the Linnean Society for one, the council of the Geological Society for another, and the council of the Zoological Society for a third class of questions in natural history, to say nothing of the council of the mother of all our learned societies, viz., the Royal Society; in these we have already a guarantee against any dictatorship or arbitrary decision." Qu. 11,559.

The Earl of Derby would like to be more satisfied as to the reality of the grievance :

- Qu. 13,514. "I do not, as at present advised, see what the difficulty is of obtaining the best scientific assistance when any Government department chooses to call for it. As a matter of fact the names of the most eminent men in every department of science are perfectly well known, and they have always, as far as I am aware, been very creditably ready to give their assistance when it has been asked for; and I should be inclined to think that if there are cases where a Government department has not had the benefit of that assistance, it has rather been because it was not asked for in time than because there was any difficulty in obtaining it."
- Qu. 13,515. His Lordship also is "very sceptical either as to the necessity, or as to the utility, or as to the successful working of such a Council."
- "One objection to it is that if matters for which the head of a department is responsible are to be referred to the council, and if upon those matters the council is to pronounce an authoritative opinion, you will very materially lessen the responsibility of the one person who ought to be responsible to Parliament. I may take an instance: I have seen it stated in some of the evidence which has been given before the Commission that if the Admiralty had had proper advice as to the construction of ships, a great disaster which is fresh in all our memories would not have occurred. It seems to me impossible to suppose that you would get any competent person to advise the Admiralty in the matter of shipbuilding if he were to be under two masters, that is to say, if his plans were to go, on the one hand, to a scientific council to be approved by them, they having nothing to do with the question of expense, and, on the other hand, to go to the head of that department and to Parliament to be approved again by those two parties, they having nothing to do with the science of the matter, but looking principally to the expense. I think that that would entirely destroy the responsibility of the executive officer, and would destroy that independence which he ought to have in the performance of his functions. If you want scientific advice on a matter of that kind I would place it in the department rather than outside, or, which is practically the same thing, I would refer the specific question upon which the opinion is wanted to one or more of those persons who could bring the highest scientific authority and ability to bear upon it. It strikes me further that if you are to have a council including all the departments of science, and if that council is to pronounce its opinion collectively upon all matters submitted to it, you will in fact have every question decided by a great majority of persons who, however eminent in their own department of science, know very little of the particular matter in question."
- Qu. 13,517. In reply to the suggestion that "One function [of the Council] would probably be, to advise the State as to the application of money for the higher teaching of science and for scientific research, and also to advise the Government with respect to any applications that may come before it for grants of money connected with science," Lord Derby thinks that "is a matter which falls strictly within the province of the Minister of Education;" and although he is quite aware of the fact that "if one man is selected as the general adviser of some particular department of the Government upon a matter of science, it is not improbable that there may be some jealousy in the minds of certain other people who think that they could give quite as good advice, or possibly better;" it seems to him that "unless the proposed Council is to be unlimited in number, precisely the same difficulty will arise under that system. There will be a large number of persons outside it who will think that they have a better claim to be in it than those who actually are there; and precisely the same feeling of jealousy would then exist, and would produce the same amount of inconvenience."
- Qu. 13,521. In reply to qu. 13,521, he adds, "you may be quite sure that any Minister who wants an opinion upon a scientific matter will try and get the very best opinion that he can. He has no possible interest in doing otherwise; on the contrary, he has the greatest possible interest in doing that. And, on the whole, I think that a man in that position, with what I may call an unlimited command of assistance and advice, is quite as likely to make a good selection as anyone else could do for him."
- Qu. 13,522. He does not admit the analogy of the Indian Council, and as regards the argument from the alleged uncertainty of Government action in respect to Science, more especially as to Grants of Money, he thinks this arises chiefly from considerations depending upon the state of the Revenue in each year, and expresses his opinion that "it might be quite legitimate to grant 4,000*l.* or 5,000*l.* for exploration in Africa at a time when the finances of the country were prosperous, and to withhold a similar grant at a time when the nation was economizing to the utmost."
- Qu. 13,540. He admits that, even apart from financial considerations, a great deal of uncertainty pervades the whole of our administrative system;" and is "an inevitable condition of living under a popular government."
- Qu. 13,541. He further urges the following objection to the proposal of a Scientific Council on a large scale:
- Qu. 13,550. "I believe that you would have a great deal of heartburning and jealousy on the part of men desiring and failing to get into it; and I think that if you brought together 25, 30, or 40 of the most eminent men in science, it would be found that the practical direction of that body would very likely be in the hands of men who are by no means the highest scientific authorities. The conduct of administrative business and the management of men is an entirely different thing from the conduct of scientific research, and it might very possibly be that those who would take the lead in managing the affairs of such a council would be those whose time and attention were the least devoted to purely scientific work, and who although they might possess a good deal of administrative ability might possibly not by any means stand at the heads of their respective branches of science."

With regard to the proposal to constitute the Council of the Royal Society the recognised advisers of the Government, he expresses the opinion that it would not be possible to refer "matters concerning all branches of science to a more competent body of men than the Council of the Royal Society, constituted as it generally is." But he adds, "My objection to giving to that body an officially recognised position as the permanent Advisers of the State is this, that you thereby take it out of the power of the Government to say who their advisers are to be, because the members of council are appointed by a process with which the Government has nothing to do." Qu. 13,551.

Lord Salisbury is opposed to a Council because he has "never seen anything to lead him to believe that such a Council of Science would have anything to do." Qu. 13,560.

He further thinks "that the Government would always get better opinions, on any scientific point that arises, by applying to the most distinguished scientific man in that particular branch at the time, than it would by having a set of permanent officers to give advice on such subjects." \* \* \* Qu. 13,566.

In answer to qu. 13,563, he says that "it could hardly be contemplated that any such Council could give a stability to the Policy of the Government in matters connected with Science, because, of course, the stability of the policy of the Government depends upon the stability of our whole political arrangements;" and (qu. 13,564) "the House of Commons would never feel itself prevented from reversing the decision of a Council of Science of that kind." Qu. 13,565.

Lord Salisbury agrees with Lord Derby, in not considering the Council of India a case in point; he explains that "a veto has been lodged with this Council, enabling them to prevent any expenditure of which they disapprove. But no similar difficulty arises in questions of science. There are no large sums of money arising from the taxes of a distant people that have to be expended, and, therefore, no special check is required upon Ministers with regard to that matter. \* \* \* Besides that, the Indian Council, beyond its checking power, is really simply a bureau of administrators. The councillors act as under-secretaries." \* \* \* Qu. 13,565.

He thinks that on many points on which a Minister might refer to the Council for advice, there might be reason to apprehend "a series of minority reports."

"Supposing a council of 12 or 16 scientific men: although undoubtedly upon a great number of matters they would be unanimous in opinion when they were dealing with that which is known and accepted as scientific fact, yet on all the border points between knowledge and speculation their opinions would most probably differ, and the position of a minister who had before him two or three sets of opinions, in entirely opposite directions, would not be much more hopeful than that of a minister at present who has no opinions at all." Qu. 13,582.

"Whatever errors there may be in the opinions of one individual, at least they have an unity and a courage which is very often wanting to the compound opinion of a dozen men." Qu. 13,583.

He attaches no importance to the supposed advantage arising from the advice of a Council being subject to public opinion to a greater extent than that of individuals; considering that the admission of reporters would be a hindrance to business, while without their presence "the public at large would know very little of its proceedings;" and in reply to qu. 13,600, "I think that what has been proposed by the Witnesses who recommend a Council is, that in every case in which an opinion is asked they should furnish a Report of the reasons for the advice which they give?" he expresses fears, "that if the Council were constructed on that principle, the Ministers, who usually have their time very fully occupied, and are desirous to avoid work as much as possible, would consult the Council as little as possible." Qu. 13,595-6. Qu. 13,600.

So far as the mere Administration of Funds granted by the State for Scientific Purposes is concerned, he is of opinion that no better channel than the Government Grant Committee of the Royal Society could be found.

"There is no body which is so thoroughly well constituted for the purpose of representing the scientific world as the Committee of the Royal Society." Qu. 13,603.

"You prefer that to any new-fangled scientific council?—Yes, certainly. We know how it works, and it would be pretty sure to go on working as well as it does now." Qu. 13,604.

The Evidence of Sir Stafford Northcote is to the same general effect as that of Lord Derby and Lord Salisbury:

"My own leaning would be to throw the responsibility, as now, upon the heads of the different departments, leaving them to get the best scientific assistance they could, but providing for the maintenance of such relations between the Government and some scientific body external to the Government, such as the Royal Society, perhaps, as would enable the Government to take advice from that society as to the best men to consult, and also as to the possibility of the work that was proposed to be undertaken." Qu. 13,635.

"I should have thought that some kind of payment might be made to the society, which the society might expend, and by employing such officers as it thought proper to keep all the correspondence, and to refer it to the proper persons; and then, my idea would be, that supposing at the Board of Trade, for instance, some

new question arose upon which scientific information was wanted, the President of the Board of Trade would write to the Council of the Royal Society, and would say, such and such business has to be done, and I want such and such advice. Then the secretary, or whoever it might be, would bring the subject before his council, and would write back, What you propose appears to be feasible; you ought to consult Mr. so-and-so, or professor somebody, and you would then be placed by an independent authority in direct relations with the proper man to deal with the subject. Then it would be a question of remunerating that gentleman by a fee as you would remunerate a lawyer by a fee, for the service which he was to render."

Qu. 13,637. He thinks that a Council "would cause jealousy on the part of the Departments; and that it would also very likely cause jealousy on the part of other men of Science."

"I feel sure that there would be a great deal of jealousy on the part of the departments if any council were appointed to regulate the conscience of the Government in scientific matters, and to say how money ought to be spent, what money ought to be spent, and what ought to be done, and what ought not to be done."

"With regard to that case of which I was speaking, of the School of Design, I know what there was very great jealousy at that time. The organization of that council, was this—A certain number of eminent architects, sculptors, and painters, and other persons were put upon [the Council], and they partly fell out among themselves, and then it was necessary for the President of the Board of Trade, who was responsible for the spending of the money, to side with one party or the other, and to decide what was to be done, which he was, of course, not very competent to do. Then came a great deal of external jealousy on the part of the other artists whose views were set aside, and there was, at the same time, a good deal of jealousy on the part of the Board of Trade, it being told that because these artists held this and that, therefore they were to spend the public money in this way or the other way."

"And he speaks of similar jealousies as having arisen between the Committee of Military Sanitary Organization and the Military Members of the Indian Council."

"Similarly, I might mention as an instance in which I saw the germs of jealousy, the Committee of Military Sanitary Organization, which is referred to, I see, by Captain Galton in his evidence. Whilst I was at the India Office it was perfectly true that a great many questions were referred to that Committee, and they gave very valuable advice, but I could see that there was a great deal of jealousy on the part of those who were the military members of the Council of India of the interference, as it was said, of this Sanitary Committee. The military members said, 'We are the people who are responsible for the spending of the money and for doing what is to be done; we do not see why those gentlemen, who have nothing to do with that, are to dictate to us; and we will not accept their suggestions.' Then would come from the Sanitary Committee remonstrances, and they would say, 'We have special knowledge of this subject; it is what we are paying attention to; and we think it very wrong that you should not attend to our suggestions, and that you should spoil what we are doing.'"

At the same time he does not agree with Lord Salisbury in his approval of direct reference by the Minister to an individual.

Qu. 13,647. "I do not like the present system of applying to irresponsible advisers, and I should desire to see some more systematic mode of proceeding adopted."

In reference to one of the proposed functions of the Council, that it should advise the Government on the Management of Institutions like the Meteorological Office, the British Museum, and the Royal Gardens at Kew, he would still prefer the advice of a body not appointed by the Government.

Qu. 13,654. "I doubt whether such a council would either command public confidence very long, or command the respect which it should have from the Government itself, if it were a creation of the Government. You might appoint in the first instance some very eminent men. Probably you would not get a great many of the most eminent men to give a great deal of time to work of that sort, and you would have to take those who were willing to spare the time necessary for the discharge of the duties of the council. They would continue for some time in office, and they would adopt certain ideas, and their constant contact with the Government would rather lead them to say, 'This sort of thing cannot be done, because they would take into consideration administrative points, and would not give purely scientific advice. They would, therefore, cease to possess the confidence of the public outside. There would also be more eminent men who would say, 'These are old women who are going on in a certain routine, and we do not attach much value to what they say.' And, on the other hand, they would not have the same advantageous independent position for offering advice or making suggestions to the Government which a body recruited *ab extra* from the scientific world would have."

Upon the suggestion that a Council advising on the Advancement of Science should also advise on Scientific Education, he remarks

Qu. 13,656. "I think that it would be very desirable that the Council of Education, or the Minister of Education, should have the advice of good scientific persons to assist him in directing the scientific education of the country; but I should doubt its being very advantageous to mix up that work with the other kind of duties to which you have referred."

Dr. Carpenter's Evidence is also in favour of recourse to the Council of the Royal Society whenever the Government requires advice on subjects involving questions of Science.

Qu. 10,931. "I think that there is a great advantage in having any question of that kind discussed, not merely by the representatives of one department of science, but by the representatives of the scientific body generally,—the *corps scientifique* of the nation. Under the present constitution of the Royal Society, the Council of the Royal Society may be regarded as a very true representative of the scientific life, so to speak, of the nation. It would doubtless, if it saw occasion, seek the advice (as it does at present in the administration of the Government Grant) of competent men outside its own body."



But he considers that "the present state of things" is unsatisfactory, in so far as "there is no Systematic Arrangement for the Promotion of Science." Qu. 10, 934.

Sir E. Sabine, President of the Royal Society for many years, appears, on the whole, to incline to the opinion that it would be best that the Royal Society should remain the official adviser of the Government in scientific matters; suggesting, however, that in particular cases "Special Committees might be appointed with such emoluments as it might be proper to recommend." His Evidence contains some interesting statements relating to the Board of Longitude, which formerly existed, and which he acknowledges to have rendered "valuable services to the country during the period of its existence," matters being frequently referred to it which it was admirably adapted to judge of. Qu. 11, 122. Qu. 11, 129.

#### REMARKS ON THE FOREGOING EVIDENCE RELATING TO THE ESTABLISHMENT OF A MINISTRY AND COUNCIL OF SCIENCE.

We have given careful consideration to this part of the Inquiry entrusted to us; and, in the course of our deliberations, we have been led to attach much importance to the facts stated in the First Part of our Report, which show that the Scientific Work of the Government is at present carried on by many different Departments.

There is nothing to prevent analogous, if not actually identical, investigations being made in each of these, or to secure to one department an adequate knowledge of the results obtained, and the circumstances under which they were obtained, by another.

Investigations admitted to be desirable, nay, practical questions, the solution of which is of the greatest importance to the public administration, are stated by the witnesses to be set aside because there is no recognised machinery for dealing with them; while, in other cases, investigations are conducted in such a manner as to involve a needless outlay of time and money, because they were originally planned without consultation with competent men of Science.

Passing to the question of the Advancement of Science, we have arrived at the conclusion that much has to be done which will require continuous efforts on the part of the Administration unless we are content to fall behind other Nations in the Encouragement which we give to Pure Science, and, as a consequence, to incur the danger of losing our pre-eminence in regard to its Applications.

These considerations, together with others which have come before us in the course of our Inquiry, have impressed upon us the conviction that the Creation of a Special Ministry dealing with Science and with Education is a Necessity of the Public Service.

This Ministry would be occupied (1) with all questions relating to Scientific and General Education, so far as these come under the notice of Government; (2) with all questions incidental to the application of National Funds for the Advancement of Science; and (3) with all Scientific Problems in the Solution of which the other Departments may desire external Scientific Advice or Information. It would also be desirable that the Department should receive Information as to Scientific Investigations proposed by other branches of the Government, and record their progress and results.

It is not within our province to express an Opinion as to whether the subject of Art should be included among the Functions of this Department; but we are satisfied that the Minister's attention should not be distracted by any immediate Responsibility for affairs which have no connexion with Science, Education, or Art.

We have considered whether the Official Staff of such a Ministry, however carefully selected, could be expected to deal satisfactorily with all the varied and complicated Questions which would come before the Department. We have given full weight to the Objections which have been raised against the creation of a Special Council of Science, and to the Arguments in favour of referring Scientific Questions to Learned Societies, or to Special Committees appointed for the purpose, or to private Individuals; but nevertheless we have arrived at the Conclusion that an additional Organization is required through which the Minister of Science may obtain Advice on questions involving Scientific considerations, whether arising in his own Department or referred to him by other Departments of the Government.

Such questions have from time to time been referred to the Council of the Royal Society, in which the best Scientific Knowledge of the time is fairly represented. The Committee chosen by that Council for the Administration of the Government Grant of 1,000*l.* per annum in Aid of Scientific Investigations has performed its work to the satisfaction of the Government, of men of Science, and of the Public. But if much more is to be done for the Advancement of Science than at present, and if the Departments in conducting their Investigations are to have the benefit of the Scientific Advice which appears

now to be frequently wanting, the Council of the Royal Society, chosen as it is for other purposes, could scarcely be expected to take upon itself Functions which, it is true, are not different in kind, but which would involve increased Responsibility and the Expenditure of additional time and trouble. Moreover, amongst the questions on which the Departments would require Scientific Advice, there would no doubt be many requiring a Knowledge of the peculiar exigencies of the Public Service, which would be more readily understood and solved if some persons in direct relation with the Departments formed a part of the body to be consulted. It is obviously of great importance that the Council should be so constituted as to possess the confidence of the Scientific World, and we believe that this confidence would be extended to a Council composed of men of Science selected by the Council of the Royal Society, together with Representatives of other important Scientific Societies in the United Kingdom, and a certain number of persons nominated by the Government. We also believe that such a Body would deserve and receive the confidence of the Government; and that it would be well qualified to administer Grants for the Promotion of Pure Science.

The general opinion we have expressed as to the proper Remuneration of Scientific Work would be applicable to the Members of this Council, but the degree and manner in which the principle should be applied in this instance must be so largely dependent on circumstances that we cannot make any specific Recommendation on the subject.

It would be impossible that the Council should in all cases undertake the direct solution, by itself or even by Sub-Committees, of the problems submitted to it. In many instances, especially when experimental investigations are required, its duty would be accurately to define the problem to be solved, and to advise the Minister as to the proper persons to be charged with the Investigation.

We are of opinion that the Council should not have the power of initiating Investigations; it should, however, not be precluded, in exceptional cases, from offering to the Minister such suggestions as it may have occasion to make in the Public Interest.

We believe that Reference to such a Council would be found to be so useful and convenient that it would become the usual course in cases of difficulty, but we would not diminish the Responsibility or fetter the Discretion of any Minister by making such Reference obligatory, or by preventing a Reference to Committees or to Individuals chosen by him, whenever that course might appear to him to be more desirable.

### Conclusions and Recommendations.

I. The Assistance given by the State for the Promotion of Scientific Research is Inadequate, and it does not appear that the Concession or Refusal of Assistance takes place upon sufficiently well defined Principles.

II. More complete means are urgently required for Scientific Investigations in connexion with certain Government Departments; and Physical as well as other Laboratories and Apparatus for such Investigations ought to be provided.

III. Important Classes of Phenomena relating to Physical Meteorology, and to Terrestrial and Astronomical Physics, require Observations of such a character that they cannot be advantageously carried on otherwise than under the Direction of the Government.

Institutions for the study of such Phenomena should be maintained by the Government; and, in particular, an Observatory should be founded specially devoted to Astronomical Physics, and an Organization should be established for the more complete Observation of Tidal Phenomena and for the Reduction of the Observations.

IV. We have stated in a previous Report that the National Collections of Natural History are accessible to Private Investigators, and that it is desirable that they should be made still more useful for Purposes of Research than they are at present. We would now express the opinion that corresponding Aid ought to be afforded to Persons engaged in important Physical and Chemical Investigations; and that whenever practicable such persons should be allowed access, under proper limitations, to such Laboratories as may be established or aided by the State. Fourth Report.

V. It has been the practice to restrict Grants of Money made to Private Investigators for Purposes of Research to the Expenditure actually incurred by them. We think that such Grants might be considerably increased. We are also of opinion that the restriction to which we have referred, however desirable as a general rule, should not be maintained in all cases, but that, under certain circumstances and with proper safeguards, Investigators should be remunerated for their time and labour.

VI. The Grant of 1,000*l.*, administered by the Royal Society, has contributed greatly to the Promotion of Research, and the amount of this Grant may with advantage be considerably increased.

In the case of Researches which involve, and are of sufficient importance to deserve, exceptional expenditure, Direct Grants in addition to the Annual Grant made to the Royal Society should be made in Aid of the Investigations.

VII. The proper allocation of Funds for Research; the Establishment and Extension of Laboratories and Observatories; and, generally, the Advancement of Science and the Promotion of Scientific Instruction as an essential part of Public Education, would be most effectually dealt with by a Ministry of Science and Education. And we consider the creation of such a Ministry to be of primary importance.

VIII. The various Departments of the Government have from time to time referred Scientific Questions to the Council of the Royal Society for its Advice; and we believe that the work of a Minister of Science, even if aided by a well-organized Scientific Staff, and also the work of the other Departments, would be materially assisted if they were able to obtain, in all cases of exceptional importance or difficulty, the Advice of a Council representing the Scientific Knowledge of the Nation.

IX. This Council should represent the chief Scientific Bodies in the United Kingdom. With this view its composition need not differ very greatly from that of the present

Government Grant Committee of the Royal Society. It might consist of men of Science selected by the Council of the Royal Society, together with Representatives of other Important Scientific Societies, and a certain number of persons nominated by the Government. We think that the Functions at present exercised by the Government Grant Committee might be advantageously transferred to the proposed Council.

All of which we humbly beg leave to submit for Your Majesty's Gracious Consideration.

(Signed)

DEVONSHIRE.  
LANSDOWNE.  
JOHN LUBBOCK.\*  
JAMES P. KAY-SHUTTLEWORTH.  
BERNHARD SAMUELSON.  
W. SHARPEY.  
THOMAS H. HUXLEY.  
G. G. STOKES.  
HENRY J. S. SMITH.

J. NORMAN LOCKYER,  
*Secretary.*

June 18th, 1875.

# APPENDIX TO EIGHTH REPORT.

## APPENDIX .

EXTRACTS from the ESTIMATES for the FINANCIAL YEAR 1874-75.

<b>TOPOGRAPHICAL SURVEY.</b>		
	£	£
Pay and extra pay of and allowances to staff	7,002	
Extra pay, and allowances to non-commissioned officers and sappers	15,700	
Pay, &c., of Civil assistants, messmen, and labourers	95,068	
Travelling expenses	3,425	
Fuel, light, &c.	1,700	
Stores	4,250	
Contingences	4,855	
(Civil Service Estimates)	132,000	

<b>HYDROGRAPHICAL SURVEY.</b>		
	£	£
Salaries, wages, and allowances, Hydrographical Department	8,480	
Drawing, engraving, printing, and mounting charts	11,000	
Instruments, repairs, chart boxes, &c., books, and contingences	1,000	
Coast and other surveys (hire of ships, extra pay, &c.)	26,500	
Pay to the Officers and Crews of Her Majesty's ships and vessels employed in the surveying service, also the pay of those employed in hired vessels and boats, but borne on the books of Her Majesty's ships	40,728	
Victuals, &c., for ditto	12,220	
Stores, machinery, and coals supplied to surveying ships and vessels, and also repairs	31,720	
Medicines, &c., supplied to ditto	153	
Pilotage of ditto	50	
	131,911	

In these figures is included an additional sum of 10,856*l.* (over and above the ordinary requirements of the service) to provide for the employment of Her Majesty's ship "Challenger," on a voyage of Scientific Research round the world

(Navy Estimates)	10,856	
	121,055	

<b>GEOLOGICAL SURVEY OF THE UNITED KINGDOM.</b>		
	£	£
<b>ENGLAND —</b>		
Salaries	11,589	
Travelling	1,800	
Incidental expenses	250	
<b>SCOTLAND —</b>		
Salaries	3,065	
Travelling	450	
Incidental expenses	220	
<b>IRELAND —</b>		
Salaries	4,376	
Travelling	970	
Incidental expenses	200	
(Civil Service Estimates)	22,920	

<b>ASTRONOMY.</b>		
	£	£
<b>ROYAL OBSERVATORY, GREENWICH —</b>		
Salaries, wages, and allowances	3,914	
Contingences (Navy Estimates)	1,728	
<b>EDINBURGH OBSERVATORY —</b>		
(Civil Service Estimates)	690	
<b>OBSERVATORY AT THE CAPE OF GOOD HOPE —</b>		
(Navy Estimates.)	3,371	
	9,703	

<b>METEOROLOGY.</b>		
	£	£
<b>METEOROLOGICAL COMMITTEE —</b>		
Appointed to conduct Meteorological Observations and Experiments on behalf of the Government (Civil Service Estimates)	10,000	
<b>ROYAL OBSERVATORY, GREENWICH —</b>		
Salaries, Magnetic and Meteorological branch	805	
Contingences (Navy Estimates.)	416	
<b>MAGNETICAL AND METEOROLOGICAL DEPARTMENT, WOOLWICH —</b>		
For the Reduction and Publication of Observations.		
Salaries	446	
Contingences (Army Estimates.)	150	
<b>ROYAL OBSERVATORY, EDINBURGH —</b>		
Allowance for Meteorological work (Civil Service Estimates)	115	
<b>REGISTER OFFICE, GENERAL, ENGLAND —</b>		
Reports of Meteorological Observations furnished to the Registrar General	150	
(Civil Service Estimates.)	12,082	

<b>BOTANY.</b>		
	£	£
<b>ROYAL BOTANIC GARDENS, KEW:—</b>		
Establishment	3,714	
Travelling	40	
Clothing	85	
Police	1,170	
Works	537	
Maintenance	11,250	
Furniture	250	
Rents	46	
Rates	300	
Contingences and incidental expenses (Civil Service Estimates)	180	
	17,572	
<b>EDINBURGH BOTANIC GARDEN —</b>		
Allowance for the Royal Botanic Garden	1,400	
Allowance to the Regius Professor of Botany in lieu of a house	120	
Salary of the Curator	236	
(Civil Service Estimates.)	1,750	

50 APPENDIX TO EIGHTH REPORT OF THE ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION, ETC.

BOTANY—cont.		STANDARDS DEPARTMENT OF THE BOARD OF TRADE.	
	£	£	
<b>BOTANIC GARDENS, DUBLIN:—</b>			
Salaries and wages -	1,598		Salaries - - - - - 1,383*
Incidental expenses, including purchase of seeds and plants	550		Incidental expenses - - - - - 680
(Civil Service Estimates)	<u>2,148</u>		(Civil Service Estimates) - - - - - 2,063
	<u>21,470</u>		

[\* In addition to this sum, there are the salaries of two Third Class Clerks and two Supplementary Clerks, at present employed in this Department.]