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HUMAN NUTRITION AND DIET

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HUMAN NUTRITION AND DIET

By

W. R. AYKROYD

M.D.

DIRECTOR OF NUTRITION RESEARCH, INDIAN RESEARCH FUND
ASSOCIATION : LATE MEMBER OF HEALTH SECTION,
LEAGUE OF NATIONS (1931-5)



LONDON

Thornton Butterworth Ltd

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INTRODUCTION

ON Diet and Regimen in Sickness and Health, by Horace Dobell, M.D., was a popular text-book during the seventies and eighties of last century. The seventh edition was published in 1882. It is of interest to note what the author has to say about the dietary requirements of human beings :

“ Practical experience in the dieting of large numbers of men, and other means, have enabled us to establish the fact, that an average man, as above described (weight 150 lb.), requires for the maintenance of health, a diet which shall contain about 4 oz. of plastic materials, 3 oz. of fat, and 10 oz. of carbohydrates ; and on careful analysis of the diet, we find that it can supply the required 10,000 British units of heat.”

Converting ounces into grammes and using Rubner's figures for the calorie values of 1 gramme of protein, carbohydrate, and fat respectively, we arrive at the following standard dietary :

Protein.	Fat.	Carbohydrate.	Calories.
113 gm.	85 gm.	283 gm.	2,417

(Actually, 10,000 British units of heat = 2,500 calories, but Dobell was using less accurate conversion factors than Rubner's.)

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Dobell proceeds to lay down the following rules :

“ A healthy adult man requires daily from 900 to 1,130 grammes of dry nutritious food of which $\frac{1}{200}$ must be mineral matter ; 3 or 4 oz. of plastic matter may be combined with 3 or 4 times that quantity of heat-giving material. The heat-giving constituents must contain a mixture of fats with saccharine materials (carbohydrates) in the proportion of about 1 of the former to 3 of the latter. Every complete diet must include some vegetable and fruit which contains potassium, and the total amount of water taken in 24 hours, including that contained in the dry food, must not be less than 2 litres.”

There will be plenty to say in later chapters about heat units (calories), plastic materials (protein), mineral matter, and so on. We are not specially concerned here with the accuracy of Dobell's estimate of calorie, protein, fat, carbohydrate and mineral requirements. The point to be stressed is that in Dobell's day, and until very recent times, very little was, so to speak, demanded of a diet, and moreover it was difficult to put forward a very clear case in support of unexact-ing text-book standards. The result was that the majority of human diets were found, on investigation, to fulfil the requirements de-

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manded by science ; for practical purposes dietary needs were satisfied as long as there was no hunger ; and there seemed nothing further to be said about the matter. A lecture or two on nutrition had to be given to medical students, but they soon forgot all about a subject which seemed to have no close relation to the problems of medicine and public health. Dietetics was, in fact, a "dismal science" which repelled and bored the student, as the reader can discover for himself by questioning a few elderly doctors of his acquaintance. The writers of text-books on dietetics would insert a chapter or two about calories and proteins and hurry on to more entertaining questions such as the digestibility of oysters and the alcoholic content of port and sherry.

The essence of the change in outlook which has taken place in recent years can be described in a sentence : modern dietary standards are much more exacting than those which preceded them. The problem of adequate nutrition can no longer be regarded as a simple one, instinctively solved by uninstructed humanity. A child may have plenty to eat, may even consume protein and fat in the quantities recommended by Voit in 1870, and yet be in a state of grievous malnutrition ; to put it in text-book style, quantitative suffi-

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ciency may co-exist with a whole series of qualitative defects, any one of which may produce the most serious physical consequences. A great mass of evidence has been collected which proves that there is a close relation between general health, both bodily and mental, and diet, between physical development and diet, and that dietary deficiency is responsible for some of the commonest and most serious diseases from which humanity suffers. The modern student of dietetics casts his net wide; he looks for dietary deficiency in unexpected places. He has little respect for the traditional dietary habits of mankind, or for the idea that because millions of people seem to rub along fairly well on a particular diet, that diet is perfectly adapted to their needs. As a result of this change in view, the science of dietetics is now passing through an active and progressive phase.

Modern nutritional science has been built on a foundation of observation and experiment for which a great variety of workers in many countries have been responsible. Clinicians, epidemiologists, public health workers, laboratory workers, animal husbandry experts and practical animal breeders have all contributed; observation and experiment on man have run side by side with observation and

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experiment on animals, the one confirming the other. The development of the science has been hastened by two catastrophes: the Great War and its privations, and the economic *débâcle* of recent years which brought unemployment, poverty and the dangers of malnutrition to millions in the wealthiest countries of the world. Considered separately, many of the observations which have gone to build up what McCollum calls the newer knowledge of nutrition might seem unimportant. It is when they are considered as a whole that their full weight becomes manifest. The author hopes that this book will not only supply the reader with a brief statement of modern ideas on dietary questions, but also, by means of suitable selection and presentation, convince him of the importance of recent discoveries in this field in relation to the whole structure of our civilization. In its broader aspects dietetics is a common-sense subject, demanding no great effort of comprehension on the part of the student. Courageous men attempt to teach the layman, entirely without tears, the elements of physics or astronomy. The present writer has a simpler task.

The literature of the science of nutrition is extensive. The 5th volume of *Nutrition Abstracts and Reviews* (1935-6) published 4,762 abstracts of scientific papers and books

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on various aspects of the subject, and the flood appears to be increasing rather than diminishing. Without such admirable publications, the modern scientific worker would either lose touch with the work of his colleagues or spend a large part of his time in seeking out and reading original articles. There are now a considerable number of journals devoted entirely to diet and nutrition. In the circumstances it is impossible to supply a comprehensive bibliography, and that given on p. 248, though it includes many of the better-known text-books, is rather a random selection.

A number of references are made in the book to work carried out by the author under the Indian Research Fund Association, for which grateful acknowledgement is due to the Association.

CHAPTER I

CALORIES

“FAMINE is something quite peculiar. It concentrates all effort and thought and feeling on one thing. It makes everyone a frustrated glutton. In a famished town, as in a cheap restaurant, there is always a flavour of food in the air. Everyone brooding on food makes a smell which hangs about them like the smell of gravy and cabbage about a dirty tablecloth. Somehow famine goes beyond hunger, and puts in each face a kind of lewdness ; a kind of grey unwholesome longing. People’s white gums and mouldering flesh suggest rather a consuming disease like leprosy than appetite. They seem diseased, even evil, rather than pathetic. Their eyes are greedy and restless, and linger greedily, it sometimes seems, on one another’s bodies. Their skin gets unnaturally dry and their breath parched and stale like dry air in a cellar.”

The passage is from Mr. Malcolm Muggeridge’s striking book *Winter in Moscow*, published in 1934.

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Human beings, it may be said, are never in any doubt whether they have enough to eat or not. They do not need to be carefully informed of the amount of food they should consume daily to avoid falling into the condition described by Mr. Malcolm Muggeridge. But for many practical and administrative purposes, for the formulation of "food policies," for drawing up schedules for those who have no free choice of food, etc., a scientific approach to the question of "enough to eat" is essential. This chapter deals with the basic food energy requirements of human beings.

The pioneer worker in this field was the great Antoine Laurent Lavoisier, who, unfortunately for himself, was not only a successful scientist but also a successful financier, and was executed in 1794 along with his colleagues in the *Ferme Générale*, the private company which, much to its own profit, collected the "indirect revenue" in pre-revolutionary France. During the years 1782-9 Lavoisier laid the foundations of the modern science of nutrition.

This was a sequel to his solution of the problem of combustion, achieved with the help of Joseph Priestley. Priestley, in his usual casual manner, discovered oxygen. Lavoisier, making brilliant use, as was his habit, of other men's discoveries, proved that

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combustion is an oxidative process ; that when a substance is burnt, oxygen is absorbed and carbon dioxide given off. It had long been vaguely realized, even by chemists of the " phlogiston " school, that combustion and respiration are to some extent parallel phenomena. Lavoisier, with assistance from the mathematician Laplace, showed that combustion and respiration are analogous in so far as they both involve absorption of oxygen and evolution of carbon dioxide, and he arrived at the conclusion that animal heat is generated in the same way as the heat given off by a furnace. This last was a somewhat primitive conception, but it pointed in the right direction.

Lavoisier thought that the substances burned by the body were carbon and hydrogen, originally derived from food, and that the place of combustion was the lungs. But it was soon discovered that the fuel of the body is not carbon and hydrogen as such, but certain complex chemical substances, and that the process of oxidation or combustion takes place, not in one particular part of the organism, but in all the living cells of which the organism is composed. From the combustion of these chemical substances—protein, carbohydrate, and fat—which are sometimes known as the " energy-yielding " food-factors,

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the body derives its heat and energy, somewhat as a steam-engine derives its heat and energy from combustion of coal. This time-honoured analogy, though inexact, has fulfilled useful didactic purposes. The processes by which the cells decompose these substances, and the subsequent oxidation of their breakdown products, are included under the term *metabolism*. The energy derived from this phase of metabolism is transformed by the organism into muscular work and heat.

The energy unit invariably employed today in the science of nutrition is the "large calorie," or the amount of heat required to raise the temperature of 1 litre of water 1° Centigrade. Strictly speaking, the large calorie of physiology and dietetics should be spelt with a large C, but this spelling has been so generally abandoned that it seems pedantic to follow it. A device for measuring "amount of heat" is called a calorimeter. The calorie content of a foodstuff is usually determined by burning a known quantity of it in what is known as a bomb calorimeter, the heat produced being measured by the change in temperature in water surrounding the chamber in which combustion takes place. Heat is a form of energy, and when we talk about the calorie content, and the energy content, of a

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pound of beefsteak, we mean the same thing in each case.

It is possible to calculate, in terms of calories, the energy obtained by an organism from the metabolism of protein, fat, and carbohydrate derived from food, or (should it be a starving organism) from its own tissues. There are several ways of doing this, one of which is known as *indirect calorimetry*. This method of investigation usually involves the determination of oxygen intake and carbon dioxide output, and of the relation between them—the respiratory quotient.

$$\text{Respiratory Quotient} = \frac{\text{Volume of CO}_2 \text{ produced}}{\text{Volume of O}_2 \text{ consumed}}$$

The value of the R.Q. depends on which of the three energy-yielding food-factors is being burnt by the organism under investigation. When carbohydrate is being burnt, it is unity; carbohydrate, in the form in which it is oxidized by the body, contains 2 atoms of hydrogen to every atom of oxygen (Glucose = $\text{C}_6\text{H}_{12}\text{O}_6$), and in combustion all its hydrogen and oxygen unites to form H_2O , leaving all the carbon atoms free to unite with the newly acquired oxygen. But in the combustion of fat and protein, which contain more hydrogen in proportion to oxygen than does carbohydrate, some oxygen combines with the

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excess of hydrogen to form water. Hence the R.Q., when protein and fat are being burnt, is less than 1—for fat 0.71 ; for protein 0.80. The determination of the R.Q. provides a clue to the type of food-factor which is being metabolized.

If oxygen intake and carbon dioxide output over a certain period are known, it is possible to deduce the nature and amount of the food-factors which the cells are burning, and hence to discover, in terms of calories, the energy expenditure of the organism. Indirect calorimetry, as applied to human subjects, has proved of great practical use in medicine and industry. Long experience has shown how the operations and calculations involved may be reduced to a minimum.

Metabolism may also be investigated by "balance experiments." The energy value of the substances eliminated from the body—urine, fæces, sweat, etc.—is deducted from the energy value of food consumed, and the result indicates the metabolic activity of the organism. Experiments of this nature, originated by Voit and his co-workers of the Munich school, usually last several days.

We come now to *direct calorimetry*, which is simply the determination of the heat given off by the organism. The subject, whether man or beast, is enclosed in a special chamber,

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which permits of the actual measurement of heat produced. A large calorimeter for the study of human metabolism is a complicated piece of apparatus, but the principle by which heat output is measured is simple, depending on the change in the temperature of water circulating through pipes in the wall of the chamber. If the subject is at rest, all the energy produced by the metabolic activities of the cells is eventually transformed into heat. Indirect and direct calorimetry may be carried out simultaneously, and, in the best experiments, the calorie figure obtained by both methods is the same, proof being thereby provided that the principle of the conservation of energy holds good for the living organism as for the machine.

Many physiologists helped to establish the fundamental conceptions outlined in the preceding paragraphs. One thinks particularly of Voit, Pettenkoffer, Atwater, and Rubner, but many less famous scientific workers participated. As a result of their activities it has been proved that the number of calories produced when a certain quantity of food is burned outside the body very nearly equals the number produced when the same quantity is burned inside the body. We say very nearly. Most foods are a combination of protein, fat, and carbohydrate, and while the

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two latter are oxidized as completely in the body as in a calorimeter, protein is not ; to use Hutchison and Mottram's expressive phrase, it is not quite reduced to ashes. After making allowance for this fact, and carrying out a thorough investigation of every aspect of the problem, Rubner put forward the following figures as representing the calorie value to the body of 1 gramme of each of the energy-yielding food-factors :

1 gramme of protein	= 4.1 calories
” ” ” carbohydrate	= 4.1 ”
” ” ” fat	= 9.3 ”

These figures, often in a simplified form without the decimal, are widely used to-day in practical dietetics.

The technique for the study of metabolism, laboriously evolved during the second half of last century, made possible a scientific approach to the problem of human quantitative dietary requirements. Of paramount importance in this connection is the concept of basal metabolism—i.e. the rate of metabolism in a subject whose energy output is reduced to the minimum possible while awake. In practice, basal metabolism is determined with the subject completely at rest in warm surroundings, 12–18 hours after the consumption of the last meal. The eating of food

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raises the metabolic rate from 15–20 per cent.

The basal metabolism of a well-nourished European man of average size is from 60–75 calories per hour. He expends that amount of energy to keep his body machine running at its lowest possible rate—ticking over, as it were. Although his limbs are at rest, his heart is beating, his respiratory muscles moving, his glands secreting, and so on. For reasons not quite understood, basal metabolism rate is proportional to surface area, a law which probably holds good for all warm-blooded animals in good nutritive condition. In the human species it is slightly lower in females than in males; thus, at the age of twenty, the “standard” rate per square metre of body-surface per hour is 39·5 calories for males, and 37·0 for females.

The basal metabolism rate is influenced by a number of factors. During the period of active growth it is higher per unit surface area than in adult life. Over-activity of the thyroid gland (Graves' disease) raises it; under-activity (myxœdema, cretinism) lowers it. During prolonged under-nutrition basal metabolism is materially reduced, probably owing to diminished activity of the body-cells. It varies somewhat under different conditions of climate, season, housing, and clothing. In

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a cold atmosphere the body, in maintaining its customary temperature (which it must do if it is to go on living at all), must produce more heat than in a warm atmosphere.

Given the height, weight, age, and sex of an individual, it is possible, by the use of standard tables and formulæ, to calculate his or her surface area and thence theoretical basal metabolism. A big man expends more energy keeping himself alive than a small man, though actually basal metabolism per unit of surface decreases with size. In calculating total energy output or requirements per day, it is usual to begin with the basal metabolism rate, which serves as a foundation. Let us take an average man whose B.M.R. is at the level of 68 calories per hour. During sleep it will probably be 10 per cent. lower than this figure. Let us suppose he sleeps 8 hours. During that period his energy output will be $68 \times \frac{90}{100} \times 8 = 489$ calories. During the remaining 16 hours, if he is out of bed and moving about, his output *must* be above the basal rate.

By means of direct and indirect calorimetry, the energy expended for a considerable number of human activities has been investigated. The following figures, taken from Sherman's *Chemistry of Food and Nutrition*, represent the

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output per hour of an average man weighing 70 kilograms, engaged in various kinds of activity.

TABLE I

ENERGY EXPENDITURE PER HOUR OF AN AVERAGE MAN
UNDER VARIOUS CONDITIONS OF MUSCULAR ACTIVITY

Form of Activity.	Calories per Hour.
At rest in a warm atmosphere 12 hours after a meal (basal metabolism)	68
Sitting at rest	100
Standing relaxed	105
Dressing and undressing	118
Typewriting rapidly	140
Shoe-making	180
Walking slowly	200
Carpentry, industrial painting	240
Stone-working	400
Sawing wood	480
Running	570

Life, as normally lived, demands a great variety of muscular movements in the 24 hours. The most sedentary pen-pusher has to heave himself out of bed in the morning, shave, dress, stand, sit, talk, write, walk a little, pant up a few stairs, perhaps even run along a platform to catch a train. But the number of muscular movements performed by a sedentary worker is very small compared with the number performed by a man who earns his living by muscular labour. The

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most careful experiments have failed to show that metabolism is materially increased by purely mental exertion. A glance at Table I shows how enormously it is increased by strenuous physical exertion. The average man spends a large proportion of his waking hours at work, which may be sedentary (e.g. clerking), light (e.g. bookbinding), moderate (e.g. carpentry) or strenuous (e.g. stoking a liner). In attempting to estimate the energy expenditure of an individual, or a group of individuals, the most important point to be taken into consideration is the type of work performed. The harder a man works, the more combustion takes place in his tissues.

Lavoisier realized this. He was struck by the implications of his discovery that work increases oxygen consumption, that, to put it roughly in his own words, a man at work *burns* more rapidly, consumes more of his substance, than a man at rest. Clearly, Lavoisier reasoned, the harder a man works, the more need he has of food to replenish his substance. But food costs money. "As long as we considered respiration simply as a matter of the consumption of air," Lavoisier remarked, "the position of the rich and poor seemed the same; air is available to all and costs nothing; the labourer has indeed better opportunities than most of obtaining this gift

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of nature. But now we know that respiration is in fact a process of combustion, by which each instant some of the substance of an individual is consumed ; that this consumption increases as the rate of the pulse and of breathing accelerates ; that, in fact, it increases in accordance with the labour and activity of an individual's life ; a whole host of moral questions seems to spring into being from observations that are themselves purely material in nature."

" By what mischance does it happen that a poor man, who lives by manual work, who is obliged, in order to live, to put forward the greatest effort of which his body is capable, is actually forced to consume more substance than the rich man who has less need of repair ? Why, in shocking contrast, does the rich man enjoy an abundance which is not physically necessary, and which seems more appropriate to a man of toil ? "

Lavoisier next expresses the hope that the " wise institutions " promised as a result of the Revolution, which tended " to equalize all incomes, to raise the price of labour, and ensure its just reward," would do something to correct the balance in favour of the poor man. He was writing in 1789. Four years later he perished on the scaffold.

In investigating energy output in industrial

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pursuits the method of "indirect calorimetry" is usually employed. A man is set to perform some particular form of work for a definite period, say half an hour, and his consumption of oxygen and output of carbon dioxide during that time are measured. The experimental period must be short, because the subject has to breathe through a tube, and usually wear uncomfortable apparatus. If the investigator wishes to discover the expenditure required for a whole day's work at the activity in question, he multiplies the time occupied by the experiment by the time occupied by the day's work. This procedure has an obvious disadvantage. Experience has shown that a man working for a short period, with the eye of an investigator upon him, is inclined to show off, to put forward his greatest effort, instead of proceeding at his usual working rate. But the investigator desires, as a rule, to discover his ordinary energy output, and not his output under specially stimulating circumstances. Another point to be observed is that short indirect calorimetric experiments can be more suitably used to estimate energy output per day at steady repetitive kinds of work, than output at work which demands a variety of different movements—such as agricultural work, for example.

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A further approach to the problem of energy expenditure and work is supplied by ergometer experiments, by means of which the amount of work performed in carrying out certain repetitive movements, such as hammering, riding a stationary bicycle, or turning a handle, can be measured. Work and heat are both forms of energy, and each can be calculated in terms of the other. 1 calorie = 3,086 foot-pounds of work, or 426.6 kilogrammetres. But, in actual fact, only about one-quarter of the heat energy liberated from food can be converted into external work by the human body—to put it in another way, the *mechanical efficiency* of the body is about 25 per cent. Thus if a man does work equal to 80,000 kilogrammetres or, roughly, 200 calories, his actual expenditure of energy would be 800 calories. Attempts have been made to estimate, in terms of kilogrammetres, the value of an “average day’s work.” We may sum up by saying that the data provided by ergometry do not provide much help in solving practical problems of human food requirements, but they provide a useful check on other methods of investigation.

We are now in a position to consider drafting energy expenditure budgets. Suppose it is reckoned that expenditure during spare time is 105 calories per hour, i.e. a little

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greater than that involved by sitting at rest. The daily budget of an average shoemaker would then work out as follows :

	Calories.
8 hours' sleep at 62 calories per hour	496
” ” work ” 180 ” ” ”	1,440
” ” spare time at 105 calories per hour	840
	2,776
Total expenditure per day	2,776
Total food requirements (gross) ¹	3,084

Clearly the above estimate of the energy expenditure of an average shoemaker is extremely rough and ready. No two physiologists would be likely to arrive at exactly the same figure. Such estimates have, of course, no application to individuals.

Of greater practical value, perhaps, is the *statistical method* of studying dietary requirements. It is possible to discover with considerable exactness the actual calorie intake of groups of individuals who have no reason to stint themselves of food—who eat what their appetites bid them. In the vast majority of human beings, appetite accurately adjusts food intake and energy requirements.

¹ i.e. as purchased. It is usually reckoned that, in order to allow for waste in cooking, digestion, etc., food as purchased should have a calorie value 10 per cent. higher than the actual energy expenditure. This estimate of “waste” may be excessive.

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If an individual is not losing or gaining in weight, it may be inferred that the calories yielded by the food he eats cover his energy expenditure. An enormous amount of information, of varying accuracy, about the calorie intake of groups of human beings of different occupation and nationality has been collected. Under ordinary conditions of life the family, not the individual, is the dietary unit, and in most statistical dietary inquiries the total food intake of individual *families* is ascertained, this figure being subsequently divided by the number of "consumption units" in the family. The result is intake per "consumption unit" or, as it is sometimes put, per "man," for the intake of a man is usually assumed to be unity and that of women and children as fractions of it. Many different "scales of family coefficients," representing very roughly the average difference between the consumption of individuals of various age and sex, have been used in the attempt to deduce intake per "man" from total family consumption. The following scale is that of Cathcart and Murray :

Age.	Consumption coefficient.
0-1 0·2
1-2 0·3
2-3 0·4
3-6 0·5

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Age.	Consumption coefficient.
6-8	0·6
8-10	0·7
10-12	0·8
12-14	0·9
Female sex above 14	0·83
Male " " "	1·00

Text-books on dietetics offer figures of observed calorie intake such as the following :

Class.	Calorie intake (gross).
Munition workers (England, 1917)	3,463
Farmers in Connecticut	3,410
Brahmins	3,181
Essex labourers and their families (1926)	2,871
German labourers and their families (1926)	2,866

What conclusions can be drawn from all this about human calorie requirements? Estimates of energy expenditure and investigations of dietary habits both suggest that average men require about 2,600-3,000 calories (gross) a day. Many years ago Voit suggested 3,050 calories as a standard requirement for an average man at "moderate" work, his standard being based on food as eaten (i.e. it represents net requirements). Perhaps the majority of physiologists would agree that 2,800-3,000 calories (gross) cover the requirements of average men at average work, but it is not difficult to make out a good

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case in support of a higher or lower figure. The English reader may remember puzzled comments in the Press, when, in 1933, two expert committees, appointed by the Ministry of Health and the British Medical Association respectively, arrived at different conclusions as to the calorie needs of the unemployed. One group suggested 3,000 calories, the other 3,400, both figures referring to food as purchased. But neither side could possibly *prove* the other in the wrong, since the nature of the subject makes exact figures impossible.

Standards of calorie intake, drawn up by distinguished physiologists or expert committees, with all the relevant information at their disposal, have often proved of practical value. They are of assistance when it is necessary to draw up dietaries for institutions ; they can be used for the purpose of estimating very roughly the sufficiency or otherwise of the diet consumed by a population group. When, as a result of war or some other calamity, food shortage threatens a population, and it becomes necessary to calculate how long available food supplies will last and draw up rations, generally accepted standards of calorie intake fill an essential rôle. We repeat once more that such standards do not apply to individuals. The reader may be tall or short, slender or sturdy, male or female, sixty or

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twenty, fond of strenuous exercise or of sitting in a pub ; all these things influence his energy requirements. But if a sufficient number of individuals of his class, profession, etc., be considered together, it is possible to arrive at an average figure representing energy requirements which is accurate enough to fulfil useful social purposes.

The result of excessive calorie intake, or, in other words, of greed, is obesity. There is no space in this little book to enlarge on the repulsive problem of obesity, which has a vast literature of its own ; the problems of dietary deficiency are more urgent and appealing. We may, however, remark here that the modern treatment of obesity usually involves exact calculations of calorie intake, and is greatly facilitated by the existence of a quantitative dietary unit.

What happens when the calorie intake of human beings is insufficient ? What, in other words, are the effects of semi-starvation ? One result is a lowering of basal metabolism. With reduction of weight and loss of body tissue the total metabolic activity of the body is diminished ; Benedict and his co-workers observed that when students, given an experimental diet of low calorie value, had lost 12 per cent. of their weight, their average daily B.M.R. was reduced from 1,700 calories to

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1,400. The flame of life, to use Lavoisier's expression, was burning more dimly. In all probability, lowering of the B.M.R. as a result of loss of body tissue often helps the unemployed, and other victims of our civilization, to continue existence on an inadequate diet. Society here takes advantage of the human body's power of adapting itself to a restricted food intake.

A diet insufficient as regards energy value is, as a rule, insufficient as regards the various food-factors necessary for adequate nutrition. Victims of famine do not get their daily quotas of vitamins and mineral salts as recommended by Professor Sherman. Faced with the task of famine relief, however, one would scarcely stop to consider what *kinds* of foods the victims needed completely to satisfy their physiological requirements. The pre-eminent necessity would be to provide *food* as quickly as possible, one important point being borne in mind : it should be *familiar* food. Men and women have before now starved rather than eat food to which they were totally unaccustomed.

The horrors of famine have been described by many. We have quoted a passage by Malcolm Muggeridge. All such accounts are essentially the same. One reads of steadily growing weakness and despair ; delirium ; cannibalism ; heaped-up corpses. To give a practical and dramatic bearing to the discus-

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sion of calorie requirements, another vivid account of famine may be added. It is taken from *The Great Famine*, by William P. O'Brien, and is actually a description of conditions in West Cork during the Irish potato famine of 1846.

“To His Grace

“Field-Marshal, The Duke of Wellington.”

“MY LORD DUKE,

“Without apology or preface, I presume so far to trespass on Your Grace as to state to you, and, by the use of Your illustrious name, to present to the British Public, the following statement of what I have myself seen within the last three days :

“Having for many years been intimately connected with the western portion of the County of Cork, and possessing some small property there, I thought it right personally to investigate the truth of the several lamentable accounts which had reached me of the appalling state of misery to which that part of the country was reduced. I accordingly went on the 15th instant to Skibbereen, and to give the instance of one townland which I visited, as an example of the state of the entire coast district, I shall state simply what I there saw. It is situated on the eastern side of Castlehaven Harbour, and is named South Reen, in

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the parish of Myross. Being aware that I should have to witness scenes of frightful hunger, I provided myself with as much bread as five men could carry, and on reaching the spot I was surprised to find the wretched hamlet deserted. I entered some of the hovels to ascertain the cause, and the scenes that presented themselves were such as no tongue or pen can convey the slightest idea of. In the first six famished and ghastly skeletons, to all appearance dead, were huddled in a corner on some filthy straw, their sole covering what seemed a ragged horse-cloth and their wretched legs hanging about, naked above the knees. I approached in horror, and found by a low moaning they were alive. They were in fever—four children, a woman and what once had been a man. It is impossible to go through the details ; suffice it to say, that in a few minutes I was surrounded by at least 200 of such phantoms, such frightful spectres as no words can describe. By far the greater number were delirious, either from famine or from fever. Their demoniac yells are still ringing in my ears, and their horrible images are fixed upon my brain. My heart sickens at the recital, but I must go on. In another case—decency would forbid what follows, but it must be told—my clothes were nearly torn off in my endeavours to escape from the

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throng of pestilence around, when my neck-cloth was seized from behind by a grip which compelled me to turn. I found myself grasped by a woman with an infant, *just born*, in her arms, and the remains of a filthy sack across her loins—the sole covering of herself and babe. The same morning the police opened a house on the adjoining lands, which was observed shut for many days, and two frozen corpses were found lying upon the mud floor *half-devoured by the rats*.

“A mother, herself in fever, was seen the same day to drag out the corpse of her child, a girl about twelve, perfectly naked, and leave it half-covered with stones. In another house, within 500 yards of the cavalry station at Skibbereen, the dispensary doctor found seven wretches lying, unable to move, under the same cloak—one had been dead many hours, but the others were unable to move either themselves or the corpse.

“To what purpose should I multiply such cases? If these be not sufficient, neither would they hear who have the power to send relief, and do not, even ‘though one came from the dead.’

“Let them, however, believe and tremble that they shall one day hear the Judge of all the Earth pronounce their tremendous doom, with the addition, ‘I was hungered and ye

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gave Me no meat ; thirsty and ye gave Me no drink ; naked and ye clothed Me not.' But I forget to whom this is addressed. My Lord, you are an old and justly honoured man. It is yet in your power to add another honour to your age, to fix another star, and that the brightest, in your galaxy of glory. You have access to our young and gracious Queen—lay these things before Her. She is a woman, she will not allow decency to be outraged. She has at her command the means of at least mitigating the sufferings of the wretched survivors in this tragedy. They will soon be few, indeed, in the district I speak of, if help be longer withheld. Once more, My Lord Duke, in the name of starving thousands, I implore you, break the frigid and flimsy chain of official etiquette and save the land of your birth—the kindred of that gallant Irish blood which you have so often seen lavished to support the honour of the British name—and let there be inscribed upon your tomb, *Servata Hibernia*.

“ I have the honour to be,

“ My Lord Duke,

“ Your Grace's obedient humble servant,

N. M. CUMMINS, J.P.”

“ Ann Mount, Cork,

“ December 17th, 1846.”

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We may hope that, partly as a result of the recent development of the science of nutrition, such catastrophes as that so eloquently described by the worthy Irish magistrate will be unlikely to occur in the future. Human dietary needs, quantitative and qualitative, are tolerably well established ; to adjust the food production of the world to the needs of its entire population, leaving something over for emergencies, is well within the bounds of possibility. Such an idea may appear visionary ; in reality, it is simple common sense. Or rather, let us hope, it will be simple common sense to our great-grandchildren. .

CHAPTER II

THE ENERGY-YIELDING FOOD-FACTORS

To be satisfactorily fed, a human being must have (a) enough food to eat and (b) the right sort of food to eat. The essential dietary elements are the following :

Protein
Fat
Carbohydrate
Vitamins
Mineral salts
Water

As far as practical dietetics is concerned, we may say that all six are essential. Diets containing very little carbohydrate are compatible with life, and have been used in the treatment of diabetes. It has been found that laboratory rats can exist on a fat-free diet as long as they are supplied with fat-soluble vitamins. But these are very special cases ; all ordinary human diets contain both carbohydrate and fat. Without protein, vitamins, mineral salts and water, life is impossible under any circumstances.

All natural foods differ in their content of the energy-yielding food-factors, protein, car-

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bohydrate, and fat. The following table, which gives the percentage composition of various common foods as regards these factors, will help to clarify the later part of the chapter.

TABLE II
PROTEIN, FAT AND CARBOHYDRATE CONTENT OF VARIOUS COMMON FOODS

Food.	Grammes per 100 grammes of food material.		
	Protein.	Fat.	Carbo- hydrate.
Whole wheat	10·9	1·2	70·4
Wheat bread (white)	7·2	0·2	48·1
Milled rice	6·5	0·3	80·0
Potatoes	1·6	—	21·0
Turnips	1·2	0·1	4·4
Beans (broad)	23·9	1·3	54·5
Peas (green)	20·4	0·6	57·1
Meat (lean beef)	20·0	3·5	—
Fish muscle (cod)	14·6	0·1	—
Liver (beef)	20·4	4·5	1·7
Eggs	13·4	10·5	—
Milk (whole liquid)	3·3	3·6	4·8
Cheese (full milk)	25·7	35·0	3·7
Butter	0·2	83·0	—
Margarine	0·2	84·8	—
Tomatoes	0·7	0·1	4·5
Oranges	0·8	0·2	11·6
Apples	0·3	0·2	10·8
Cabbage	1·4	0·1	4·5
Sugar	—	—	100

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Fruits and leafy and root vegetables contain little solid matter in the form of protein, carbohydrate, and fat. This is because they are largely composed of water. Butter and margarine, on the other hand, have a low water content. The water content of the foods listed here may be roughly deduced from the percentage of their weight made up by the three factors.

CARBOHYDRATES

Where the dietary habits of Western civilization are followed, about two-thirds of total energy requirements are supplied by carbohydrates. The carbohydrates provide the foundation of energy on which all life is built. In the leaves of green plants the chlorophyll cells use the sun's energy to build carbohydrate material out of carbon dioxide and water, with liberation of oxygen, continually transforming inorganic matter into organic substances which supply fuel for the life process.

The carbohydrates of chief importance in human dietetics are various sugars and starch. Starch, and sugars other than those belonging to the monosaccharide group, are transformed by the action of digestive ferments into the sugar glucose before being absorbed into the blood. The monosaccharide group, of which

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glucose is the most important, consists of soluble substances ; in the digestive process large disaccharide and polysaccharide molecules are broken up into smaller monosaccharide molecules readily absorbed in the intestine. Glucose, on being absorbed, is carried to the liver, and there converted into glycogen, in which form it is stored in the liver, muscles, and other tissues. When the body requires fuel, glycogen is again converted into glucose. Strenuous exercise readily reduces the body's reserve of glycogen. It has been experimentally proved by Krogh and his co-workers that capacity for extreme and prolonged exertion is improved when the liver has previously been well stored with glycogen. Those about to swim the Channel, or contest the World Record for the Mile, should consume meals rich in carbohydrate for one or two days previously.

The pancreas is intimately associated with the metabolism of glucose. Without the hormone produced by the "islands of Langerhans" in the pancreas, to which the name "insulin" has been given, storage and utilization of glucose are impossible. The result of relative incapacity on the part of the pancreas to produce this hormone or internal secretion is diabetes mellitus, a disease of which further mention will be made.

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Most human diets contain carbohydrates, which are unsusceptible to the "splitting up" action of digestive ferments—woody and fibrous substances, such as celluloses, hemicelluloses, and pentosans, derived from the connective tissue of plants. Certain species can use carbohydrates of this kind as a source of food energy. Cows eat grass; termites eat wood; but man is unfitted by nature to imitate them. The digestion of cellulose and allied substances can be accomplished in several ways. A few species possess ferments capable of splitting them up into smaller molecules and rendering them assimilable. The majority of creatures which transform cellulose into food energy do so with the help of bacterial or protozoal parasites, which live and multiply in the intestines of their hosts, and in the process produce chemical transformations of hay or wood as they pass. Some substances rich in cellulose contain enzymes which can reduce cellulose to a digestible condition; it is possible that in certain mammals, which devour large quantities of raw cellulose-containing food, the "autolysis" or self-digestion of cellulose takes place. Man, however, does not possess facilities for dealing with cellulose in any of these ways. He secretes no ferments capable of transforming it into sugar; by cooking most of his food he

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destroys enzymes which might bring about autolysis ; his intestine is too small to permit of the digestion of cellulose by the help of micro-organisms. Certain conditions, unfulfilled in man, are necessary for the digestion of cellulose on a large scale : the passage of food must be slow, to give the bacteria time to act, and there must be a large area of intestinal wall to absorb the energy-containing by-products. Within certain limits man can digest cellulose and allied substances well enough, but the limits are so narrow that polysaccharides of this nature are unimportant as a source of food energy. (We may leave out of count here the possibility that the chemist may evolve a commercially practicable method of producing assimilable food from wood, let us say, a discovery which would throw a spanner into the none too smoothly running machinery of world economics.) At the same time, however, cellulose may fulfil a useful purpose by increasing the bulk of food residues and fæcal material in the intestines, which are thereby stimulated to greater excretory efforts. Constipation is often successfully treated by unassimilable polysaccharides, such as agar-agar. Among familiar human foods, those richest in cellulose are green vegetables, fruits, and whole cereal grains.

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The most important of human foods—the cereal grains—contain about 75 per cent. of starch. The proportion of starch in the solid matter of the potato and other tubers, and root vegetables, is equally high. Sugar, not so long ago a luxury, has become a cheap and abundant source of food energy in civilized countries. A few carnivorous peoples, such as the Masai and Eskimo, live on a diet containing very little carbohydrate, but in most freely chosen diets the world over the proportion of carbohydrate greatly exceeds that of protein and fat. There does not seem to be any reason why human beings should not draw the bulk of their food energy from carbohydrate, as long as their needs of other food-factors are satisfied. In practice, however, a “high carbohydrate” diet tends to be deficient in protein, vitamins, and mineral salts. Millions of human beings in the poorer countries of the world live on a diet of which 70–90 per cent. is composed of cereal grains. This is a defective diet, incompatible with *optimum* development and physical efficiency. But it is defective, not because of its high carbohydrate content, but because it lacks sufficiency of other elements which play an essential part in nutrition.

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FAT

One gramme of fat provides the organism with more than twice the amount of energy provided by 1 gramme of protein or carbohydrate. A full meal containing fat is therefore much less bulky than a meal of the same energy value without fat. If fat did not exist, a greater proportion of our time would be spent in chewing.

In digestion fat is split up into fatty acids and glycerol, these digestion products being immediately reconverted into fat during their passage through the intestinal wall. On reaching the tissues via the blood, fat may be burned as fuel, its potential energy being as readily utilized by the body as that of glucose. If not required for combustion at once, fat may be stored in various parts of the body and particularly in the subcutaneous tissues, in which situation it provides an envelope for keeping the body warm. Subcutaneous fat is deposited more thickly and evenly in women than in men ; hence feminine curves and the well-known capacity of wives, when bathing, to remain in the water longer than their husbands. Of the three energy-yielding food-factors, fat is the most readily stored. The fat deposits in the subcutaneous tissues and elsewhere provide the organism with a

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reservoir of energy, which may be drawn on in starvation. For a number of reasons, therefore, the power of the body to store fat is biologically useful, but under certain circumstances of life it becomes a curse. When a great deal of unwanted fat is consumed and stored, the result is obesity.

The body readily converts carbohydrate into fat, so that a fat individual may derive no benefit from simply cutting down his fat intake. The amount of fat which can safely be metabolized depends on the amount of carbohydrate which is being metabolized at the same time. Unless glucose is being burnt, fat is not completely oxidized to CO_2 and water; intermediate noxious fatty acids—sometimes known as “acetone bodies”—are formed. When these are abundantly present in the body the result is the condition known as acidosis. It has been neatly said that “fat burns in the fire of carbohydrate. If there is no fire, it smokes.” The inter-relationships between fat metabolism and carbohydrate metabolism are of great practical importance in connection with the treatment of diabetes, in which carbohydrate metabolism is profoundly disturbed.

The amounts of fat and carbohydrate in the diets of healthy human beings are variable within wide limits. It is unlikely that we

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shall eventually arrive at a figure which represents ideal fat intake. Fat has a high satiety value ; a meal containing fat keeps hunger at bay for a longer period than a meal without it ; because of its high calorie value, it reduces the bulk of food intake ; it is a vehicle for vitamins A and D. It may have some intrinsic physiological value which has not yet been discovered. All these reasons might be used to support arguments in favour of a reasonably large fat intake.

PROTEIN

All plant and animal cells contain proteins ; no life exists without them. While plants can build up protein from inorganic materials, animals must construct their tissue proteins from the disintegration products of proteins obtained from living organisms. Proteins are necessary, not only for the formation of new substance, but also for the maintenance and repair of existing tissues. An organism which is not increasing in size has relatively less need of protein than an organism which is laying down new tissue ; adults, per kilogram of body-weight, have smaller requirements than children. In certain circumstances, however, adults may form new tissue—we may quote as examples a pregnant woman (during intra-uterine development a

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fœtus stores daily on the average about 3 grammes of protein), and a patient recovering from a wasting disease which has left him an emaciated skeleton.

There is a constant demand on the part of the body for protein for purposes of construction, maintenance, and repair. While fat and carbohydrate can supply the body with energy, they cannot supply it with new substance; protein yields not only energy, but also material essential for the formation of living cells. It is this fact which gives it its importance in dietetics, and accounts for the enormous amount of discussion and controversy which has taken place regarding the protein requirements of human beings. Chemically, protein differs from fat and carbohydrate in containing not only carbon, hydrogen, and oxygen, but also nitrogen and sulphur.

Protein taken in the food reaches the blood in the form of amino-acids. In the process of digestion the complex protein molecule is broken down into these relatively more simple compounds, sometimes known as "building stones" or "bricks." Amino-acids circulating in the blood (derived either from the food or from the disintegration of tissue proteins) are used either for the rebuilding of protein, or oxidized to supply energy. Glycogen and glucose are yielded in the pro-

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cess—a point of practical importance in connection with the treatment of diabetes.

It is the non-nitrogenous residues of the amino-acids which are oxidized ; nitrogen is split off by the process known as deaminization, which takes place mainly in the liver, in the course of which the nitrogen-carrying fraction is converted first into ammonia, then into ammonium carbonate, and finally into urea. Protein contains about 16 per cent. of nitrogen, and investigation of the amount of nitrogen excreted provides a clue to the amount of protein being used by the body, either as energy or for the formation of tissue. Similarly, the amount of nitrogen in a food-stuff can be used as index of its protein content.

A starving man excretes 4–5 grammes of nitrogen daily in the urine. Though the consumption of protein is nil, protein derived from the breaking up of body-cells is being metabolized in the same way as protein derived from food ; some of it is being rebuilt into tissue and some of it is being oxidized. It appears that, in a starving animal, amino-acids derived from tissues whose preservation is not strictly necessary for life may be used for the maintenance of vital organs, such as the heart. On a normal protein-containing diet protein metabolism is essentially the same,

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except that a small proportion of the total amino-acids provides amply for repair, and the greater part is oxidized to provide energy. Protein is not stored. It follows that the amount of nitrogen excreted, except in starvation, corresponds with the amount of nitrogen consumed. If a man takes in, daily, protein containing 16 grammes of nitrogen (i.e. about 100 grammes of protein), that amount of nitrogen will be excreted. If he consumes 20 grammes of nitrogen, he will excrete 20 grammes. In such circumstances he is said to be in "nitrogenous equilibrium." The starving man, excreting daily 4-5 grammes more nitrogen than he consumes, is not in this happy condition. Total energy metabolism fluctuates from day to day in accordance with the activity of the organism; protein metabolism, on the other hand, depends on the amount of protein ingested. If the amount of protein consumed is suddenly altered, protein metabolism may not adjust itself to protein supply immediately, but in a few days output tends to equal intake. It does not appear that moderately strenuous activity produces any increase in protein metabolism. Maintenance protein requirements are independent of muscular activity.

The cheapest and most efficient source of food energy is carbohydrate. Considered

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simply as a source of energy, protein may have certain disadvantages. Let us consider first what is known as its "specific dynamic action." For some reason not yet clearly understood, protein exerts a stimulating action on metabolism. Carbohydrates and fat also possess a "specific dynamic action," but in a much smaller degree than protein. Arctic explorers are said to find the increase of heat production resulting from protein intake grateful and comforting, but in more ordinary circumstances of life the heat so produced is of no value, and indeed an embarrassment, to the body, since it cannot be used for work but must be eliminated via the skin and other channels. Of common foods, meat is one of the richest in protein, and it is sometimes urged that meat intake should be cut down in hot weather because its protein may excite unnecessary heat production; in point of fact, however, the slight reduction of the total protein intake, brought about by reducing the proportion of meat in average European and North American diets, would have an almost unappreciable influence on total metabolism. One way or the other, "specific dynamic action" does not appear to be of great importance in practical dietetics. It does not, so to speak, put protein, in comparison with fat or carbohydrate, in a position of

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serious disadvantage as a source of food energy.

In a healthy body, carbohydrate and fat are completely oxidized. Protein, on the other hand, is not. In the course of protein metabolism, incompletely oxidized substances are produced which have to be eliminated by the kidneys. It has been urged by some that these waste products exercise a deleterious effect on the arteries, the result being arteriosclerosis and senile decay. On the whole, however, the evidence indicates that, unless protein intake is very excessive, the kidneys can eliminate the products of its metabolism without injury to themselves. It is true that kidney damage has been observed in rats fed on diets containing 80 per cent. or more of protein, but no freely selected human diet could possibly contain so high a proportion. The ordinary mixed diets of man contain, as a rule, from 8-15 per cent. of protein, and there is no convincing evidence that the raising of the proportion to 20 or 30 per cent., let us say, would *of itself* produce ill effects on the kidneys.

There remains the economic argument in favour of a minimum protein intake. While 100 grammes of protein supply roughly the same number of calories as 100 grammes of carbohydrate, the cost of the former, in most

parts of the world, exceeds that of the latter. In practical dietetics we are closely concerned with the price of things, for the majority of human beings are so poor that they must perforce exist on the cheapest available food. The more successfully we can prove that human protein requirements are small, and that protein is largely replaceable by carbohydrate, the easier it will be to draw up dietaries for those whose choice of foods is drastically limited by penury.

In considering the question of minimum necessary protein intake, we come against the problem of "biological value." All proteins differ in their amino-acid constitution, and the nearer their amino-acid constitution corresponds to that of the body, the greater their "biological value." The protein molecule, Fearon has remarked, "may be compared to a box of assorted biscuits. Each variety of biscuit represents a particular species of amino-acid; there are many duplicates, and the least attractive are the most abundant. To obtain the biscuit one wants it is necessary to buy the entire box." To extend an elegant simile a little further, one may add that certain boxes are devoid of the most nutritious biscuits.

Some proteins contain the amino-acids required by the human body in reasonably cor-

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rect proportions. Others have too much or too little of this or that amino-acid, and yet others lack some of the essential amino-acids altogether. The body can itself synthesize, from material derived from fat and carbohydrate, certain of the simpler amino-acids; on the other hand, of the twenty known amino-acids there are four—histidine, lysine, tryptophane, and cystine—which are indispensable for growth and life, and which the body is incapable of synthesizing. The composition of various familiar proteins as regards their content of these amino-acids may be studied in the table on the following page.

It will be noted that gelatin contains no tryptophane, while zein is deficient in both tryptophane and lysine. If zein is fed to young animals as the sole source of protein, they will cease growing and ultimately die. Nor will zein maintain adult animals. Gelatin, deficient in other amino-acids besides tryptophane, will not support growth or life. Other proteins, which contain essential amino-acids in relatively small amounts, may be capable of maintaining fully grown animals, but will not suffice for normal growth unless supplemented by the specific-amino-acids in which they are relatively or absolutely deficient. Growth tests in rats have further indicated that certain whole proteins may

TABLE III

PERCENTAGE OF FOUR ESSENTIAL AMINO-ACIDS IN CERTAIN PROTEINS

	Wheat Proteins.		Maize Proteins.		Pea Proteins.		Milk Proteins.		Beef Muscle.	Gela- tin.
	Glutenin.	Gliadin.	Maize Glutenin.	Zein.	Legumin.	Vicilin.	Casein.	Lactalbumin.		
Cystine . . .	1.80	2.32	0.90	0.85	0.83	0.57	0.50	1.73	1.55	0.31
Histidine . . .	1.76	3.35	3.06	0.82	1.69	2.47	2.84	2.61	1.76	0.90
Lysine . . .	1.92	0.92	2.93	0.00	4.98	5.40	7.62	9.87	7.59	5.92
Tryptophane .	1.80	1.14	0.90	0.00	1.76	0.15	2.20	3.00	1.25	0.00

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“supplement” efficiently other proteins with a different amino-acid constitution. Thus, meat and liver proteins “supplement” cereal proteins, pea proteins “supplement” wheat, but not maize, proteins, and so on.

Growth tests in animals provide one way of studying the “biological value” of different proteins; another way is by the “balance sheet” method. A man on a protein-free (nitrogen-free) diet excretes daily, let us say, 4 grammes of nitrogen derived from the breaking up of tissue proteins. If he is now supplied with a “perfect” protein containing the correct proportion of the amino-acids his tissues require, then, theoretically at any rate, 25 grammes of perfect protein (4 grammes nitrogen) will replace the “wear and tear” quota—i.e. keep him in “nitrogenous equilibrium.” A greater intake of a less perfect protein will be required for the achievement of “nitrogenous equilibrium.” “Nitrogen balance experiments,” involving the study of nitrogen intake and loss in a variety of dietary circumstances, have shown that there are considerable differences in the biological value of the various proteins consumed by man. Experiments of this nature, and growth tests in animals, both suggest that on the whole animal proteins have a greater “biological value” for man than vegetable proteins. At the moment,

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however, the whole question of the "biological value" of various proteins in human nutrition needs further clarification. Unfortunately, many experiments on "biological value" were carried out before the importance of vitamins was realized, and it is somewhat difficult to-day to interpret them.

Nitrogen loss in starvation is an untrustworthy index of nitrogen requirements when energy needs are satisfied by a varied diet. On a nitrogen-free diet containing fat and carbohydrate, nitrogen loss is smaller than in starvation—fat and carbohydrate act as "protein spacers," checking, so to speak, the tendency of the body to use its own protein as fuel. In the hope of establishing a theoretical minimum protein intake, various investigators have attempted to discover the amount of protein needed for the maintenance of nitrogenous equilibrium when energy requirements are covered by a diet mainly composed of carbohydrate and fat. It has been discovered that less than 30 grammes of protein may suffice to keep the body in nitrogenous equilibrium when the other energy-yielding factors are liberally supplied.

So low a protein intake has never been recommended by physiologists. In practical dietetics, a "margin of safety" is desirable. Allowance must be made for the fact that

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proteins differ in biological value, although, it is true, in ordinary human diets the absence of certain amino-acids in one protein is usually compensated for by their presence in another. It is also necessary to remember that some protein-containing foods are more readily absorbed from the intestinal tract than others. The proteins of animal foods such as meat, fish, milk, and eggs are absorbed almost completely, while with proteins of vegetable origin there may be a loss, due to incomplete absorption, of as much as 15 per cent.

Physiologists who have put forward estimates of the optimum amount of protein required by human beings have, in point of fact, been very little influenced by the results of nitrogen balance experiments and by other facts about protein and protein metabolism gathered by the laboratory worker. Much more weight has usually been given to observations of the amount of protein contained in freely chosen human diets. This method is clearly fallacious; human beings have no dietary instinct prompting them to choose a perfect diet; there is no reason to suppose that what is, should be. The fact that the average daily protein intake per consumption unit of 1,000 English families, with reasonable choice of food, is 100 grammes, does not prove that 100 grammes is the optimum

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protein intake. All it proves is that human beings can exist on 100 grammes. They might, for all we know, be much better off on 70 or 150 grammes; the Masai and the Eskimo live strenuously on an intake which exceeds 200 grammes. Actually, standards of protein requirements set up by physiologists have invariably reflected the dietary habits of the physiologist's contemporaries and fellow-countrymen. We may be sure that when the Eskimos found universities and begin to study nutrition, their physiologists will argue that 200 or more grammes of protein daily represent the optimum intake for human beings.

Another fallacious argument has been used in the interminable controversy about protein requirements. In practice a diet with a low protein content is a diet mainly composed of vegetable foods, because in general animal foods such as cheese, meat, fish, eggs, etc., are richer in protein than cereals and root vegetables. Of vegetable foods, only the legumes have a protein content which equals that of lean meat and fish. (See Table II.) It has been observed that peoples or tribes which exist largely on cereals, and thus have a lower protein intake than others which consume larger quantities of animal food, are in general of inferior physique. The contrast

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is particularly noticeable among the peoples of India, where the physique of the rice-eating Bengali and Madrassi compares unfavourably with that of certain Northern Indian peoples whose diet, based on whole wheat and milk products, is richer in both animal and vegetable protein. Rice, it happens, has the lowest protein content of all the cereals. Observations of this nature gave birth to the idea that physical development is directly related to protein intake, which has sometimes been popularly interpreted to mean that meat-eating produces strength and vitality. In point of fact, "low protein diets," as met with in practice, tend to be inferior to "high protein diets" in other food-factors besides protein—namely, various vitamins and mineral salts—deficiency of which is just as likely to impair physical development as deficiency of protein. It follows that no argument in favour of a high protein intake can rationally be based on the observation that certain peoples with a low protein intake show poor physical development.

In a later chapter, in connection with "dietary standards," we shall return once more to the question of human requirements of protein, fat, and carbohydrate.

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DIABETES MELLITUS

Laboratory investigation of the problems of protein, fat, and carbohydrate metabolism has provided data of the utmost importance for the understanding and treatment of the disease diabetes mellitus. In diabetes, the pancreas fails to produce in sufficient quantity the secretion insulin, which is necessary for the metabolism of carbohydrate. The essential cause of pancreatic failure is still unknown. The cells of the body are unable to oxidize glucose, with the result that it accumulates in the blood and is excreted in the urine. Prolonged hyperglycæmia, or high concentration of sugar in the blood, seems to be partly responsible for the arterial degeneration which underlies many of the serious complications of diabetes.

Disturbance of carbohydrate metabolism involves a disturbance of fat metabolism. Incomplete oxidation of fat leads to the production of the "acetone bodies"—poisonous substances the accumulation of which may produce coma and death. Protein metabolism also comes into the picture. Glucose may be derived from protein, so that the elimination of carbohydrate from the diet need not necessarily bring about the reduction of the blood sugar to normal levels, and

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the disappearance of sugar from the urine. Further, certain amino-acids may be converted into "acetone bodies," the risk of acidosis, coma, and death being thereby increased.

Before insulin was discovered fifteen years ago, the generally followed method of treating diabetes was to cut carbohydrate out of the diet as completely as possible. This reduced the blood sugar concentration, and did something to prolong life. But the average patient led a miserable limited existence on a carefully controlled and unsatisfying diet, while the smallest dietary indiscretion might lead to fatal results. To-day, thanks to many workers in many countries, and particularly to Banting and Best of Toronto, the diabetic's deficiency of insulin can be made good by supplying him with insulin extracted from cattle and other species. Injections of insulin enable a patient to burn carbohydrate efficiently once more; it has even proved possible to discover roughly how many units of insulin are needed for the metabolism of so much glucose. A relation also exists between insulin and protein and fat metabolism. "Insulin works, and works extraordinarily well. When properly used it restores normal health and activity to the severest diabetic if no complications are

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present. It has assured the normal development of thousands of children, and made severe operations safe for all diabetics." The quotation is from an article by Dr. R. D. Lawrence.

But insulin will not work well of itself, so to give the patient large doses and tell him to eat what he liked would bring disaster. The greatest care and skill are required for the regulation of his diet. If a diet which contains a high proportion of carbohydrate is desired, a great deal of insulin is required ; if only a little carbohydrate is allowed, then the patient is bound by irksome dietary restrictions and cannot enjoy a decent meal. Diets rich in fat and low in carbohydrate and protein have been advocated by some physicians, but a disadvantage of these diets is that they involve danger of acidosis and coma should the patient exceed his already liberal intake. The modern tendency in the treatment of diabetes is to allow the patient to consume a moderate but strictly defined amount of carbohydrate, just sufficient insulin being given to ensure its combustion ; carbohydrates derived from the connective tissue of plants need not be reckoned in the total allowance of carbohydrate, since the amount of glucose derived from these is negligible. Protein and fat intake is uncon-

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trolled. This method of dieting allows a maximum of freedom in the choice of meals.

The reader will realize, even from this brief and incomplete résumé, that the successful treatment of diabetes demands a sound knowledge of the physiology of nutrition. This applies not only to physicians, but also to patients. The intelligent diabetic will readily learn the fundamental facts about the metabolism of carbohydrate, protein, and fat, and the distribution of these factors in foodstuffs. He will soon learn to adjust his insulin intake exactly to his food intake and his energy expenditure, and as a result will be able to lead a full and active life, inconvenienced only by having to inject insulin into himself once or twice a day. This, it may be added, is quite a considerable inconvenience. One of the reasons why the death-rate from diabetes remains high is that there are stupid patients and stupid physicians, incapable of taking advantage of the assistance which science has placed at their disposal.

CHAPTER III

VITAMINS

“ As food constituents, vitamins are characterized by the disproportion between the great importance of their nutritional functions and the very small amount necessary for the adequate fulfilment of those functions. In a normal dietary they are present in quantities too small to yield any appreciable contribution to the energy supply of the body, or to bulk appreciably as structural elements for the tissues. They are, nevertheless, definite chemical entities, and in the last eight years much light has been thrown upon the actual chemical nature of some among them. It would seem, indeed, that at least one has now been artificially prepared. During the same period, extended researches have shown that they are more numerous than was earlier suspected. Eight years ago only three were clearly recognized ; now we must believe in the existence of at least eight. Each one upon good evidence has been shown to exert its own individual functions in nutrition.”

The passage quoted above, which provides

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in small compass a good deal of information about vitamins, is the opening paragraph of the Medical Research Council's Report, *Vitamins : A Survey of Recent Knowledge*, published in 1932. This useful report runs to 332 pages, and contains references to some 1,500 original articles. Since 1932 great progress has taken place in the chemical identification of the known vitamins, and several new ones have been discovered.

Some consider that during recent years the vitamins have received more than their due share of attention, with the result that equally important dietetic problems have been thrust into the shade. There are some slight grounds for this criticism ; every department of advancing knowledge suffers from enthusiasts who can see only one thing at a time to the exclusion of everything else. But from the very beginning there has been some excuse for excessive fervour on the part of the vitamin worker. An element of drama, which fires the imagination, constantly recurs in the history of vitamin research. The discovery that formidable and widespread disease can be caused by deficiency in the diet of small amounts of physiologically necessary substances is as remarkable a contribution to knowledge as the discovery that infectious disease is spread by micro-organisms.

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Professor McCollum dedicates his well-known text-book *The Newer Knowledge of Nutrition* to "Dr. C. Eijkman, who First Produced Experimentally a Disease of Dietary Origin." During the closing years of last century, Eijkman, at that time working in Java, conceived the idea that beriberi, a common disease in the East, is due to faulty feeding. The disease, as Eijkman observed it, occurred in Javanese whose staple diet was polished rice, and he found that birds, fed on polished rice and nothing else, developed a paralytic condition which he considered analogous to the human disease. Birds fed on unmilled rice remained healthy, and rice polishings, fed apart from highly milled rice, prevented or cured the paralysis. Other foods, e.g. beans, were found to be effective in the cure and prevention. It was clearly demonstrated, by Eijkman and his colleagues, that polished rice produced disease, not because it was poisonous, or because it was deficient in protein and salts, but because it lacked a "certain something." That "certain something" is known to-day as the "antineuritic vitamin" or vitamin B₁.

Eijkman's experiments in Java were extended and developed by medical officers in American and British colonies striving to combat beriberi. By 1914 evidence had

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accumulated that beriberi is a food deficiency disease, attacking, as a rule, those who eat milled cereals and little else, and sparing those who consume a well-balanced diet. Medical authorities in many parts of the world were faced with a new type of problem in disease prevention, for the solution of which the emphasis lay not on sanitation, but on food.

Meanwhile, vitamin research was developing in quite another environment. Physiologists in England and America were attempting to devise diets, composed of proteins, carbohydrates, fats, and mineral salts in suitable proportions and in a purified state, on which animals could grow and thrive. Sir F. G. Hopkins, now President of the Royal Society, carried out some remarkable feeding experiments at Cambridge, and in the United States McCollum, Osborne, and Mendel worked along similar lines. Hopkins, in a famous experiment, demonstrated that rats, fed on a purified synthetic diet containing protein, fat, carbohydrate and mineral salts in adequate amounts, died in a few weeks ; but if a little milk was added to the diet, in amounts too small to make appreciable additions of protein and fat to the diets, the animals lived and grew. McCollum and his collaborators, helped by experiments carried out at Yale by Osborne and Mendel, proved

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that a synthetic purified diet of the type used by Hopkins lacked two essential food-factors, which were named "Fat soluble A," and "Water soluble B," respectively.

We have given here but the barest outline of certain pioneer investigations which were the starting-point of much subsequent work in vitamins. There is no space to refer to Lind's experiments in scurvy, carried out in 1747, to Babcock's curious and suggestive feeding experiments in Wisconsin in 1906, to the production of scurvy in guinea-pigs by Norwegian workers in 1912, to Funk's remarkable work on avian beriberi in 1912-13, and his invention of the word "vitamine." The reader who is interested in the history of vitamin research must turn to larger and more comprehensive volumes. Here it is only possible to give, very briefly, a few facts about certain of the vitamins as we know them today.

VITAMIN A AND CAROTENE

Vitamin A and the pigment carotene appear to have the same physiological action, the latter being converted into the former in the liver. Among the most abundant sources of one or other of these food-factors are whole milk and fat-containing milk products (butter, cream, cheese made from whole milk), tissue

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fats, liver and liver oils, green leafy vegetables, carrots, and certain fruits (e.g. tomatoes, oranges, mangoes). Liver is the richest-known natural source of vitamin A (*strictu sensu*), which is not found in vegetable foods. Deductions as to the functions which vitamin A fulfils in the body can be drawn from a consideration of the effects of its absence. It has been called growth promoting. An animal on a vitamin A deficient diet stops growing as soon as it has used up the stores of the vitamin contained in the liver and other tissues, and capacity to support growth in vitamin A deficient animals has been much used as a criterion for estimating the vitamin A potency of test materials. It is probable, however, that there is no specific relation between vitamin A and growth; an animal fed on a diet deficient in vitamin A stops growing because it becomes too ill to grow. In such an animal, the layer of cells in the surface of the skin and mucous membranes—the epithelium—becomes degenerated; the vital activity of the cells is lowered, and they become dry and horny (keratinized); their capacity to resist the attacks of micro-organisms is impaired. In an animal which has been fed on a vitamin A deficient diet for a prolonged period, infectious processes and abscesses occur at many points—the eyes, the

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lungs, the kidneys, the ears, etc. Epithelium cannot live and function normally if the trophic nerves which control its vital processes are cut or degenerated. Mellanby has shown that in vitamin A deficiency degenerative changes occur in the central nervous system and peripheral nerves, and has suggested that these are in fact the cause of the characteristic lesions in skin and mucous membranes. Later work has, however, not supported this theory.

One of the most serious results of vitamin A deficiencies is a lesion affecting the conjunctiva and cornea of the eye. There are several degrees of this, ranging from mild dryness of the conjunctiva (xerophthalmia) to a destructive invasion of the cornea. When the latter occurs the condition is known as keratomalacia. Keratomalacia has often been observed in human beings; during the War it occurred in Denmark among poor children fed on oatmeal and skim milk, who went short of vitamin A because Denmark was selling, for enormous prices, more butter and other animal fats to Germany than she could spare. A distinguished Danish physician, Bloch, realized that the serious eye disease afflicting ill-fed children was due to dietary deficiency, and showed that it could be prevented by a well-balanced diet containing animal fat, and

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cured by cod-liver oil if not too far advanced. In many parts of the tropics and the East today, vitamin A deficiency, resulting in keratomalacia, is one of the commonest causes of permanent blindness.

A less serious eye disease which occurs as a result of vitamin A deficiency is hemeralopia—inability to see in a dim light. The retina is normally capable of forming a substance called visual purple or rhodopsin, which sensitizes it to vision in dim lights. Visual purple is bleached by strong light and disappears from the retina, and before the eye, exposed to bright illumination, can adapt itself to a dim light, visual purple must be re-formed. It seems that vitamin A is in some way necessary for the formation of visual purple, so that an individual whose diet is deficient in the vitamin tends to become “night blind,” particularly if he spends long hours in bright sunlight; in medical language, there is a raising of the “light threshold.” In full daylight his vision will be normal, but for him night will fall quickly. In a light which is strong enough to enable a normal person to walk along a path or steer a boat for a headland, he will be blind and helpless.

Treatment is simple. The consumption of some food rich in vitamin A will very quickly cure dietetic hemeralopia; after a few meals

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of liver, or a few doses of cod-liver oil, capacity to synthesize visual purple may be regained, and the sufferer is no longer in danger of falling into a ditch or walking off a pier in the dusk. Liver, which contains abundant vitamin A, has been much used in the treatment of hemeralopia, but there are many other curative foods. In many parts of the world it is common knowledge that night-blindness can be cured by eating liver; it has, in all probability, been common knowledge for centuries. The "liver" treatment is mentioned in Eber's Papyrus (about 1500 B.C.), one of the earliest medical treatises, and was familiar to Hippocrates, who recommended ox liver dipped in honey.

During recent years a great deal of work has been carried out to throw light on the relation between vitamin A and susceptibility and resistance to infection. Vitamin A has been called the "anti-infective" vitamin; in what sense is this true? We know that laboratory animals suffering from pronounced degrees of vitamin A deficiency fall victim to infectious invasion. Bloch and others have observed that a high proportion of children suffering from keratomalacia die of broncho-pneumonia. In the East vitamin A deficiency, as shown by the presence of night-blindness and xerophthalmia, is very common among the

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poorer classes. Children suffering from these conditions are, as a rule, in a poor state of health and their vitality is low, but their susceptibility to infectious invasion does not appear to be any greater than that of children showing no obvious evidence of vitamin A deficiency. The death-rate for infants and growing children in most Eastern countries is very high (in Ceylon it is three times as high as in England) and one may certainly venture the general statement that in many parts of the tropics and the East the consumption of diets very deficient in vitamin A and other essential food-factors plays a notable part in producing ill-health and paving the way for infection. There does not, however, appear to be a specific relationship between the presence of symptoms of vitamin deficiency and lowered resistance to infection.

No reliable evidence has been obtained that the ordinary diets of Western civilization contain insufficient vitamin A to maintain the integrity of epithelial surfaces. Clinical investigation of this point has produced conflicting results. Hess and his colleagues observed that respiratory infections were no more common in infants given partially skimmed milk (containing 1.5 per cent. of fat) than in children given whole milk supplemented by cod-liver oil. The implication is that a diet

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of partially skimmed milk contains sufficient vitamin A to cover the needs of infants, and that the ordinary diets of Western civilization contain enough of it. Other investigators have obtained parallel results.

Attempts have been made to discover the effect of "vitamin A therapy" in established infections. So far we have no clear-cut proof that large doses of vitamin A help a patient to build up resistance to disease which has already gripped him, or to stave off complications. Investigations of the amount of vitamin A in the liver of patients dying from pneumonia and other infections have revealed that there is no simple relation between the amount of vitamin A stored in the body and the severity of infectious processes.

The conclusion seems to be that, in such countries as England and the United States of America, the diet of average families, even of the poorer classes, usually contains sufficient vitamin A, and that no advantage is likely to be gained by consuming more vitamin A units. We say "seems"; the question cannot be regarded as finally settled. On the other hand, there is no doubt that the effects of vitamin A deficiency *have* been observed, though with comparative rarity, among the children of the poor in England.

The term "anti-infective vitamin" is not a

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satisfactory one in so far as it conveys the idea that in vitamin A a universally applicable agent for combating infectious disease has been discovered. There can, however, be no doubt that vitamin A is an important food-factor from the standpoint of practical dietetics.

VITAMIN B₁

Vitamin B₁, which, in contradistinction to vitamin A, is "water-soluble," is widely distributed in nature. Nearly all foodstuffs in their natural state contain it; egg-white, honey, and cereal endosperm are exceptions. It is found in abundance in yeast, eggs, cereal integuments, particularly the germ, legume seeds, and green vegetables. Milk and meat are not rich in this food-factor.

It is clear that deficiency of vitamin B₁ (sometimes called the antineuritic vitamin) is the cause of infantile beriberi. This fact alone lends it great clinical importance, for infantile beriberi is a common disease in certain rice-eating countries. The relation between the vitamin and adult beriberi is less clear-cut, but all are agreed that at least one of the reasons why men and women who consume diets largely composed of highly milled cereals, and especially of polished rice, tend to suffer from beriberi, is that highly milled

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cereals are deficient in the antineuritic vitamin. It may be that other factors are involved, though indeed the old hypothesis that adult beriberi is due simply to lack of the antineuritic vitamin seems to cover many of the facts.

The relation between vitamin B₁ deficiency in the diet and the various symptoms which make up the syndrome labelled "beriberi" is still obscure. But recently the work of a school of biochemists in Oxford, led by Professor R. A. Peters, has begun to throw light on the problem of the vitamin's physiological action. In pigeons it is concerned with carbohydrate metabolism and oxidative changes in brain-tissue. It may soon be possible fully to explain why a bird suffering from vitamin B deficiency shows "head-retraction" and various ataxic symptoms, and why a beriberi patient has a degenerated heart muscle and paralysis of the lower limbs.

The chemical identification of the vitamin now appears to be almost complete. No doubt pure vitamin B₁, synthesized in the laboratory, will soon be available. As in the case of vitamin C, the existence of a cheap and abundant supply will greatly facilitate clinical experiments.

There is at present little evidence that vitamin B₁ is of clinical importance in such

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countries as England and Germany. The ordinary diets of Western civilization seem to contain enough of this vitamin. Some would disagree with this statement, and one must admit that future clinical trials may show that mild degrees of vitamin B₁ deficiency are more widespread than is at present supposed. But this seems unlikely.

THE VITAMIN B₂ GROUP

It has been proved by a group of workers in the United States Public Health Service, led and inspired by the late Dr. Joseph Goldberger, that the disease pellagra can be prevented by the consumption in sufficient quantities of a vitamin. This vitamin was christened by Goldberger and his colleagues the P.-P. (pellagra-preventive) factor. The P.-P. factor is found, in more or less abundance, in yeast, lean meat, liver, fish muscle, milk, cheese, egg-yolk, legumes, and in green leafy vegetables and tomatoes. Cereals and root vegetables do not contain much of this vitamin. Pellagra is almost entirely a disease of populations whose diet consists very largely of maize and lacks food rich in the P.-P. factor. Perhaps maize is more deficient in the factor than any other cereal, but there may be other explanations of the association between maize and pellagra.

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Dogs fed on diets resembling those which produce pellagra in man develop "black-tongue," so called because in the later stages of this disease, which affects the whole intestinal tract, the tongue becomes gangrenous and black. Probably black-tongue in dogs is analogous to pellagra in man; both conditions seem to be prevented and cured by the same kinds of food.

The vitamin B₂ complex of the laboratory worker is distinct from the P.-P. factor and the black-tongue-preventive factor. Rats on a diet lacking vitamin B₂ fail to grow and usually develop types of dermatitis essentially different in nature from the dermatitis which is so prominent a symptom of human pellagra. Recently it has been clearly shown that vitamin B₂ complex is divisible into two components. It was found that vitamin B₂ concentrates had a yellow colour and a green fluorescence, due to the presence of a pigment identical with, or related to, the pigment flavine found in eggs and milk. Flavine is a necessary element in the diet of rats, which in its absence fail to grow and sometimes develop *mild* dermatitis. But the addition of flavine to a vitamin B₂ deficient diet leaves rats still deprived of another element in the B₂ complex—now usually known as vitamin B₆—which is equally necessary for growth and

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prevents the development in rats of a *severe* dermatitis of the paws. Flavine is distributed in natural foodstuffs in a rather similar manner to the P.-P. factor, and possibly flavine deficiency occurs among populations subsisting largely on cereals—e.g. rice. Vitamin B₆, being present in cereals, which enter abundantly into almost all human diets, seems unlikely to prove of clinical and public health importance, but we have at present no information on this point. Like other vitamins, vitamin B₆ is found in greater abundance in the germ and the outer layers of cereal grains than in the starchy endosperm.

It seems clear that the vitamin B₆ group, taken as whole and including the P.-P. factor, is of profound significance in human nutrition. We shall refer later to experiments showing that "extra milk" in the diet of school children accelerates growth and enhances vitality. Similar experiments have been carried out on laboratory rats with similar results. Sherman, for example, observed that giving "extra milk" to a colony of rats already receiving an adequate diet which had sustained the colony through twenty-seven generations, produced remarkable effects: growth was more rapid, maturity hastened, a greater average size was attained, life was prolonged; throughout the life-cycle there was a higher average level of

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health, and the animals possessed the characteristics of youth at an age when average rats are falling into senile decrepitude. Whole milk contains a number of valuable food-factors ; proteins of a high biological value, calcium, vitamin A, and the vitamin B₂ complex. Any or all of these factors may have been operative in producing the general enhancement of well-being observed in children and rats. But there are grounds for suspecting that an important rôle was played by certain factors in the vitamin B₂ complex.

VITAMIN C OR ASCORBIC ACID

Deficiency of vitamin C leads to scurvy. The antiscorbutic vitamin, as every schoolboy knows, is found in fresh fruits and vegetables. The word *fresh* must be emphasized ; when vegetables become dry and stale vitamin C is almost completely destroyed. To a lesser extent it exists in fresh muscle meat and in fresh milk. Cereals and legumes, in the dry state, are devoid of it ; if allowed to germinate, they re-develop the vitamin, some pre-existing substance being transformed into the vitamin as the seed sprouts. The suprarenal gland is a very rich source.

Of the known vitamins, vitamin C is the most sensitive to heat, and in general, the higher the temperature, the more rapid the

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loss. The greater part of the destruction which takes place upon heating under ordinary conditions is, however, of an oxidative nature. In the absence of air and oxidizing agents, the rate of destruction by heat is very greatly diminished. Destruction is accelerated by an alkaline medium. The effect of drying is variable. Dried vegetables in general are devoid of vitamin C—a fact of profound importance in the history of navigation. Dried fruits may, however, retain some antiscorbutic potency. The destructive effect of heat, alkalinity, and drying on vitamin C is of importance in the sphere of public health. Considerable progress has been made in the development of canning processes which do not destroy the vitamin C originally present in fruits and vegetables.

The fact that fresh fruit and vegetables can prevent and cure scurvy has been known for centuries. Intensive study of vitamin C was made possible in 1912, when two Norwegian workers, Holst and Frölich, observed that guinea-pigs fed on a diet composed entirely of cereals and lacking fresh vegetables developed a disease exactly resembling human scurvy. Hundreds of thousands of guinea-pigs have since been used for the study of vitamin C. Monkeys are susceptible to scurvy, and have been employed for experimental work, but in

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general they are unsatisfactory animals for dietary experiments. The rat can apparently synthesize vitamin C in its own tissues and does not develop scurvy when fed on a diet lacking vitamin C.

In 1927, a Hungarian chemist, Szent-Györgyi, isolated a substance from the suprarenal gland and from various plant sources which he called hexuronic acid. At that time he conceived the idea that hexuronic acid was identical with a reducing substance in lemon-juice which, as it seemed from the work of another investigator, had no relation to the vitamin C activity of lemon-juice. But when a third worker arrived at the contrary conclusion that there was a close relation between reducing substance and activity, Szent-Györgyi decided to test the antiscorbutic power of hexuronic acid. He found that 1 milligramme per day could protect a guinea-pig from scurvy. Later workers have observed that hexuronic acid—or ascorbic acid, as it is now called—will cure human scurvy.

Szent-Györgyi and his colleagues found that antiscorbutic material could be obtained in large quantities from paprika or Hungarian pepper. Large quantities in a pure state became available for chemical investigation, and as a result its chemical composition has been discovered. It is now possible to make

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vitamin C in the laboratory, and the synthetic vitamin has the same antiscorbutic effect as the natural substance as it occurs in oranges and lemons.

A few years ago vitamins were mysterious entities whose essential nature could scarcely be hinted at ; to-day, the substance for lack of which thousands of sailors in the seventeenth and eighteenth centuries miserably perished can be made by manufacturing chemists and sold in tins at so much per gramme.

VITAMIN D (THE ANTIRACHITIC VITAMIN)

Rickets has been defined as a condition in which mineral metabolism is disturbed in such a way that deposition of calcium phosphate in growing bones does not take place normally. The definition is incomplete : bone lesions form the most striking part of the symptomatology of rickets in its various forms, but the disturbance of mineral metabolism influences other tissues also. In rachitic conditions the fluid which bathes the young bone contains abnormal concentrations of calcium and phosphorus. In the commonest type of the disease, as it occurs in human beings, the calcium content of the serum is normal, but its phosphorus content is sub-normal. Gross bone lesions may result,

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forming the typical picture of rickets so familiar to the physician a few short years ago. The "low phosphorus" type of rickets is the type most readily produced experimentally in the rat. In "low calcium" rickets, in which the concentration of serum phosphorus is normal, but that of calcium below normal, bone development is also seriously affected, and, in addition, nervous symptoms (tetany) often occur, the latter being presumably due to the deficiency of calcium in the blood. When both the calcium and the phosphorus content of the blood serum are below normal, the result is usually thin, weak, transparent bones—a condition called osteoporosis.

The effect of supplying an infant suffering from low phosphorus rickets or low calcium rickets with tetany, with sufficient vitamin D, is to normalize the calcium or phosphorus content of the serum and promote ossification. It has frequently been suggested that vitamin D acts mainly by increasing the absorption of calcium and phosphorus from the intestine and by diminishing their excretion. There is no doubt that when rickets is being successfully treated by vitamin D an increase in the absorption and retention of mineral elements takes place. But it is possible that vitamin D produces these effects indirectly by influencing mineral metabolism within the tissues

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themselves. It may be concerned with facilitating the "anchorage" of some special compound of calcium and phosphorus to the ends of the growing bones.

Broadly speaking, human rickets results from deficiency of vitamin D, while osteoporosis is more closely associated with deficiency of minerals in the diet. But the mineral content of the diet nevertheless influences the development of rickets. Experimental rickets in the rat is usually produced by giving a diet rich in calcium and poor in phosphorus; it is difficult, in fact, to induce rickets in rats by simply depriving them of vitamin D, unless the diet contains abnormal proportions of the bone-forming mineral salts. While rickets may occur in infants and puppies whose diet shows no mineral imbalance or insufficiency, it is reasonable to suppose that in certain circumstances the mineral content of the diet may turn the scale in one direction or the other.

But the most important cause of human rickets is deficiency of vitamin D; if infants do not receive enough of this food-factor, they will develop the disease. When the problem of rickets was in course of elucidation, two apparently discordant facts were *proved* by different investigators. First, rickets was shown to be a food deficiency

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disease, and secondly, it was shown to be related to physical environment. The contradiction was due to the fact that the body can obtain vitamin D by two channels—via the skin and via the mouth. When ultra-violet rays strike the skin, vitamin D is manufactured by irradiation of the ergosterol which is normally present in skin, and vitamin D so produced is as effective in preventing rickets as cod-liver oil or irradiated ergosterol taken by the mouth. Historically, rickets presents itself as a disease of Northern countries, smoky towns and dark slums; its rarity in children living in the tropics was noted many years ago. If all the infants in the world were fed on a diet relatively deficient in vitamin D, then the determining factor in the development of rickets would be the amount of ultra-violet light available. In many parts of the world there is not enough sunshine at all times of the year to ensure freedom from rickets. Infants living in the temperate zone tend to develop rickets unless special means are taken to increase their intake of vitamin D via the mouth or skin. One of the ways by which intake via the skin can be assured is by exposure to artificial sunlight.

The influence of sunlight in rickets is shown by the seasonal incidence of the disease. During the summer rickety bones tend to

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heal "spontaneously"; the infant manufactures more vitamin D in its skin, and furthermore, the milk it drinks will tend to be richer in vitamin D in the summer than in the winter.

Very few foodstuffs in their natural state contain vitamin D in abundance. The richest known natural source of the vitamin is the liver oil of fishes; it is for commercial reasons that cod-liver oil has been so widely used as an antirachitic agent, for there are other fish whose livers are well stored with the vitamin. Egg-yolk is fairly rich in vitamin D and has been used to prevent rickets. In general, eggs laid in summer, when the hen is exposed to sunlight and has access to fresh green grass, are richer in vitamin D than eggs laid by hens kept in pens on winter rations; it is possible to increase the antirachitic potency of "winter" eggs by irradiating the hen. Milk fat, while poorly supplied with vitamin D as compared with cod-liver oil, may nevertheless be an important source of the vitamin, because milk is the staple food of infants. But it is particularly necessary in this case to bear in mind the principle that the food value of milk depends on the living conditions and diet of its donor. The female mammal is not a machine, producing a standard unvarying substance for the benefit of her young. She

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cannot give out what she has not taken in. Milk and butter produced in summer are richer in vitamin D than milk and butter produced in winter, because in summer the cow and her food are more exposed to sunlight. In the same way, the vitamin D value of human milk is dependent on the diet and environment of the mother who supplies it—so that it is an important public health activity to ensure an abundant supply of vitamin D by some means to women during pregnancy and lactation. In this connection we may note the old observation that breast-fed infants are less likely to develop rickets than artificially fed infants, the obvious explanation of which would appear to be that human milk in general is richer in vitamin D than cows' milk. But this is not the case. The greater immunity of breast-fed infants may be due to the more suitable constitution of breast milk as regards mineral salts.

One other source—a comparatively unimportant source—of vitamin D may be mentioned: fresh green leaves previously exposed to sunlight. Just as the cow in summer may obtain a certain amount of vitamin D from fresh pastures, so human beings can obtain it in small quantities from freshly cut green lettuce and other green vegetables.

Vitamin D, compared with certain other

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vitamins—notably vitamin B₁—is not widely distributed in foodstuffs as ordinarily produced and consumed. But the majority of foods are *potential* sources of vitamin D. In 1924 it was discovered (by Hess and Steenbock simultaneously and independently) that many foods can be rendered antirachitic by irradiation with ultra-violet light. Ergosterol is present in most living matter ; it lies there awaiting the touch of the ultra-violet rays which will transform it into vitamin D. Sugar is almost the only natural food which cannot be made antirachitic by irradiation ; all the rest contain the activable substance. Irradiated milk, both dry and liquid, has been widely used as an antirachitic agent. The irradiation of foodstuffs and medicinal preparations is covered by a patent. It is illegal to use a mercury vapour lamp to make vitamin D on a commercial scale without paying for the privilege.

Wilson has shown that ergosterol in yeast can be activated by Indian sunlight.

It is clear that if many ordinary foodstuffs, by virtue of the small amount of ergosterol which they contain, can be rendered antirachitic by exposure to ultra-violet light, the irradiation of pure ergosterol will produce vitamin D in highly concentrated form. Ergosterol owes its name to the fact that it

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was first obtained from ergot; its richest known source is yeast. Irradiated ergosterol preparations are to-day largely used in the treatment of rickets. A crystalline substance, infinitesimal amounts of which possess anti-neuritic activity, has been isolated from the products formed when ergosterol is irradiated. This substance, named "calciferol" by the group of workers in the National Institute for Medical Research, London, who isolated it, has been generally considered to be vitamin D in pure form. German workers, using different methods, have prepared a similar substance which they call vitamin D₂. Calciferol or vitamin D₂ can cure experimental rickets in rats in doses of less than one-tenthousandth part of a milligramme.

It seems unquestionable that the anti-rachitic substance produced in ergosterol by irradiation has been isolated in a state of purity. But it is conceivable that the anti-rachitic substance in cod-liver oil, and that produced when certain foods—e.g. milk—are irradiated, is of a different nature. Let us suppose that we discover, by experimental means, the amounts of the international standard solution of irradiated ergosterol, a sample of irradiated milk, and a sample of cod-liver oil which all produce the same antirachitic effect on laboratory rats. All

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three amounts contain the same number of international units. The curious discovery has been made that the antirachitic potency of the three substances, in the amounts described, though precisely similar as regards the rat, is dissimilar as regards human beings. Fifty to 56 international units daily in the form of irradiated milk will prevent rickets. To be equally effective "yeast milk" (i.e. milk from cattle fed with irradiated yeast) must supply not less than 90 units, cod-liver oil not less than 250 units, and viosterol (a preparation of irradiated ergosterol) from 600-800 units. The most feasible explanation of these remarkable facts is that there are two, or several, antirachitic substances, no doubt closely related to each other, but not completely identical.

VITAMIN E

The discovery of a vitamin necessary for successful reproduction in both sexes was made by Evans and his colleagues of the University of California. It was found that when rats were reared on a diet which was adequate as regards protein, mineral salts, and the known vitamins, they became partially sterile in the first generation and completely sterile in the second. The pathological basis of this sterility has been carefully studied.

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In the female rat the ovaries are not damaged, mating, fertilization, and implantation of the foetus in the wall of the uterus take place normally. But the mechanism by means of which the foetus obtains from the mother the materials necessary for its development is impaired, so that it soon dies and is re-absorbed. In the male, there is gradual degeneration of the cells of the testes which produce spermatozoa, resulting after a time in permanent sterility.

Vitamin E resembles vitamin B₁ in that it is found in most common foodstuffs. Leaves and seed embryos contain it in abundance, and wheat germ oil has been much used for preparing vitamin E concentrates. Cod-liver oil, rich in the other fat soluble vitamins, A and D, is a poor source of vitamin E. It requires patience and skill to produce symptoms of vitamin E deficiency in the laboratory rat; sometimes it is necessary to feed animals on a diet deficient in the vitamin for several generations before typical reproductive failure manifests itself. Taking everything into consideration, and particularly the wide distribution of vitamin E in ordinary foodstuffs, it does not seem likely that vitamin E deficiency is a common cause of sterility in human beings. Various attempts have been made to treat an excessive tendency to abortion in

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women by vitamin E concentrates, but conclusive results have not been obtained. On the other hand, it is not improbable that vitamin E may prove of importance to the farmer and stockbreeder.

But while specific deficiency of vitamin E *may* be uncommon among human beings, the dependence of successful reproduction on satisfactory diet must be emphasized. It is during pregnancy and lactation that the ill effects of a diet deficient in vitamins and mineral salts are most likely to manifest themselves; what sufficed for one may not suffice for two, and both mother and child may suffer. If a woman is to bear fine children without exhaustion or impairment of her own health, and feed them successfully with her own milk, she must herself consume a well-balanced diet containing all the essential food-factors in abundance.

VITAMIN K

Vitamin K, which belongs to the fat-soluble group, is often known as the "anti-hæmorrhagic" vitamin. In fowls fed on a diet deficient in this vitamin, the clotting period of the blood is prolonged: in a word, a condition is produced resembling that present in "bleeders," who may bleed to death as the result of a tooth extraction.

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The distribution of vitamin K in foodstuffs is now being worked out ; it is present in green leafy vegetables and liver. The importance of this food-factor in human nutrition and its possible clinical applications will doubtless be actively studied during the next few years.

INTERNATIONAL VITAMIN UNITS

International vitamin units have been established for four vitamins—A, B₁, C, and D. In 1931 the Permanent Commission on Biological Standardization of the Health Organization of the League of Nations convened a conference of vitamin workers drawn from many countries to deal with this question. Provisional units were then adopted, and the work of the 1931 meeting was subsequently reviewed and revised by a second similar conference held in 1934. International standards and units are now replacing the various national units, which, for commercial purposes, had been adopted in various countries before the 1931 conference.

Perhaps the most useful purpose fulfilled by vitamin units is that they enable the strength of commercial vitamin preparations to be stated in exact figures. The medical profession is thereby assisted in arriving at an accurate scale of dosage, and the purchaser

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has some indication of what he is buying. Further, the existence of a generally accepted system of standards and units simplifies legislative control of preparations offered for sale. In the United States all cod-liver oil sold for medicinal purposes must contain a certain minimum number of vitamin A and D units per gramme.

Vitamin units assist the laboratory worker attempting the purification and chemical identification of the various vitamins. They make it possible to consider human vitamin intake and requirements in reasonably exact quantitative terms. Their use helps to make the results obtained by different research workers comparable.

It is now possible to estimate the vitamin C content of foodstuffs by a chemical test. For the estimation of vitamin A, a spectrophotometric method of assay, based on the fact that vitamin A has a specific absorption band at $328\text{ m}\mu$, is now widely used, and spectrophotometric and colorimetric methods of estimating carotene have proved of practical value. There is no doubt that the time will shortly arrive when the vitamin potency of test materials will be expressed in terms of pure active vitamin present.

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THE VITAMIN CONTENT OF FOODSTUFFS

There is no space, in this little book, to include tables giving the vitamin value of foodstuffs. The reader may be referred to the tables given in the Medical Research Council's Report, *Vitamins: A Survey of Recent Knowledge*. In that report, drawn up before the establishment of international units, values are expressed in terms of +, + +, and so on. More recently investigations in various countries have worked out the vitamin potency of samples of common foodstuffs in terms of "biological" units, international units, or of the pure vitamin itself. There is very considerable variation in the vitamin content of the same type of foodstuffs in different circumstances, and we have as yet little knowledge of the influence of various factors on the absorption and utilization of vitamins.

CHAPTER IV

MINERALS

THE student of the practical problems of nutrition gives as much attention to mineral elements as to the energy-yielding food-factors and vitamins. Apart from carbon, hydrogen, oxygen, and sulphur, there are some thirteen elements which are essential components of human tissues, and a number of others which have been found in the body in very small amounts and may or may not fulfil an important physiological rôle. The essential mineral elements, like protein and fat, undergo metabolism and exchange ; they are continually being discarded by the body and need replacing. Unless the loss is made good by the intake of equal quantities in water and food, physiological equilibrium cannot be maintained and health will suffer.

The functions fulfilled by mineral elements in the body are manifold. The skeleton, for example, is largely composed of calcium phosphate. They are essential to the formation of the various organic compounds which constitute the soft tissues. In solution in the

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body fluids, they influence the functions of muscular contraction and nervous irritability, and supply material for the formation of digestive juices. They safeguard the comparative neutrality of the body fluids, including the blood. Without calcium, the blood will not coagulate. For the transport of oxygen from the lungs to the tissues, and of carbon dioxide from the tissues to the lungs, hæmoglobin is necessary, and iron is part of the hæmoglobin molecule. Internal secretions or hormones, which profoundly influence the whole economy of the body, require mineral elements for their formation. We may say, in short, that such elements, entering into the composition of every living cell, are necessary to all the fundamental processes of life.

For the purposes of practical dietetics, particular stress must be laid on four elements: calcium, phosphorus, iron, and iodine. These are the elements which, as far as our present knowledge indicates, are most likely to be present in insufficient quantities in human dietaries. Curious and remarkable deficiency diseases have been produced in the laboratory by depriving rats wholly of such elements as manganese, magnesium, and zinc; their production indicates that these elements are essential to the mammalian organism, but there is as yet no evidence that such diseases

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occur outside the laboratory. Deficiency of sodium chloride is a practical reality, but it occurs in human beings only when excessive amounts of salt are lost in the sweat. Stokers and others who work in very hot atmospheres may suffer from malaise and even from severe cramp in the abdomen as a result of loss of salt through sweating. It has been found that "stoker's cramp," and allied conditions, can be prevented by drinking water containing a little common salt. For those whose work is of a less strenuous and sweaty nature, ordinary mixed diets supply sodium chloride in abundance, even apart from the large quantities which are usually added as a condiment.

CALCIUM

Let us consider first the mineral element which occurs in the largest quantities in the human body—calcium. It has been reckoned that a normal man weighing 70 kilos contains about 1,050 grammes of calcium. The physiological functions of calcium—or rather the results of calcium deficiency—are well described in the *Annual Report of the Chief Medical Officer of the Ministry of Health for the year 1933* in the chapter dealing with the problems of nutrition.

“ A deficiency of calcium during the growth

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period, when the effects of inadequate diets are particularly liable to become manifest, would result in defective development of the bony skeleton. This is the most obvious effect of such a deficiency, but others less striking, though just as important, would occur. The proper functioning of contractile tissues depends on the presence of a certain concentration of calcium ions in their environment, and as the calcium in the blood is lowered by calcium-poor diets, the contractile elements in the body, e.g. the musculature of the circulatory and alimentary systems, would not play their requisite parts in a proper fashion. There is also evidence for believing that absorption of carbohydrates would be reduced by deficiency of calcium in the blood. Further, the metabolism of calcium is intimately bound up with that of phosphorus and with the function of the parathyroid gland, so that any disturbance of the former is bound to lead to disturbances in the metabolism of phosphorus and in parathyroid function. In addition, since calcium plays a dominant rôle in maintaining the selective permeability which is an essential characteristic of all living cells, there is probably not a function in the body which would not be adversely affected by continued ingestion of diets low in calcium. Widespread and far-reaching effects may thus

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be liable to result from even a single dietary deficiency."

Considerable importance, then, must be attached to the question of an adequate supply of calcium. During the period of growth, requirements are greater, relative to the size of the body, than in adult life, because of the large demands of the growing skeleton. The importance of an adequate supply is equally pronounced during pregnancy and lactation; a healthy breast-fed baby of three months contains large amounts of calcium obtained from its mother. Sherman, of Columbia University, has analysed the results of ninety-seven "calcium balance" experiments quoted in the literature. He found that the amount of calcium excreted by average men and women ranged from 0.27 to 0.82 grammes daily, with an average of 0.45 gramme "per man per day." This figure has been taken to represent the minimum amount of calcium which must be present in the food to make good daily loss. But in practical dietetics we are not concerned, or should not be concerned, with minimum requirements; a large margin of safety is desirable. Sherman has therefore proposed a figure 50 per cent. higher than the average amount excreted—0.68 grammes per day. Requirements of children

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have been reckoned as high as 1 gramme per day; those of pregnant and lactating women as 1.6 grammes per day. It will be recalled that the retention of calcium and phosphorus is regulated by vitamin D; the less vitamin D available, the more important it becomes to ensure an adequate intake of these elements.

Sherman considers that the ordinary mixed diet of Americans and Europeans is probably more often deficient in calcium than in any other mineral element. The easiest way to ensure sufficiency of calcium is by a large intake of milk and milk products (except milk fats). A litre of milk contains about 1 gramme of calcium, and a kilo of cheese over 9 grammes. Among other valuable sources of calcium may be mentioned most leafy vegetables, egg-yolk, and nuts. But it seems that children assimilate milk calcium more readily than calcium contained in other foods, and the best way of making sure that their calcium requirements are fulfilled is by a large intake of milk. Milk, of course, contains other valuable food factors, such as vitamins A and B₂, and also proteins of high biological value, and it is not only because of its richness in calcium that a high intake on the part of children—750 to 1,000 c.c. per day—is recommended by authorities in the United States of America and elsewhere.

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PHOSPHORUS

Phosphorus, like calcium, is essential to all the actively functioning tissues of the body. It is of less importance than calcium only because it is less likely to be insufficiently supplied by ordinary human diets. Using the same methods which he employed to reckon calcium needs, Sherman has calculated the phosphorus requirements of an adult as 1.32 grammes per day, a figure which allows for a 50 per cent. margin of safety. Eggs, meat, fish, milk, whole cereals, legumes, and nuts are among the common foods rich in phosphorus.

While the ordinary diets of Western civilization appear to contain phosphorus in adequate amounts, it is not improbable that phosphorus deficiency is a cause of ill-health in many parts of the world. It is of paramount importance in connection with the feeding of domestic animals. On millions of acres of grazing land throughout the world the mineral content of the pasture, and most commonly the phosphorus content, is the limiting factor in stock-raising. There are large areas in South and East Africa and in the United States where the soil and grass are deficient in phosphorus and healthy sheep and cattle cannot be reared unless special measures are taken. It has

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been observed that cattle in a condition of "aphosphorosis" will readily devour animal food to satisfy their craving for phosphorus. The eating of putrescent carcases may in its turn lead to botulism.

Since soil poor in phosphorus tends to produce plant life poor in phosphorus, human beings as well as livestock may in certain parts of the world suffer from mild degrees of "aphosphorosis."

IRON

The body of a man of average size and weight contains rather less than 3 grammes of iron, the physiological importance of which is out of all proportion to the amount present. Iron is located mainly in the red blood corpuscles as part of the hæmoglobin molecule, and we associate iron deficiency particularly with hypochromic anæmia, which is essentially a diminution of the colouring matter of the blood. But iron is found not only in the 5,000,000,000,000 red blood cells; it is present in all actively functioning cells as part of the chromatic substances which stand in close relation to cellular vital activity. It is possible that copper is intimately associated with iron in the oxidation reactions which take place within the cell.

There is little reserve of iron in the body,

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and if output of iron (derived mainly from the disintegration of red blood corpuscles) exceeds intake, anæmia will result. Some years ago Sherman tentatively suggested an intake of 15 milligrammes per adult per day as standard ; subsequent investigations suggest that the figure is somewhat on the high side as far as adult men are concerned, and may perhaps be reduced by half or more. The requirements of children may perhaps be taken as lying between 5 and 10 milligrammes. The requirements of women in the child-bearing age are considerably greater than those of other age-groups—20 milligrammes or over. Nutritional anæmia, related to deficiency of iron in the diet, is most commonly seen in women of the child-bearing age.

These estimates are derived from experiments in which it was assumed that all the iron in the food can be utilized. Recently, however, a group of American workers have observed that the *availability* of iron in various foodstuffs (i.e. the proportion that can be absorbed and utilized) is very variable. Blood, for example, is found by ordinary chemical assay to be rich in iron ; in fact, the richest in iron of all natural foodstuffs. (Blood is an important food in certain parts of the world.) But it has been found that blood iron is largely present in a form which cannot

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be utilized by the body. The iron in green vegetables may be largely unavailable also. The whole problem of iron requirements in terms of ordinary diets and foods will need re-examination in the light of these facts.

Nutritional anæmia, related to insufficient iron intake, may be one of the most widespread of food deficiency diseases. Mackay, for example, has shown that 50 per cent. of infants in the East End of London develop some degree of anæmia during the first year of life. Milk, the staple food of infants, is deficient in iron, and prolonged feeding on an exclusively milk diet renders young animals liable to anæmia; the danger in babies is greater if they are fed on cows' milk or the milk of an anæmic mother. Nutritional anæmia in infants can be prevented by dietetic treatment of their mothers during pregnancy and lactation, or by providing them with "extra" iron from the third or fourth month of pregnancy onwards. Another method of prophylaxis is to give the infant a mixed diet before anæmia has had time to develop. The modern tendency in infant feeding is to give solid food at an earlier age than formerly. Recent investigations in Aberdeen showed that, of 1,000 women of the poorer classes, 50 per cent. had some degree of anæmia, 15 per cent. being severely anæmic. The victims

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were chiefly women of the child-bearing age, subject to loss of blood during labour and the puerperium and to excessive menstrual flow between pregnancies, who at the same time consumed a diet deficient in iron—e.g. a diet largely composed of bread, margarine and potatoes. Many of these anæmic women did not consider themselves ill; they accepted with resignation their condition of ill-health and general wretchedness as the usual lot of the harassed wives of working men.

Anæmia of this nature can be rapidly improved by iron medication. This method of treatment is more effective than the provision of a diet containing abundance of iron-rich foods, because it ensures a larger intake. But as regards the *prevention* of nutritional anæmia in adult women, the importance of a diet rich in iron is clear.

A similar or closely related condition—chlorosis or green sickness—has largely disappeared within the last thirty years. Chlorosis occurred chiefly among working girls—waitresses, shop assistants, domestic servants, etc.—and not so long ago was one of the commonest diseases seen in the wards and out-patient departments of city hospitals. Its victims probably lived largely on a diet of white bread, margarine, potatoes, and tea. In 1898 Stockman found that the iron content

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of the extremely inadequate diet of two chlorotic girls varied between 1·2 and 3·2 milligrammes per day. Modern working girls have a higher standard of life, and a more satisfactory diet, than their predecessors. There seems no reason why the nutritional anæmias of infancy and the child-bearing period should not, in the wealthier countries of the world, follow chlorosis into oblivion.

In the East, serious and often fatal anæmias among pregnant women are extremely common. One type of anæmia is associated with deficiency of iron in the diet, the ill-effects of which may be accentuated by the steady destruction of red blood corpuscles by ankylostomiasis or malaria. Or vice versa. Treatment by massive doses of iron is indicated. Another type seems to be due to the deficiency of a specific factor, of unknown nature, in the diet; this responds, like pernicious anæmia, to liver therapy, and is not benefited by iron. In any Indian maternity hospital one can find rows of anæmia cases, many in a parlous state, and the "anæmias of pregnancy" must be counted as among the more important of the food deficiency diseases.

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IODINE

There are about 25 milligrammes of iodine in the body of a man of average size ; of this the thyroid gland contains about 10 to 15 milligrammes. The secretion of the thyroid gland—thyroxin—contains iodine as one of its chemical constituents. If it is inadequately supplied with iodine, it enlarges, apparently in an effort to increase its efficiency. There is little doubt that *one* of the factors leading to simple enlargement of the thyroid gland—goitre—is insufficiency of iodine in food and drinking water. Goitre of this nature is one of the commonest of food deficiency diseases. It has been emphasized by McCarrison that factors other than lack of iodine—e.g. vitamin deficiency, contaminated water supply, unhygienic conditions—may also play a part in its genesis.

Iodine deficiency may produce more serious results than a swelling in the neck. If children suffer from birth from insufficiency of thyroid secretion, they may become cretins—ugly, dwarfish, under-developed, semi-imbecile creatures only too commonly met with in certain parts of the world. Cretins may be greatly improved by the administration of extracts of the thyroid gland. In adults the condition corresponding to cretinism is called

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myxœdema. For a description of myxœdema the reader may be referred to medical text-books which usually contain striking photographs of victims of this disease before and after treatment.

Endemic goitre is most prevalent in mountainous areas far from the sea, in which, for reasons still under discussion, the iodine content of soil and water is low. Public health measures designed to prevent goitre have been adopted in a number of countries, notably Switzerland, New Zealand, and the United States of America. Among methods of prophylaxis are the regular administration of iodine compounds to school children, and the encouragement of the use of table salt containing sodium iodide. In goitrous areas not only human beings but domestic animals are likely to suffer from goitre.

The iodine content of common foodstuffs varies from place to place. Sea foods in general are rich in iodine; cod-liver oil may be of value for its high content of iodine as well as for its richness in fat-soluble vitamins.

CHAPTER V

DIETARY AND PHYSICAL STANDARDS

FOR practical public health nutrition work, it is essential to have dietary standards: something to measure diets by. For this purpose certain figures, representing average needs and applicable to large numbers, but not to individuals, have been widely used. The following are among the best-known schedules of calorie, protein, carbohydrate, and fat requirements, representing the needs of average men engaged in "average" work.

STANDARD DIETARIES

	Protein (grammes).	Fat (grammes).	Carbo- hydrate (grammes).	Calories.
Voit . . .	118	56	500	3,055
Rubner . .	127	52	509	3,092
Atwater . .	125	125	450	3,520
Advisory Committee (Ministry of Health)	100 (animal protein 35 g.)	100	400	3,000
Von Tyszka	80-100 (animal protein 40 g.)	60-80	500	3,000

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A valuable schema of dietary requirements is that drawn up by Stiebeling, of the Bureau of Home Economics, Washington (Table IV). This is based on laboratory researches and dietary surveys; the figures representing mineral requirements are derived from the investigations of Sherman.

The original schema includes an estimate of vitamin A and C requirements, which has here been translated into international units. It will be noted that Stiebeling assesses protein requirements at a figure which is lower than those put forward by Voit, Rubner and Atwater. This is in conformity with the trend of modern dietetics. In the days when the classical standards, such as those of Rubner and Atwater, were formulated, protein was thought to be the all-important dietary element, and there was a natural tendency to insist on the importance of a high intake.

It is quite probable that some of the estimates in Stiebeling's tables are unnecessarily generous. There is evidence, for example, that iron requirements, except for women in the child-bearing period, are less than half the amounts given. On the question of vitamin requirements there remains much to be learnt, but the problem is in process of being reduced to a satisfactory quantitative basis.

It is important to realize that such assess-

TABLE IV
QUANTITIES OF NUTRIENTS REQUIRED FOR INDIVIDUALS PER DAY (Stiebeling)

Individuals by age, sex, and activity groups.	Dietary allowance in :						
	Energy value.	Protein.	Calcium.	Phosphorus.	Iron.	Vitamin A.	Vitamin C.
	Calories.	Grammes.	Grammes.	Grammes.	Grammes.	International units.	
Child under 4 years . . .	1,200	45	1.00	1.00	0.006-0.009	1,500	1,085
Boy, 4-6 ; girl, 4-7 years .	1,500	55	1.00	1.00	0.008-0.011	1,500	1,160
Boy, 7-8 ; girl, 8-10 years .	2,100	65	1.00	1.00	0.011-0.015	1,750	1,230
511 Boy, 9-10 ; girl, 11-13 years	2,400	75	1.00	1.20	0.012-0.015	1,750	1,300
Moderately active woman ; boy, 11-12 years ; girl, over 13 years	2,500	75	1.00	1.20	0.013-0.015	2,000	1,370
Very active woman ; active boy, 13-15 years	3,000	75	0.88	1.32	0.015	2,000	1,450
Active boy, over 15 years .	3,000-4,000	75	0.88	1.32	0.015	2,000	1,450
Moderately active man . .	3,000	67	0.68	1.32	0.015	2,000	1,450
Very active man	4,500	67	0.68	1.32	0.015	2,000	1,450
Average per head of the popu- lation	2,810	68	0.9	1.23	0.013-0.014	1,900	1,370

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ments of dietary requirements have very little relation to individuals. Further, they are tentative to a degree not generally realized by conventional nutrition workers. A distinguished scientist cautiously suggests that human needs of a particular food-factor may be in the neighbourhood of a certain figure ; his figure is copied into text-books and soon comes to be regarded, not as a provisional estimate, but as an absolute standard requirement.

An experienced nutrition worker can readily draw up dietary schedules and menus which comply with current standards in respect of their content of calories, protein, fat, carbohydrate, mineral elements, and vitamins. Having collected detailed information about the diet of a group of human beings, he can work out intake of the various food-factors and use the standard yard-stick to decide whether their diet is all it should be. In both cases, of course, some laborious calculations will be necessary. This is all very well for the expert who is accustomed to think in terms of food-factors rather than of food, but for many practical purposes we need a simpler approach. Much of what modern nutritional science has to say as regards dietary *quality* can be stated in a few paragraphs in terms of actual foodstuffs.

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To McCollum we owe an invaluable phrase, the *protective* foods. Food may roughly be divided into *non-protective* and *protective*. Among the former are bread, cereals in general, root vegetables, sugar, and vegetable fats (e.g. margarine); among the latter, animal fats, liver, cod-liver oil, dairy products, eggs, green vegetables, and fruits. Foods belonging to the first group supply calories, but in general they are poor in proteins of high biological value, vitamins, and mineral salts; those belonging to the latter are more richly supplied with these food-factors.

In November, 1935, a Commission of the League of Nations met in London and drew up a report entitled *The Physiological Bases of Nutrition*. The Commission was composed of leading nutrition workers from the United States of America, the United Kingdom, France, Scandinavia, and the U.S.S.R. In its report, it attempts to define a series of *optimum* dietary schedules in terms of the dietary habits of Western civilization. It is noticeable that in these schedules the "protective" and "energy-yielding" foods are separately listed, the importance of the former being thereby emphasized. Table V reproduces the dietary schedule recommended by the League Commission for pregnant and nursing mothers.

TABLE V.—DIETARY SCHEDULE FOR THE PREGNANT AND NURSING WOMAN .

A. Protective Foods.

Food.	Amount.	Cal- cium.	Phos- phorus.	Iron.	Iodine.	Vita- min A.	Vita- min B ₁ .	Vita- min B ₂ .	Vita- min C.	Vita- min D.	Cal- ories.
		Grammes.		Milligrammes.		International units.			International units.		
MILK	1,000	1.2	0.9	2.4	0.02-0.05	3,000	50-150	Rich	Poor	Poor	660
MEAT (or fish or poultry)	120	—	0.3	1.5		Poor	Poor	Rich	Poor	None	260
EGGS (one)	50	—	0.1	1.4		1,300	14	Rich	None	40	70
CHEESE (Cheddar)	30	0.3	0.2	0.4		800	Poor	Good	Poor	Poor	125
Green and Leafy VEGETABLES	100	0.5	—	1.0		100	25 (raw)	Good	300 (raw)	None	30
POTATOES	250	—	0.2	3.0		Poor	50	Good	320 (cooked)	None	250
LEGUMES (Dried)	10	—	—	2.0		Poor	15	Good	None	None	35
COD-LIVER OIL	3.5	—	—	—	Richest source	3,500	None	None	None	300	30
An available source of vitamin C (from raw fruits and vegetables)									250-500		
Total yield		2.0	1.7	11.7	Adequate	8,700	154-254	Ade- quate	870- 1,120	340	1,460

B. Supplementary energy-yielding foods by means of which the individual's energy requirements can be met.

CEREALS as needed :											
Highly milled	250	—	0.2	3.0							1,000
or											
Whole grain	250	—	0.9	9.0			270				1,000
FATS as needed											
SUGAR as needed											

Protein content between 75 and 80 grammes.

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The basis of almost all human diets is one of cereal grains : millions of the human race consume a preponderantly cereal diet containing a minimum of animal foods and vegetables. On such a diet rats will not grow to full-sized maturity ; if they survive at all they will be small and scraggy, and they will be unable to reproduce their kind as efficiently as rats on a more satisfactory diet. If a diet which is largely cereal is analysed and compared with current standards, it will be found to be deficient in protein, vitamins, and mineral salts. By a reduction of a proportion of cereal in favour of some of the protective foods, standard requirements can be fulfilled.

A good diet, then, should contain plenty of protective foods and particularly of milk, green vegetables, and fruit—rather more, in fact, than is usually included in average Western European diets. Milk and cheese are rich in calcium and supply protein of high biological value and vitamin B₁ ; milk fat in its various forms is an important source of vitamin A. The food value of eggs resembles that of milk ; the former are, however, poorer in calcium and richer in iron. Green vegetables are moderately rich in calcium, vitamin A, and vitamin C. Fruits are valuable in that they supply vitamin C and other vitamins. In the East, the various pulses are useful

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supplements to diets otherwise poor in protein and the B vitamins.

A second point of importance is the following : in the temperate zone it is difficult to supply sufficient vitamin D to infants and young children through the medium of sunshine and ordinary foodstuffs. They need "extra" vitamin D in some form—e.g. cod-liver oil. Such provision will ensure freedom from rickets, and—assuming the hypothesis of Mrs. Mellanby and her school is correct—from dental caries. We may recall that infants, particularly bottle-fed infants, should be given fruit-juice or vitamin C in some other form, to protect them from scurvy.

If plenty of protective foods are eaten, elasticity in the remainder of the diet is permissible, and choice may be allowed free rein. Other foods are valuable in their several ways. The cereals supply energy in concentrated form and contain from 7 to 15 per cent. of vegetable protein, rice being the lowest as regards protein content and wheat the highest. Unmilled cereals are superior to milled cereals in protein, vitamins, and mineral salts, but the latter are wholesome foodstuffs as long as they form part of a varied and nutritious diet. They are more easily transported and stored than unmilled cereals. The greater the quantity of cereal included in the diet, the more

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important it becomes that the most nutritious parts of the grain should not be removed. American workers recommend that one-third of the cereal eaten should be in unmilled form, which, applied to the comparatively varied diets of Western civilization, seems a sound and reasonable idea. We may add the suggestion that children and pregnant women should consume wholemeal bread.

Muscle meat—sometimes classed as a protective food—is in moderation a useful and palatable article of diet, supplying animal protein, vitamin B, and available iron; glandular organs and blood are, however, richer in vitamins and mineral salts. The vegetarians who insist that excellent health is possible without meat are perfectly justified, but most of us find meatless meals a shade dull. Certainly those who because of poverty can obtain little meat (i.e. the majority of human beings) consume it with enormous relish on the rare occasions when it comes their way. What is true of meat is, in general, true of fish.

The legumes, of which the most important are beans, peas, and lentils, have a high content of B vitamins, and of vegetable protein. There is evidence, however, that legume proteins are of lower biological value than the proteins of meat, eggs, and milk. It is also

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less absorbable. While a cereal-plus-legume diet (consumed by millions in India) is preferable to a diet entirely composed of cereals, it cannot support *optimum* development and health.

The tubers and root vegetables, which contain little protein and are not rich in mineral elements, cannot be classed as protective foods. Like cereals, they supply carbohydrate in the form of starch for the body to use as a supply of energy. In general, they are a useful source of vitamin C, particularly in Northern countries where fresh fruit and leafy vegetables are not abundantly available.

Nuts are rich in fat and protein; commercially they are of importance as a source of vegetable fat. Vegetable fats and oils—olive oil, cotton-seed oil, sesame oil, etc.—have assumed a prominent position in the diet of modern civilization and are consumed in large quantities in most countries of the world. They are a cheap source of calories and fat, but lack fat-soluble vitamins. Margarine is to-day usually made from vegetable fats and is not equal to butter in nutritive value unless it is specially enriched by the addition of substances containing vitamins A and D. Brands of margarine are now on the market which are equivalent in vitamin con-

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tent to good summer butter. The popularity of such "vitaminized" margarine is growing.

Sugar supplies calories cheaply and in concentrated form; it is rapidly and easily absorbed and is more easily transformed into muscular energy than any other food. Those who indulge in strenuous and prolonged exercise learn that sugar is the best "muscle restorer." There is little objection to the inclusion of reasonable amounts of sugar in ordinary diets, but when the amount taken is excessive the physiological value of the dietary may be reduced owing to the crowding out of protective foods.

This brief account may help the reader to estimate roughly the value of dietaries—his own and other people's. The distinction between "protective" and "non-protective" foods is not clear-cut at every point, but it is highly useful for rapid assessment. And outside a few favoured countries, the defects in the diet of the mass of the population are so pronounced that no very refined methods are required to discover them.

MALNUTRITION

In the preceding section we have outlined an answer to the question, "What is the best type of diet?" We have noted the existence of dietary "standards" built up by a long

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series of clinical and laboratory experiments and observations. Very closely allied to the problem of dietary "standards" is the problem of detecting "malnutrition" in human beings. The ultimate test of the adequacy or otherwise of a diet must be its effect on development and health.

Faulty feeding impairs health in a variety of ways. Deficiency of certain vitamins may result in serious disease and even in death. If rickets, scurvy, or some other food deficiency disease is rife among a population, then clearly its diet is defective. One valuable criterion of the "state of nutrition" of a population group is the prevalence of food deficiency diseases, whether in a severe or mild form.

In very ill-nourished parts of the world, such as South India and Ceylon, obvious symptoms of food deficiency disease—"toad-skin," xerophthalmia, stomatitis—will be found in a certain percentage of almost any group of school-children belonging to the poorer classes. The "state of nutrition" of different groups can be roughly compared by recording the incidence in each of such symptoms; and, if data can be obtained about the diet of the groups, light is thrown on basic dietary requirements of human beings. In well-fed countries obvious symptoms of food deficiency disease will not be

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commonly found in average groups of school children and this criterion of "state of nutrition" cannot be employed. During recent years attempts have been made to devise tests by which the existence of food deficiency diseases in their most incipient stages, before obvious symptoms are present, can be discovered. It is possible to detect rickets in a very early and mild stage by X-rays or by blood analysis. Mention may be made of Hess's "capillary resistance test" in incipient scurvy, Jean and Zentmire's visual test for detecting slight degrees of vitamin A deficiency, and the urinary excretion tests for vitamins C and B₁, devised by Harris and his co-workers, in which the output of vitamins in the urine is used as an indication whether intake is sufficient. Further confirmation is required of the scientific and practical value of these and similar tests. If this is forthcoming, they should provide the public health worker with a useful weapon with which to detect and combat malnutrition.

In what other directions should we look for evidence of faulty feeding? This is a problem of great interest to public health authorities and school medical officers. A satisfactory "state of nutrition" involves the full realization of inherited physical potentialities. The chief medical officer of the British Board

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of Education, in his 1928 Report, connects the term "nutrition" with "the total well-being and right functioning of the whole body: height, weight, substance, colour, elasticity, balance and carriage of the body, the effective functioning of the nervous system, heart, lungs, and alimentary tract, the readiness and relative strength of the muscular system"—all these, he implies, must be taken into account in judging an individual's "state of nutrition." While the "state of nutrition," in this wide sense of the term, may be affected by a number of factors (e.g. lack of sleep, rest, and fresh air; physical defects, such as septic tonsils), the most important factor, in the majority of cases, is the quality and quantity of the diet consumed. An adequate and well-balanced diet will usually produce a state of good nutrition, while a defective diet will ultimately give rise to a state of malnutrition. The detection of the effects of improper feeding, and the detection of "malnutrition," tend, in practice, to be very similar activities.

Clinically, however, the relation between diet and the general condition of the body is far from simple. Outside the laboratory, dietary deficiency tends to be multiple; we do not meet human beings who, in the familiar words of scientific papers on vitamins, consume diets "deficient in vitamin X but com-

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plete in all other respects." Further, the various food-factors have complex functions to fulfil; deficiency of any one of them may produce a variety of ill-effects on the various systems of the body. Hence diets which are qualitatively inadequate, but not very inadequate, tend to give rise to indeterminate states in which health and physical efficiency suffer—in fact, to the condition of "malnutrition," the detection of which is so serious a physiological, social, and even political problem.

Since malnutrition involves an impairment of function in many systems of the body, it follows that tests of a physiological nature are likely to prove most valuable for discovering its presence. In certain states of malnutrition, for example, the hæmoglobin content of the blood is lowered; hæmoglobin estimations are not too time-consuming and might be carried out on large numbers of children. Physical efficiency tests, e.g. the ratio of strength, as measured by a dynamometer, to weight, have been suggested by some authorities. So far, however, no physiological test really suitable for general application has been discovered, and further research in this field is greatly to be desired. We must remember that any method of detecting malnutrition must be of such a nature that it can be applied

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to large numbers of school children by busy medical officers.

There is at present considerable controversy as to the best methods of assessing "state of nutrition." One method is by clinical examination, by means of which the physician seeks to "assess" the general condition of the body. He notes whether the child is fat or thin, listless or gay, pale or rubicund, active or lethargic; whether its musculature has a good tone and its skin a healthy sheen, and so on. The figures of malnutrition supplied by school medical officers of health in England, which give rise to abundant commentary in the Press, are obtained by means of such clinical assessment. The disadvantage of this method of judgment is that it is purely subjective. One physician's idea of good, bad, or poor nutrition may be very different from another's; hence the disconcerting fact that two school medical officers, working in adjacent and precisely similar manufacturing towns, may return widely different figures representing the percentage of malnourished children in their districts. It must be remembered that a physician's judgment is strongly influenced by the type of child he habitually examines. If he is used to examining children in a very poor district which suffers from unemployment, then his idea of a "good

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state" of nutrition tends to be a low one—what he labels "good" would be "bad" to a colleague working in a more prosperous area. When Dr. Eliot of New Haven, Connecticut, and a number of colleagues, used to examining New England children for evidence of malnutrition, went to carry out studies on children in Porto Rico, they found themselves in difficulties for this very reason. "Though every attempt," Dr. Eliot says, "was made to maintain the same basis for judging the physical condition and development of the children as that used in New Haven, it is probable that the great prevalence of poorly nourished children so influenced the physicians that the whole scale of clinical estimate was lowered from that used in New Haven."¹

In England, as already observed, the diagnosis of malnutrition in schools is based on clinical examination. The subjective element which enters into the assessment is illustrated by the following: Bootle (which is for all practical purposes an integral part of greater Liverpool) returned in 1933 a malnutrition rate twelve times as high as Liverpool itself; Leeds and Wigan, containing very similar industrial populations, returned rates of 31 and 9 per 1,000 respectively.

¹ U.S. Department of Labour Children's Bureau. Pub. No. 217, 1933.

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The "Dunfermline scale," used in the assessment of nutritional status by clinical examination, includes the following groups :

- (1) "Excellent." The state of nutrition of a healthy child of good social standing.
- (2) "Good." Children whose state of nutrition falls just short of excellent.
- (3) "Nutrition requiring supervision."
- (4) "Nutrition seriously impaired and requiring treatment."

Pirquet's well-known "sacratama" method is essentially similar in principle. Four diagnostic elements, the amount of blood (colour of skin), the amount of fat, the water content of the tissues, and the state of the muscles, each represented by a consonant, are graded into five degrees of excellence, each represented by a vowel. The results of the examination of each child are enshrined in a word of four syllables easily comprehended by those familiar with the system.

It is usually agreed that the most reliable method of detecting malnutrition is by clinical examination. But for public health nutrition work on a wide scale, the method has considerable disadvantages, of which the chief is the large subjective element. Figures obtained by clinical assessment purporting

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to represent the amount of malnutrition in some particular population group, often mean very little ; some consider them worse than useless, because actually misleading. Most other methods of assessing nutritional status are equally unsatisfactory, though for different reasons.

After the War, when Germany was still suffering from semi-starvation as a result of the blockade, Quaker relief organizations came to the rescue by offering to provide free food for children most in need of it ; only the worst sufferers could be supplied. German physicians were faced with the task of selection, and for this purpose they used Rohrer's " Index für Körperfülle " :

$$\frac{\text{Weight in grammes} \times 100}{\text{Height in centimetres}^3}$$

The idea underlying Rohrer's " Index für Körperfülle," and many very similar " indices of nutrition," is that a body of a certain height, if well nourished, should be of a certain thickness. If the " amount of covering " on the skeleton is reduced as a result of deficient diet, then the normal relation between height and weight is disturbed, and the disturbance will be reflected in a regular manner in the individual's " Index für Körperfülle." Thin children will have a lower index than fat children

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of equal height. This sounds plausible, and a little thought is required to realize the fallacies involved. If average figures representing weight in grammes $\times 100$ and height in centimetres³ are plotted on a graph for a series of age-groups, it will be found that the relationship between the two curves is not linear; the height curve rises more steeply, and as a result the index *sinks* with increasing size. When the indices of particular children are compared, not with average indices of children of equal height, but with the average indices of their age-group, the most paradoxical results are obtained. Let us take as an example three children, aged six, nine, and twelve respectively, equal in height and weight to the average at nine years. The "Index für Körperfülle" of the gigantic child of six will be below the average for that age-group, that of the child of nine equal to the average, and that of the child of twelve, who is extremely retarded in development, will be above the average. Comparison of the average indices of groups of children may be equally misleading. Thus, the fact that country children (in post-war Germany) were taller than city children gave the former a smaller average index than city children of the same age, in spite of the well-marked physical inferiority of the latter.

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All numerical "indices of nutrition" are, in fact, open to damaging criticisms. Pirquet's "pelidisi" index

$$\frac{\sqrt[3]{10 \text{ weight in grammes}}}{\text{Sitting height in centimetres}} = 100$$

was extensively used in post-War Vienna to pick out the most serious cases of malnutrition. It happens that the relation of the cube root of the weight in grammes to the sitting height in centimetres is approximately linear during the period of growth, and this fact influenced Pirquet in his choice of the index. According to Pirquet, the "pelidisi" of a muscular adult or fat child should be 100, and that of a healthy growing child should be about 94.

As a matter of fact, the average "pelidisi" index varies with age more than Pirquet imagined. This is one drawback to the method. But its main disadvantage lies in the fact that sitting height is very difficult to measure exactly, because the subject sits on the posterior muscles of the thigh, and can increase or decrease his sitting height by contracting these muscles. Weight being reflected in the index only by its cube root, it would require a change of weight of 1 kilogramme in a child weighing 25 kilogrammes, with a sitting height of 63 centimetres, to alter

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the index to the same extent as a difference of 1 centimetre in height. In practice larger errors than 1 centimetre in the measurement of sitting height must occur.

Pirquet's system of detecting malnutrition has the great advantage of combining anthropometric and clinical methods of examination. It proved of value in post-War Vienna. Tried out in the United States of America (without, it must be confessed, a great deal of enthusiasm), it was not a success. It may be recalled that in Vienna measurements and assessments were made by highly trained and experienced teams of workers, and that most of the children examined were in such a serious state of malnutrition that minor fallacies inherent in the method were obliterated.

Mere comparison of weight with a chosen standard provides little information about the "state of nutrition." Many ill-nourished children are under-weight, but many under-weight children are not ill-nourished. Very thin, but wiry, children, are often in excellent health. On the other hand, a child allowed to stuff itself with biscuits and chocolate may be over-weight for its age and yet in a wretched "state of nutrition." Individual weight *curves* provide a more valuable criticism; a steady, not excessive, gain in weight suggests a good nutritional status. This test is most useful

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in infancy. But it cannot be employed in assessing the condition of an infant or child not previously the object of investigation, and its employment is complicated by seasonal variations in the growth of children, the cause of which is not yet understood. Weight in relation to height has been much used in assessing the state of nutrition. In the United States of America it has been common practice to class a child as malnourished if he is 10 per cent. below standard weight for height, the standard tables being based on the measurement of a large number of children of good physique. Sometimes the higher limit of 7 per cent. is chosen.

Emerson employs the following classification :

10 per cent. or more (or 7 per cent.) below average weight for height = malnutrition.

Under average but less than 10 (or 7) per cent. = borderline.

Average to 20 per cent. above = normal (about 10 per cent. above is considered ideal); 20 per cent. above average = over-weight.

If a child is found by its school teacher to be much below weight, a red card is sometimes sent to its parents bearing the warning that attention must be given to the child's diet and health.

The basic principle underlying this method

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of detecting malnutrition, like that of most numerical "indices of nutrition," is that a body of a certain length should be of a certain "thickness." It has, however, been noted again and again that the comparison of "weight for height" of children with a given standard does not satisfactorily "select" children who are malnourished and whose diet requires improvement—at the best it "selects" only a certain percentage of these. In recent years efforts have been made in the United States of America and elsewhere to discover a system of measurement which will give more satisfactory results. The A.C.H. index, involving measurements of arm, chest, and hip girth, which has been elaborated by Franzen and his colleagues on behalf of the American Child Health Association, may prove valuable to school medical authorities, but it has not received an extensive trial in practice.

For public health purposes, clinical and anthropometric methods of detecting malnutrition are usually applied in association. It may be remarked that the branch of the subject of nutrition which is briefly and inadequately treated in the preceding paragraphs, is of great practical importance. Probably it is impossible to devise perfect methods of detecting malnutrition, but some-

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thing could be done to improve existing methods and clear up some of the confusion which reigns in this field.

Light is thrown on the question of physical standards and "state of nutrition" by the study of the physique of various peoples and classes in relation to diet. A pioneer worker in this field was McCay, who showed that the physique of the Bengali, whose staple diet is rice, is greatly inferior to that of certain North Indian peoples, whose diet is based on whole wheat and is richer in protein. The relation between diet, physique, and health in India has been extensively studied by McCarrison. In one striking experiment, McCarrison fed groups of rats on diets resembling those of various peoples of India—Sikhs, Pathans, Maharattas, Kanarese, Bengali, and Madrassis. Of these the Sikh has the best physique, the Madrassi the worst. The "Sikh diet"¹ used in the experiments was as follows: "freshly ground whole wheat made into cakes of unleavened bread (*chapattis*), milk, and the products of milk—butter, ghee, curds, butter-milk—*dhal* (legume), vegetables (fresh carrots and cabbage), tomatoes, root vegetables, fresh meat with bone and fat once

¹ It would be more accurate to use the term "Punjabi diet" here. Other communities besides the Sikh living in North India have a good diet and good physique.

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a week and water." The Madrassi diet was very different—"washed parboiled rice, *dhal* (a pulse), fresh vegetables, condiments, vegetable oil, ghee (sparingly), coco-nut, betel-nut and water."

It was found that the development of the experimental animals fed on the various diets corresponded very closely to that of the peoples themselves. The average weight of the group fed on the Sikh diet at the end of six months was 235 grammes; that of the group fed on the Madrassi diet 155 grammes. The diets of the other peoples produced intermediate degrees of growth, roughly corresponding to the physical development of these peoples. It is a reasonable assumption that the Sikh is a taller and stronger human being than the Bengali and Madrassi because he consumes a better diet.

Orr and Gilks compared the physique and health of the East African tribes, the Masai and the Kikuyu, living side by side in the highlands of Kenya. The Masai are a pastoral people, living largely on milk, meat, and blood; milk is taken in large quantities, up to 2 quarts daily. The Kikuyu, who are agriculturists, subsist on the usual diet of agriculturists in most parts of Africa and Asia—cereals, tubers, plantains, legumes, and vegetables, with the emphasis on cereals, which

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make up a large proportion of the diet. The latter tribe is greatly inferior in physical development and strength to the former. The Masai men are 3 inches taller and 23 lb. heavier than the Kikuyu men; the Masai women 3 inches taller and 27 lb. heavier than the Kikuyu women. These are striking differences. In the Nilgiri Hills of South India are to be found the remnants of an aboriginal pastoral people, the Todas, who consume large quantities of buffalo milk. The Todas still retain the fine physique of pastoral peoples; between them and the Badagas, agriculturists of Kanarese stock inhabiting the Nilgiri plateau, there is precisely the same contrast of that between the Masai and Kikuyu. In South India the eye becomes accustomed to small human beings; to meet a tall muscular Toda gives one a shock of surprise. Dwindling, bewildered, and pathetic, the Todas nevertheless retain a certain arrogance of bearing, a lightness and grace of movement, more characteristic of pastoral than of agricultural peoples.

The Japanese are a small people, though now steadily increasing in size as standards of living and diet in Japan improve. (The development of the fishing industry in Japan during recent years has been remarkable.) It has been observed that the children of Japanese

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and Chinese who have emigrated to the United States of America grow larger with each succeeding generation. America is one of the best-fed countries of the world, and even oriental emigrants partake of the crumbs which fall from their masters' tables. There can be little doubt that the rapid improvement in physique is largely due to diet. For practical purposes, milk is not consumed after weaning in China and Japan.

The well-fed human being, particularly the human being whose diet is rich in milk products, tends to be tall, straight, and graceful. On the other hand, a diet rich in cereals and lacking "protective" foods in sufficient quantities, seems to produce "dumpy" ungraceful men and women. In England public school boys are several inches taller than boys of the poorer classes, and very much "better-built." Though such factors as heredity and physical education play a part in producing such differences, diet is probably the most important factor. One must add that the physique of the poorer classes in the United Kingdom and in many other countries is steadily improving, and that one of the aims of public health nutrition work should be to lessen and ultimately close the gap between their development and that of the prosperous classes.

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During recent years a number of experiments have been carried out which demonstrate the value of milk in improving health and physique. The first experiment of this nature was carried out in 1922-5 by Cory Mann in a "Dr. Barnardo's Home" for boys near London. The children in this institution were living under excellent conditions, and their diet was quite a good one according to the usual standards of English charitable institutions; there was no under-feeding; "good plain wholesome food" was provided. For some reason, however, the boys were not developing as well as might have been expected, and accordingly an experiment was undertaken to discover whether a change of diet could improve matters. Six groups of thirty to sixty healthy children between the ages of seven to eleven were formed; these groups all received the same basic diet, i.e. the ordinary diet of the home, which contained 56 to 71 grammes of protein (a quarter being animal protein), 29 to 45 grammes of fat, and 288 to 347 grammes of carbohydrate; yielding on an average 1,900 calories. Each of the six groups were given, as an addition to the "basal" diet, one of the following: 90 grammes of sugar (pure carbohydrate); 50 grammes of margarine (fat); 50 grammes of butter (fat + fat-soluble vitamins); 21

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grammes of fresh watercress (rich in various vitamins) ; 21 grammes of casein (equivalent to the amount of casein in a pint of milk) ; and a pint of milk. An admirably conceived experiment. The children on these various regimes were watched for three years and a record of their growth and health were kept. The group receiving milk showed the most rapid increases in height and weight and were relatively free from minor ailments, fairly common among the other boys. They were high-spirited and mischievous, and in general showed greater energy and vitality than the other boys.

Of the remaining groups, those receiving 50 grammes of butter showed the largest height and weight increments. The addition of casein, which supplied 16 grammes of protein, did not have any very appreciable effect ; the boys in the casein group did not " grow " any faster than those on the basic diet alone.

Similar experiments have been carried out on larger groups of children in a number of countries, always with similar results. The addition of " extra " milk to the diet accelerates growth and enhances well-being. In most cases the children forming the experimental material for these beneficent investigations were poor or " lower middle class " children living on what appeared to be reason-

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ably adequate diets. Previously there had been no reason to suspect that these diets were unsatisfactory; current methods of examination would not have revealed any widespread malnutrition among the children.

One important fact emerged from large-scale experiments carried out in Scotland and Northern Ireland by Leighton and Clark: skim milk "supplements" the diets of the poorer classes in the United Kingdom as effectively as whole milk.

If the addition of "extra" milk to European diets improves their nutritive value, one might expect that a similar addition to the much less adequate diets consumed by children in Eastern countries—diets which contain no milk at all—would have an even more striking effect. It has. Elementary school children in Tokyo, given about 200 c.c. of milk daily for six months, showed gains in height and weight which were respectively 16 and 81 per cent. larger than those of controls receiving no milk. In South India one can effect a most remarkable transformation in children of the poorer classes by providing them with skim-milk powder, which is a by-product of the Australian and New Zealand butter industry. There is an immediate increase in the rate of growth, and an improvement in general appearance is clearly visible.

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Such experiments suggest a method of approach to the problem of "optimum" dietary requirements. If it could be shown, by large-scale experiments on growing children, that a certain diet produces a degree of improvement in physique and well-being which cannot be exceeded no matter how the diet is further enriched, it would be possible to define optimum standards with reasonable certainty. It is abundantly clear that there is a wide gulf, as regards diet and "state of nutrition," between the "adequate" and "satisfactory" and the "optimum." The goal of the modern nutrition worker is the "optimum." While he often finds it necessary, in an economically disorganized world, to think in terms of "minimum adequate diets," and has to content himself with low physical and health standards, he does so under protest. In a world capable of an enormously enhanced production of foodstuffs, a world said (until lately, when common sense reasserted itself) to be suffering from over-production of foodstuffs, emphasis must be placed on the optimum rather than the minimum.

CHAPTER VI

FOOD DEFICIENCY DISEASES

IN certain parts of the world food deficiency diseases are almost as lethal as the great "Captains of the Men of Death," tuberculosis, malaria, etc. We refer here, not to states of malnutrition which lower resistance to the invasion of microbes and protozoa, but to actual disease caused solely, or almost solely, by deficiency of one or more of the essential food-factors in the diet. The most serious and widely prevalent of such diseases to-day are perhaps the following: beriberi, pellagra, rickets, osteomalacia, certain types of anæmia, severe keratomalacia associated with marasmus. It is possible that certain additions may in future be made to this list: for example, portal cirrhosis, not associated with malaria or alcoholism, is a common cause of death among middle-aged Indians of the very poorest classes, and it may well be that this condition follows the consumption throughout life of a grossly defective diet. Probably many obscure conditions to be observed in hospitals in the East are related to diet deficiency.

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It is conceivable, of course, that many of the common diseases of civilization would disappear if civilized man were to adopt different dietary habits ; there is, for example, a definite group of diseases associated with over-nutrition—e.g. gout and diabetes. But to-day, in a poverty-stricken and ill-nourished world, nutrition workers in general are more interested in dietary deficiency than in dietary excess and the errors of those who can afford to lunch and dine as fancy leads them. The physician whose practice lies among the well-to-do is apt to scoff at the modern idea that most people in the world could be the better for more food of good quality to eat. Most of *his* patients would be better if they were “ to live on sixpence a day and earn it ”—for a period of, let us say, six months. If the experiment were extended over a more prolonged period, the benefits of frugality would be overwhelmed by the disadvantages of want, and the last state of the patient would be worse than the first.

Let us begin with a deficiency disease which in certain respects is no longer of urgent practical interest—scurvy. In the past scurvy could claim the proud position of being the most dreaded and destructive of dietary diseases. The crews which had sailed so hopefully from Plymouth or Rotterdam in

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search of gold or adventure would find themselves sick and despairing on the Southern seas. In the middle of the campaign a sudden lassitude would seize the soldier ; his gums would begin to bleed, his teeth to fall out, dark red patches would appear on his body and limbs, and death might follow. The arctic explorer, living on stores laboriously transported from his base camp, would find that only a healthy body can endure the hardships of snow and ice, and the expedition would return maimed and unsuccessful, leaving its dead behind.

To-day only a general break-up of civilization could restore scurvy to its former position. In Western civilization it occurs occasionally among infants whose feeding has been grossly mismanaged ; it is now part of general knowledge that infants fed on dried-milk mixtures need fruit-juice, or some source of vitamin C, to protect them against the danger of scurvy. Explorers can carry vitamin C with them in powder form. In highly developed countries modern commercial and transport organization ensures a supply of fresh fruits and vegetables all the year round. A few years ago the amount of vitamin C in the diet of the average person was closely dependent on the season ; in summer and autumn, when fruits and vege-

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tables were plentiful, his needs were fully satisfied. In the winter and early spring the amount of fresh food consumed was insufficient to fulfil vitamin C requirements. Elderly people still talk about "spring-sickness," in all probability a condition of debility occurring in early spring as a result of consuming a limited dietary, lacking in vitamin C and other elements, throughout the winter.

Dangerous illness due to deficiency of vitamin A in the diet is now a rarity in Western Europe and North America, though it was probably common enough among children of the poorer classes in industrial towns during last century, and serious outbreaks were recorded as a result of privation during the Great War. In the East, severe cases of vitamin A deprivation are commonly encountered and milder manifestations of this deficiency are found in a high percentage of children. The following account of *kerato-malacia* and the symptoms associated with it is taken from a lecture by Lieut.-Colonel R. E. Wright, I.M.S., delivered in 1935. Colonel Wright, as Superintendent of the Government Ophthalmic Hospital, Madras, has probably had to deal with more severe cases of vitamin A deficiency than any other physician in the world.

"The earliest manifestation of kerato-

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malacia is night-blindness. . . . The next evidence of this progressive deficiency is a peculiar smokiness of the conjunctiva ; this is the earliest obvious sign just as the night-blindness is the earliest symptom. One may meet either or both of these in a youth who is apparently healthy-looking in other respects. They are however danger signals. . . . When the early signs and symptoms appear, if nothing is done to augment the amount of essential food-factors in the diet, the case rapidly progresses and marasmus sets in ; the patient becomes wasted, the skin harsh and earthy-looking, the hair appears dull, brittle and thin, the mucous membranes also show a diminished secretion and the more accessible membranes of the nose, throat and mouth are seen to be abnormally dry. It is generally somewhere about this stage that babies are brought to the out-patient department. *Pari passu* with the wasting of the mucous membranes, there is an advance in the eye symptoms. As a rule, the smoky conjunctiva becomes dry, wrinkled, and greasy-looking, the cornea becomes dull and lustreless and eventually opaque. . . . Later the cornea undergoes necrosis and ulceration, and if untreated, the ulcer perforates, and the eye is ultimately lost.

“ It is sometimes quite impossible for the

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mother to observe the condition of the baby's eyes when she brings the child to the hospital, as, by the time she has made up her mind to seek relief, it requires an expert to open the lids and examine the state of the cornea ; but she has probably noted previously that there was something definitely wrong with the eyes and the progressive wasting of the infant drives her to seek relief. By the time the average mother brings the baby to the hospital, the skin is hanging in baggy wrinkles round the joints—the so-called elephant skin—the mucous membranes of the mouth, nose and throat are wasted, glazed and dry, the thin piping or hoarse croaking voice is hardly recognizable as proceeding from a human being. The alimentary tract is affected just as the mucous membrane of the respiratory tract, and diarrhœa of one type or another is present. When this condition of marasmus is reached, the child is, as a rule, blind, but in spite of the appalling general state, it is a relatively easy matter to restore it to comparative health again with cod-liver oil. Even if the child is too ill to take cod-liver oil by the mouth or to tolerate it in the intestinal tract, it is often possible to save the life of the child by wrapping it in a flannel binder soaked in cod-liver oil. . . . This is perhaps all that is necessary to

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say about the clinical aspect of the condition."

One may add that keratomalacia is one of the chief causes of preventible blindness in children in South India. Colonel Wright's striking description illustrates the fact that food deficiency diseases may be as "loathsome" as other types of disease to which the epithet has been more often applied.

Beriberi, which is caused by the consumption of a diet mainly composed of milled cereals, is chiefly met with in the rice-eating areas of the world; it also occurs, however, among wheat-eating populations who subsist largely on refined wheat flour—e.g. in Newfoundland and Labrador. The anti-beriberi vitamin (B_1) is abundantly present in the germ and pericarp of cereals, but almost absent from the endosperm. Essentially, beriberi is a paralysis of the lower limbs (other parts of the body may be paralysed also), usually accompanied by degeneration of the heart muscle and often by general dropsy. It is among the infants fed on the milk of mothers whose diet is deficient in vitamin B_1 that the greatest mortality from beriberi occurs. Cardiac rather than nervous symptoms are prominent in infantile beriberi.

During the last half of the nineteenth cen-

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ture, and the first few years of the present century, beriberi was a formidable scourge in armies, navies, prisons, labour-gangs, etc., in rice-eating countries. To-day, when the cause of the disease is known, outbreaks among bodies of men whose food is supplied by competent and instructed authorities are comparatively rare; it is widely recognized that a diet chiefly composed of milled rice will produce beriberi, and dietary schedules are designed with a view to prevention. An outbreak of beriberi in an Indian gaol or a Japanese military unit to-day would mean serious trouble for someone apart from the victims. Employers of labour on a large scale in the tropics and the East are generally aware of the danger of beriberi among rice-eating labour-gangs and take steps to prevent it by encouraging and enforcing the consumption of roughly milled or parboiled rice, or a more varied diet. As long ago as the eighties of last century the high incidence of beriberi in the Japanese navy was materially reduced by the wisdom of Admiral Takaki, Director-General of the Naval Medical Service, who increased the sailors' allowance of vegetables, fish, and meat, and cut down the rice ration by the substitution of barley. Takaki holds an honourable position in the history of medicine and dietetics. But there appears to

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have been a certain lack of co-ordination between the medical departments of the army and navy in Japan, for " during the Russo-Japanese War beriberi was prevalent in the army to such an extent that no outside observer had any conception of the facts and it is doubtful whether they have ever become fully known. Shibayama states : ' During the war Japan had 200,000 cases of beriberi in the army, and this was the only ravaging epidemic with which the army had to contend.' " ¹

In 1909 Fraser and Stanton in Malaya carried out some striking human beriberi experiments. Two parties of coolies were taken into the heart of the jungle where they were employed in road-making at a distance of seven miles from each other. One party, consisting of 220, was given white milled rice to eat ; the other, 273 strong, parboiled rice. The dangers of eating milled rice were explained to the first party, but one and all declared that they preferred milled rice to any other kind of rice and so set the consciences of the experimenters at rest. Apart from rice, the diet contained small quantities of salt fish, onions, potatoes, and coco-nuts. Within six months, twenty cases of beriberi occurred in the " milled-rice " group, while the other group remained free from the disease. Con-

¹ E. A. Vedder, *Beriberi*, 1913.

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ditions were now reversed, the first party receiving parboiled rice, the second milled. The outbreak of beriberi in the former abruptly ceased, while cases of beriberi now appeared in the latter.

In the parboiling process, as usually followed in the East, rice is steeped in water for about 24 hours, steamed for about 20 minutes, and subsequently dried in the sun. As a result the husk is split and becomes easier to remove. It was discovered by Braddon that parboiled rice does not give rise to beriberi, a fact which he explained on the grounds that in the process of steaming some toxic substance is destroyed. Parboiling toughens the grain and makes the removal of the pericarp more difficult. Rice is often parboiled in Eastern village communities in districts where facilities for machine milling are absent, and after "home-pounding" rice retains a good proportion of its integuments. But even machine-milled parboiled rice is, generally speaking, preventive of beriberi, because during steaming a transference of some vitamin B₁ from the outer to the inner layers takes place; it diffuses throughout the endosperm and cannot, so to speak, be milled off. In studying the epidemiology of beriberi, however, other factors must be taken into consideration besides the state of the staple

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cereal. Even the poorest do not live on rice alone, and the other foods entering into the diet are naturally of importance, although eaten only in small quantities. Further, McCarrison has shown that prolonged washing may remove the anti-beriberi vitamin from both parboiled and raw rice. Musty rice of poor commercial quality is often vigorously washed with several changes of water before being eaten. This observation probably explains the rare but unquestionable occurrence of beriberi among rice-eaters whose rice is not of the highly milled variety.

In spite, however, of a general understanding of the cause of beriberi, and of reasonably widespread attempts at prevention, the disease still causes many deaths, particularly among infants. In 1931, 9,398 deaths from beriberi in infants were recorded in Japan; in the same year 173 deaths in the same age-group were registered in the city of Manila, the capital of the Philippines. Apart from recognizable beriberi, insufficiency of vitamin B₁ must play a considerable part in producing the huge infantile mortality of India and other Eastern countries.

A rise in living standards and a higher level of education are necessary before the disease can be eradicated. Proposals to discourage the use of highly milled rice among Eastern

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peoples by legislative measures have been made from time to time, but so far no active measures in this direction have been taken. The problem of prevention by official action (e.g. taxation of highly milled rice ; Customs duties favouring the unmilled variety) was thrashed out at the 1923 and 1925 Congresses of the Far Eastern Association of Tropical Medicine, and the conclusion was reached that nothing effective could be done in existing circumstances. But the nutrition worker in the East must continue to stress the importance of the milled rice and beriberi problem, and the superior nutritive value of unmilled and home-pounded rice.

For example, there are vast populations in South India and other Eastern countries whose staple diet is home-pounded rice, who indeed for practical purposes live on such rice, other foods being present in the diet in very small amounts. These populations, generally speaking, are in a poor "state of nutrition," as might be expected from the lack of protective foods in their diet. But at least they are alive, and rarely suffer from beriberi ; if the rice they eat were to be highly milled, their diet would be reduced in nutritive value, and they would be in greater danger of contracting beriberi. In the circumstances, one views with alarm the ever-

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increasing spread of steam and electrically driven rice mills in the East. It is fortunate that parboiled rice, however highly milled, usually retains enough vitamin B₁ to prevent beriberi; many rural populations in the East consume "parboiled" rice rather than "raw," because the parboiling or steaming of rice splits the woody husk and makes its removal by non-mechanical methods less laborious. In practice, it is usually extremely difficult, often impossible, to persuade people of any degree of education, who are used to milled raw rice, to consume their rice in a safer but less palatable state. As a staple food, milled rice is definitely more palatable than unmilled.

Treatment by concentrates of vitamin B₁ is highly effective in infantile beriberi. Adult cases are often less rapidly responsive to similar measures, probably because other factors besides vitamin B₁ deficiency play a part in the causation of the disease. A type of paralysis akin to beriberi, which commonly occurs in women during the period of lactation, can be quickly cured by giving the patient a well-balanced diet and a daily dose of dried yeast. Usually within a few weeks the paralysed patient takes up her bed and walks.

It is possible that *pellagra*, which is perhaps

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the most horrible of all food deficiency diseases, has now passed the zenith of its destructiveness and will henceforward become rarer by slow degrees. Such optimistic statements are, however, scarcely warranted in the present precarious state of civilization ; the elimination of food deficiency disease implies a steady rise in standards of living, and world wars do not raise standards of living. Pellagra is a poverty disease. It attacks poverty-stricken maize-eaters, very rarely those consuming other staple cereals. It now seems probable that the association of maize with pellagra is due to the fact that maize is more deficient in a certain vitamin—the P.-P. factor—than other cereals, but this explanation may be incomplete. The P.-P. factor is present in many common food-stuffs, but in areas of pellagra endemicity consumption of such foods is too small to prevent the disease. The typical pellagrin is so poor that his diet contains little or no milk, meat, and green vegetables. Given a sufficient intake of such foods, there is no danger of contracting pellagra by eating maize, any more than there is a danger of contracting beriberi by eating milled rice as part of a well-balanced and varied diet.

The principal symptoms of pellagra are dermatitis, diarrhœa, and dementia. The

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dermatitis occurs most commonly on the dorsal surfaces of the limbs, the face, and other parts of the body exposed to sunlight. In a severe case the tongue is raw and glazed and the intestinal tract shows inflammatory lesions throughout its length ; if such patients are not treated on modern lines by liver extracts or other preparations very rich in the P.-P. factor, they often slowly waste away to skeletons and die. In both acute and chronic cases, mental changes of various kinds are common ; in any country—e.g. Rumania—in which pellagra is endemic, a large proportion of the inmates of mental hospitals are pellagrins. A curious, and hitherto quite unexplained, feature of the disease is its seasonal incidence. The pellagrin sickens in the late spring, and, if his attack is not too grave, recovers in the early autumn. But unless there is a change of diet pellagra tends to recur, often in a more serious form, in subsequent springs, and the general picture of the disease, as seen in backward areas lacking efficient medical and public health services, is that of an implacable progressive malady playing cat and mouse with the patient.

The greatest name in the history of pellagra research is that of the late Joseph Goldberger, an officer in the United States Public Health Service. Goldberger's fundamental work on

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pellagra was carried out during the years 1910-30. For nearly 150 years previous to his painstaking and conclusive investigations, physicians had *suspected* that pellagra was in some way due to eating a wretched diet. The connection of the disease with poverty and the consumption of maize is indeed so obvious that it could not be wholly overlooked. The medical mind has been extraordinarily slow in grasping the fact that poverty and wretchedness are the *fundamental* causes of most disease. Maize was thought by some to contain a pellagra-producing poison, but the poison could not be isolated; by others to be deficient in some essential element or elements, but exactly what elements could not be discovered. The latter theory was correct; proof of its correctness was not, however, forthcoming. Pellagra research became a happy hunting-ground for theorizers whose speculations, long since forgotten, occupied a prominent position in standard text-books. It was left to Goldberger to bring order out of chaos.

The staple cereal of the Southern States, in which Goldberger worked, is maize; the diet of the poverty-stricken negroes and whites who are the chief victims of pellagra in those regions does not contain enough foods rich in the P.-P. factor, such as milk,

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eggs, green vegetables, etc. In a long series of experiments Goldberger and his colleagues found that pellagra could be prevented in asylums and boarding-schools by enriching the diet in various ways. The regular recurrence of the disease, spring after spring, in lunatics and orphans, enabled them to test systematically the preventive efficacy of a number of different foods. In one of the earliest and most striking experiments, pellagra was entirely eliminated from a Missouri orphanage by adding liberal quantities of milk and eggs to the diet. In other similar institutions in which no dietary changes were made, the recurrence rate was 40 per cent.

It appears that pellagra is to-day somewhat on the decline in the United States of America. For this the education of the people by public health authorities may be in part responsible ; nutrition propaganda in the United States of America is well conceived and vigorous. A possible factor in the decline of the disease is a greater production of animal products and vegetables in the Cotton Belt ; the poor cultivator, finding cotton crops less profitable, is inclined to devote more of his land to feeding himself and his family, and depends less on the local stores for his food.

Pellagra is common in Rumania, Yugoslavia, South Russia, and Egypt ; wherever,

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in fact, poverty and the use of maize as staple cereal are associated. In Italy the disease has practically disappeared, probably as a result of a rise in living standards. The word pellagra is of Italian origin, and for many years pellagra, owing to its great prevalence in Italy and the voluminous writings of Italian physicians, was considered to be a peculiarly Italian disease. The elimination of pellagra from Italy makes one hopeful that ultimately it may be wiped out and forgotten throughout the world. Ridiculously hopeful, perhaps, for the permanent elimination of food deficiency disease demands peace, great constructive efforts on a national and international scale, an overhauling of the economic system of the world.

Meanwhile we may legitimately regard the discovery of the basic cause of pellagra as one of the most striking successes of modern research. Public health authorities have been presented with weapons to fight the disease; the physician can cure advanced cases which a few years ago he would have regarded as beyond aid.

Maize is a cereal which demands a reasonable degree of warmth for its ripening, and the great maize-producing areas of the world lie in the south temperate zone. The geographical incidence of pellagra follows that of

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the cultivation of maize. The next deficiency disease we have to discuss, *rickets*, is pre-eminently a disease of the North temperate zone, and is found but rarely in the warmer and sunnier parts of the world. On the continent of Europe, rickets is still sometimes known as the "English disease," a name originating in the fact that the first adequate description was given by Glisson, a Dorset man, in 1650. But until quite recently the disgraceful prevalence of rickets in England, particularly in smoky manufacturing towns, might have justified the use of the national adjective in a less complimentary sense.

The disease is still with us, particularly in its milder forms, but it no longer cripples children by the thousand. It is remarkable how seldom one hears the word cripple, as applied to physical state, nowadays: used in this sense it has a slightly Dickensian flavour. Until quite recently most cripples were the victims of rickets. In 1921 Hess and Unger wrote that "rickets is the most common nutritional disease occurring among the children of the temperate zone. Fully three-fourths of the infants in the great cities, such as New York, show rachitic signs in some degree." The same authors reported in 1917 that *almost all* the infants in the negro-community in New York City, whether

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breast-fed or bottle-fed, showed rickets in various degrees; the same was true, to a slightly less extent, of the Italian districts in the city (dark-skinned children living in Northern cities are particularly prone to rickets, because the pigment in their skin, and in their mothers' skin, screens off whatever sunlight filters through the murk, and cutaneous ergosterol is not transformed into vitamin D). In England, rickets was well-nigh universal among the children of the poor until a quite recent date, and large numbers of middle-aged and elderly men and women of the working classes bear the stigmata of the disease. It is stated that in Paris in 1912 one out of every two infants showed rachitic symptoms. In Central Europe the disease was almost equally prevalent, and during the period of war privation its incidence was increased; experiments carried out in post-War Vienna under the auspices of the British Medical Research Council, at a time when experimental material was all too abundant, helped greatly to solve the problems of causation and prevention. The disease is occasionally met with in South Europe and the tropics, among ill-fed infants reared in dark houses. In North India and China it is fairly common; in those regions, however, the most important result of vitamin D deficiency is adult rickets

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or osteomalacia. The victims of osteomalacia, or softening of the bones, are chiefly deficiently fed women in the child-bearing period, who, because of habit or religious custom, spend most of their lives indoors. In North India it is most common among Mahomedan women who observe strict "purdah."

To-day, as a result of the labours of many scientific workers in many countries, the prevention of rickets is purely a public health and economic problem. No further knowledge is required to wipe out the disease altogether. We have, in fact, reached a point at which the multiplicity of antirachitic agents is an embarrassment. The public health worker has to choose between cod-liver oil, irradiated ergosterol, irradiated foods (of which irradiated milk is the most important), milk from irradiated cows, milk from cows fed on irradiated food, milk enriched with irradiated preparations or cod-liver oil concentrates. Further, the irradiation of the infant with ultra-violet light from an artificial source, or from the sun, will prevent rickets. For treatment, concentrated irradiated ergosterol preparations are probably most effective; for prevention, there is no unanimity as to which method is most convenient and likely to give the best results. In very poor countries like India, the advan-

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tages of exposure to sunlight as an anti-rachitic measure are obvious ; cod-liver oil and irradiated ergosterol cost money ; the sun is free. One of the advantages of keeping infants out of doors, with arms and legs bare, as much as possible, is that the supply of vitamin D is thereby increased. In murky industrial towns, smoke abatement helps to prevent rickets.

Whatever may be the most effective and convenient method of prevention, there is no doubt that rickets is actually being prevented. Bow legs and knock knees, due to rachitic deformity, are becoming more and more rare. Even in the worst days of the "slump," in the districts suffering most severely from unemployment, there was no marked recrudescence of the disease. For this the work of maternity and child welfare services was probably largely responsible.

Dental decay or *caries* is one of the commonest diseases in Europe and North America. Examinations of groups of children in Northern Europe have revealed that over 90 per cent. of children have carious teeth ; in the United States of America the state of affairs is similar.* The sum-total of suffering caused by dental decay is large ; toothache and the dentist's chair provide valuable material for humorous artists and writers,

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but the actual victim finds the joke less piercingly funny. Further, there is evidence that dental caries may have more serious consequences than occasional toothache and occasional visits to the dentist. The general health of the body, and the health of various organs, may be impaired by the presence of rotten teeth in the mouth.

Mrs. M. Mellanby and her associates have shown that the teeth, like the bones, require adequate supplies of calcium, phosphorus and vitamin D for their proper formation. A tooth which is ill-formed as a result of dietetic deficiency is more likely to decay than a structurally perfect tooth. There is also evidence that abundant provision of vitamin D not only checks caries by producing well-formed teeth; independently of structure, the resistance of teeth to decay is directly influenced by the character of the diet, and suitable dietary measures can assist healing in teeth which are already carious.

There is still controversy as to the precise cause of dental caries, and the most effective methods of prevention. Theories that a bacillus is concerned, or that the *consistency* of food is of paramount importance, are still widely held. But the idea that there is a close relation between dietary imbalance and deficiency and dental decay is steadily gaining

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ground, and it appears more than probable that the most important factor involved is vitamin D. There is actually nothing new in the conception that dental decay is caused by eating the wrong sort of food ; after all, rather a close connection exists between the idea "teeth" and the idea "food." But it is only within recent years that the precise relation between diet and dental decay has been systematically studied by large-scale experiments on human beings, correlated with observations of the geographical incidence of the disease. The people of Tristan da Cunha in the south Atlantic, for example, are practically free from the scourge of dental decay ; in 1931 Sampson found that the teeth of 131 out of 156 islanders examined, belonging to all ages from infancy to nine years, were in perfect condition. Why? The Tristan da Cunchans—if one may use the expression—live on potatoes, fish, milk, penguin eggs and green vegetables—a well-balanced diet rich in protective foods. The absence of cereals from their diet may be of importance. There is a relation between dental caries and rickets and excess of cereals in the diet, the precise cause of which seems to require further investigation.

It appears, then, that dental caries may be attacked by improving the diet of expectant

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and nursing mothers, infants, and growing children—by bringing about an increase in the intake of protective foods and vitamin D, and a decrease in that of sugar and cereals. It is along these lines that public health authorities may most profitably develop their future campaigns against this scourge of modern civilization.

CHAPTER VII

THE ECONOMICS OF DIET

A GOOD diet costs more than a poor one. For precise accuracy, one should add that the statement refers to the ordinary diets of mankind, and not to freak diets which a physiologist might design or a gourmet dream about. A diet containing just two items, a whole cereal (e.g. oatmeal) and skim milk, would be reasonably adequate in nutritive value and very cheap. But no one lives on a diet of oatmeal and skim milk, or is likely to, no matter how enthusiastically such a diet is recommended by nutrition experts. Similarly, a diet exclusively composed of caviare and *pâté de foie gras* would be more expensive than an ordinary well-balanced diet, but considerably less wholesome.

The cheapest foods—cereals, root vegetables, vegetable fats, sugar, legumes—are those which are most deficient in first-class protein, vitamins, and mineral salts, while foods which are richer in these elements—milk and milk products, green vegetables, fruit, fish, meat—are on the whole dearer. A

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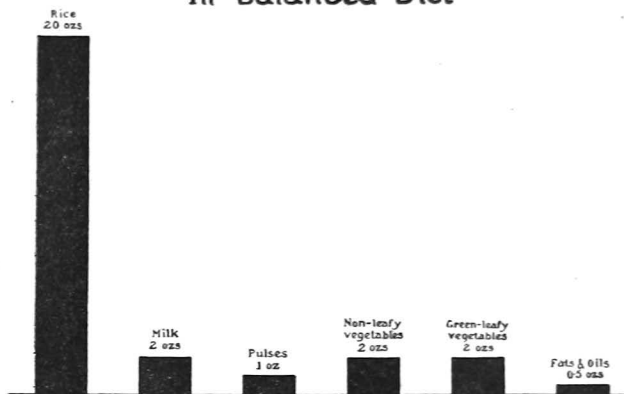
unit of money will purchase more calories in terms of the former than of the latter. Why this is so will be discussed later. The relationship between nutrition and public health, economic status, agriculture, and population must be considered in the light of the fundamental fact that dietary quality is in general dependent on cost.

The diagram overleaf, which is used for educational purposes in South India, illustrates these points.

The chief cereal in both the "well-balanced" and "ill-balanced" diets is rice; in the latter it forms a large proportion of the diet. The "well-balanced" diet contains protective foods in reasonable quantities, though actually it is far from being an optimum diet according to modern standards. Cambu and ragi are varieties of millet.

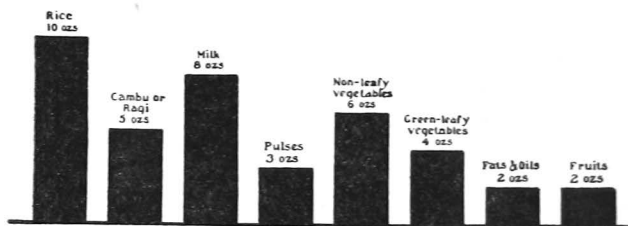
At current retail prices in South India, the ill-balanced diet would cost about three rupees and eight annas (five shillings) per adult per month. The well-balanced diet would cost about five rupees (seven shillings and sixpence). Considered in relation to the level of wealth and wages in India, the difference is enormous. If a coolie has to support himself, his wife, his father, and three children on sixteen rupees a month, the diet of the

Ill-Balanced Diet



2600 calories corresponding to average adult intake per day.

Well-Balanced Diet



2600 calories corresponding to average adult intake per day.

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family will *inevitably* be ill-balanced, and probably insufficient in quantity as well. It will, in fact, be waste of time to attempt to persuade him of the advantages of the well-balanced diet, which is quite beyond his means.

(But one point of importance must be noted. Supposing one is actually faced with the problem of recommending how a diet of the ill-balanced type shown in the diagram may be improved, but at the same time no increase in cost can be made. The substitution of some of the rice in the ill-balanced diet by millet increases the nutritive value of the diet without actually increasing cost. Another similar possibility of improvement is to substitute unmilled for milled rice. In very poor countries the nutrition worker spends little time drawing up perfect diet schedules. His chief practical task is to think out methods by which existing diets can be slightly improved and yet remain within the means of those consuming them.)

When poverty is extreme the result is semi-starvation : not enough of cheapest and least nutritious food to eat. In the poorer countries of the world, e.g. India and China, it is probable that a considerable proportion of the population does not get enough to eat. The

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poor ryot or peasant may scarcely be aware that his intake of food is insufficient, since the body is capable of adapting itself, at a low level of vitality, to a diet yielding little more than half the requisite number of calories as laid down in standard text-books. In Western countries actual hunger is rare to-day, because of a high general standard of living and the development of social services—e.g. unemployment relief. In Northern Europe and America millions of unemployed, who would otherwise starve, are being fed at the public expense.

One step out of the abyss, and it becomes possible to buy enough food to fill the belly, but not to buy a diet of good physiological quality. Even in prosperous England there must be many thousands of families who cannot afford the minimum sums necessary for the purchase of a well-balanced diet. If a family consisting of husband, wife, and two children aged six and eight has only twelve shillings a week to spend on food, their diet is bound to be deficient in quality. Above such income levels come those who have enough money to buy an adequate or optimum diet, provided the money is sensibly spent in accordance with the principles of dietetics. Ignorance of dietetics is not confined to any section of the community, nor

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are foolish prejudices about food; the wealthiest may feed themselves and their children on an ill-balanced and defective diet. But, in general, the more money there is available for expenditure on food, the more closely the diet purchased is likely to approach the optimum. On the whole, too, ignorance and poverty go together, which is another reason why diet improves with increasing income. Further, as money available for food decreases, the more skill and knowledge are required to lay it out so that all dietary requirements are fulfilled, until a point is reached when the most detailed knowledge of dietetics would be of no avail because sixpence, however wisely spent, cannot do the work of a shilling.

A detailed investigation of the relationship between diet and income in the United Kingdom has been carried out (1935) by Sir John Boyd Orr and his collaborators. Orr's report, *Food, Health, and Income*, should be carefully studied by all interested in the broader aspects of the science of Nutrition. On the first page of the report we find a significant remark: "Public interest has been aroused by the 'Newer Knowledge of Nutrition,' as it has been called. The centre of interest is passing from the research laboratory to the application in everyday life of the

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results of the researches." Even those of us who are in charge of nutrition research laboratories could scarcely quarrel with this statement. There is, indeed, plenty still to be learnt, and there need be no slackening for a long time to come of field and laboratory research. But without doubt we already know enough about nutrition to provide a sound basis for practical measures to improve nutrition, and an enormous amount could be done to improve health by better feeding without a single more fact being added to what we know already. It is, therefore, essential that some nutrition workers should leave the calm of the laboratory and tackle not uninteresting practical problems, such as: "Do people get enough of the right sort of food to eat? If not, why not? Is it because they can't afford it or because they are ignorant? And what can be done in practice to improve nutrition, by education, improvements in marketing and agriculture, and so on?"

Orr first of all works out consumption of various foods per head per day, using agricultural and import statistics, etc., for the calculation. Reckoned on this basis, the food supply of the United Kingdom amply covers the calorie, protein, fat, and carbohydrate requirements of its inhabitants.

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The average figures *per capita* per day are as follows :

Calories.	Protein.	Fat.	Carbohydrate.
3,246	Animal, 46	Animal, 109	425
	Vegetable, 41	Vegetable, 15	
	<u>Total . 87</u>	<u>Total . 124</u>	

This is the picture of a well-fed country ; for example, national intake of animal protein and fat is high. Similar methods of calculation give very different figures for Eastern countries. Thus, Grey gives the following estimate of the food supply of Japan in 1925 :

Protein .	.	88.5 grammes, of which 12.2 grammes were animal protein.
Fat .	.	17.5 grammes, of which 3.4 grammes were animal fat.
Carbohydrate .		537.6 grammes.
Calories	.	2,732.

Since 1925, as a result of vigorous and enlightened measures, the food supply of Japan has improved in quantity and quality. A similar assessment of the food supply of the Madras Presidency in relation to population (1933), made by the author, gave lower figures (except for fat) than Grey's for Japan. Average *per capita* intake of protein per day worked out at about 45 grammes, and this included very little animal protein.

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Since 1909, Orr shows, national intake of protein, both animal and vegetable, has altered very little. Fat intake has considerably risen. There has been a large increase in the consumption of butter, fruit, vegetables other than potatoes, eggs and cheese; that of meat and potatoes has remained almost stationary, while that of wheat flour has somewhat declined. These changes are in the right direction; the national diet has improved in the last twenty-five years.

On the basis of *per capita* consumption figures, the English and Scotch appear to be well-fed peoples. So they are, as peoples go. But actually these average figures conceal a great deal of sub-optimum feeding among large sections of the population. Only a very rough picture of the dietary habits of a nation can be obtained by dividing total food supply by number of inhabitants. A further necessary step is to discover how food expenditure is directed in different sections of the population at various income levels, and how far diets actually purchased and consumed conform with optimum standards.

To throw light on these problems, the population was divided into six income groups, and, by means of the study of family budgets, and diet surveys, average expenditure on food in the various groups was

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estimated. The following table provides a summary :

TABLE VI

CLASSIFICATION OF THE POPULATION BY INCOME GROUPS
AND AVERAGE FOOD EXPENDITURE PER HEAD IN EACH
GROUP

Group.	Income per head per week.	Estimated average expenditure on food.	Estimated population of group.	
			Numbers.	Percentage.
I	Up to 10s.	4s.	4,500,000	10
II	10s. to 15s.	6s.	9,000,000	20
III	15s. to 20s.	8s.	9,000,000	20
IV	20s. to 30s.	10s.	9,000,000	20
V	30s. to 45s.	12s.	9,000,000	20
VI	Over 45s.	14s.	4,500,000	10
Average	30s.	9s.	—	—

It is worth noting, in passing, that even in the poorest English group food expenditure is high compared with Eastern standards. Thus, an inquiry carried out by the Labour Office, Bombay, in 1932, showed that the average monthly expenditure on food of poor working-class families in Bombay earning less than thirty rupees a month, was three rupees and fifteen annas, or, roughly, two shillings per head per week.

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By similar methods, an estimate of the actual *direction* of food expenditure in each group was made, and the type of diet purchased by each group compared with optimum standards of protein, mineral, and vitamin intake. The results of the comparison were as follows :

“ The average diet of group I is inadequate for perfect health in all the constituents considered ; group II is adequate only in total protein and total fat ; group III is adequate in energy value, protein and fat, but below standard in minerals and vitamins ; group IV is adequate in iron, phosphorus, and vitamins, but probably below standard in calcium ; group V has an ample margin of safety in everything with the possible exception of calcium ; in group VI the standard requirements are exceeded in every case.

“ It should be kept in view that the standards with which the above comparisons are made are those compiled for the maintenance of *perfect* health, which is a standard very different from the average health of the community. The fact that the average diets of the lower income groups are inadequate according to these standards does not mean that these people are starving or even suffering from such a degree of ill-health as is expressed in the term disease. These diets

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may be sufficient to maintain life and a certain degree of activity, and yet be inadequate for the maintenance of the fullest degree of health which a perfectly adequate diet would make possible."

Consumption of almost all the most valuable "protective" foods, e.g. milk, butter, cheese, meat, fresh eggs, fruit, and vegetables, rises with increasing income. On the other hand, the poorer groups consume more condensed milk and margarine. The inquiry, taken as a whole, shows that the poorer half of the population is, on the average, not spending enough on food to obtain a diet which is in conformity with *optimum* standards.

It is dangerous to be poor. Mortality statistics make that abundantly clear. The Registrar-General's Decennial Supplements on "Occupational Mortality" (England and Wales) should be familiar to every educated person in England and Wales. The Registrar-General divides the population into five occupational classes as follows :

Class I	.	.	Upper and middle.
Class II	.	.	Intermediate.
Class III	.	.	Skilled workers.
Class IV	.	.	Intermediate.
Class V	.	.	Unskilled workers.

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In a general way there is a steady decline in prosperity from Class I to Class V. In this sense (and in this sense only) there is a correspondence between the Registrar-General's occupational classes and Orr's six income groups. Mortality steadily increases from Class I to Class V, as the figures which follow show. They represent the number of deaths between twenty and sixty-five (Census 1921, males) in the various classes expressed as percentage of deaths which would have occurred had mortality been uniform throughout and identical with that of the entire population :

Class I	.	.	.	82
Class II	.	.	.	94
Class III	.	.	.	95
Class IV	.	.	.	101
Class V	.	.	.	125

The mortality in the least favoured class is 50 per cent. higher than that in Class I. One of the diseases which steadily increases from Class I to Class V as a cause of mortality is tuberculosis. In 1921 Stevenson showed that tuberculosis mortality was some 60 per cent. higher in the prosperous than in the poorer London Boroughs. In Paris the variation of tuberculosis mortality in the different "*arrondissements*" according to the poverty or wealth of the district is even more striking.

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Greenwood, in *Epidemics and Crowd Diseases*, says : " It is not scientific or modern-minded or anything but foolish to try to believe that any other prophylaxis of this particular crowd disease (tuberculosis) is so important as raising the economic level and increasing the *commoda vitæ* of the crowd."

In Central Europe during the later years of the War and the hungry days which followed, there was a great rise in the tuberculosis death-rate. In Saxony it was almost doubled. During this period, while there was no general breakdown of social services, a large proportion of the population of Central Europe was in a state of semi-starvation. The inference is justified that the increased mortality was due to food shortage. Orr suggests that " the most effective line of attack on tuberculosis is by an improvement in diet." One must not, however, forget that there are other important factors to be considered besides poverty and deficient diet. Occupation, for example. Mortality from all forms of tuberculosis is very high among those whose occupation involves exposure to the action of siliceous particles—e.g. tin and copper miners, metal-pounders. Compositors, and workers in the boot and shoe industry, who belong to the " skilled workers " group, have a high tuberculosis mortality, either because of

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pecially unfavourable working conditions, or because such industries, which demand no great physical strength, draw recruits of poor physique.

Dr. Et. Burnet, until recently a member of the Health Section of the League of Nations, has remarked, in a striking sentence, that "the object of '*la médecine sociale*' may be described as the equalization of classes, rich and poor, in respect of health." ("Social medicine" is a simple and valuable phrase which might be used more by English writers to replace "the public health movement," "public health activity," etc.). The excess of ill-health and disease in the poorer (and larger) sections of the community provides an index of the amount of *preventible* disease which our civilization tolerates. Now it is clear that one of the chief disadvantages of being poor is that you cannot afford to buy a proper diet. This may, in fact, be the most serious disadvantage. It may, for example, give a better chance of life and health to live under bad housing and sanitary conditions on a good diet than to live in a mansion on a deficient diet. If slum families are moved from squalor to new housing estates where rents are higher, improvement in health may not follow because they can afford less money for food.

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There is no doubt that an increased consumption of nutritious food on the part of the poorer classes would mean the disappearance of much ill-health and disease. To bring about such an increase in consumption, to lessen differences in this respect between rich and poor, is among the most important functions of "social medicine." But actually the problem of increasing consumption is far more than a public health problem. The success or failure of civilization may depend on whether we can devise means by which ever-increasing numbers can benefit from the "plenty" which science has made possible.

CHAPTER VIII

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WHY are certain foods dearer than others? It is, of course, easy to understand why delicacies which demand a great deal of money, labour, and skill for their production and transport—e.g. plovers' eggs and oysters—are expensive. It must have required an army of workers to keep Cleopatra supplied with nightingales' tongues. Leaving aside, however, rare dainties of importance only to the *bon viveur*, the price of common foods is naturally influenced by labour and distribution costs. Grain and root crops take care of themselves from seed-time until harvest. The best beef comes from cattle which have been carefully tended for two to three years. A milch cow requires daily skilled attention. In highly organized countries the delivery of milk to the consumer in a safe condition requires elaborate and expensive arrangements; unboiled milk, carelessly produced and distributed, is one of the most dangerous "disease-spreading" foods. The "door-to-door" method of delivering milk to the consumer in-

volves high distribution costs. The open-air market, in which peasants from the surrounding countryside expose their eggs, vegetables, etc., for sale, is obviously one of the cheapest methods of food distribution. The thrifty housewife who purchases food early in the morning in the market and carries it home in a string-bag will naturally pay less for everything than the stockbroker's wife who orders food by telephone from the Imperial Stores and has it delivered by motor-van.

There are many other factors influencing food prices which might be enumerated : e.g. storage and preservation costs, and what might be described as "æsthetic" costs. The "commercial quality" of a sample of food depends on its freshness, taste, appearance, colour, etc.—factors which may have little relation to nutritive value. Very white highly polished rice costs more than ordinary milled rice, but is not superior in food value. A pound of big voluptuous oranges will cost more than a pound of small oranges, although vitamin C content per pound may be the same in each case. Food packed in an elegant container is usually more expensive than a similar quantity of the same food shovelled out of a sack or bin into a paper bag. Under "æsthetic" costs we may also include the cleanliness and efficiency of the big provision

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shop, the attractive display, the obsequious assistants. Mrs. Murphy, buying her half-pound of meat off a barrow on Saturday night, neither expects courtesy nor receives it; she may however reflect, as her purchase is wrapped up in a fragment of old newspaper, that she is getting it at rock-bottom price.

Of more fundamental importance in determining the relative prices of different food-stuffs is the "food energy per unit of land" relationship. To produce 1,000 calories in the form of milk, meat, and most vegetables, requires more land than to produce 1,000 calories in the form of sugar, wheat, or rice. The table on the opposite page, taken from a publication of the United States Department of Agriculture, *Land Utilization and the Farm Problem*, illustrates this point.

The protective foods—milk, vegetables, fruit, eggs—give a smaller calorie return per unit of land than cereals and root crops. Since fertile land is valuable, the foods which give the largest returns tend to be cheapest foods. Recent work on the part of Stiebeling, Ward and Baker in the United States of America throws light on the relation between diet, food prices, and production area. Stiebeling and Ward drew up four types of diet,

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TABLE VII

ACRES REQUIRED TO PRODUCE 1,400,000 CALORIES OF CERTAIN FOODS

UNITED STATES, 1922-4

Crop or Product.	Crop (acres).	Pasture (acres).
Sugar { Beets	0·28	—
{ Cane	0·34	—
Potatoes	0·76	—
Corn meal	0·79	—
Wheat flour	1·45	—
Tomatoes	1·47	—
Apples	2·35	—
Pork and Lard	3·1	0·1
Milk	2·35	1·6
Beef (dressed)	11·3	2·5

(1,400,000 calories roughly represents yearly *per capita* consumption in the United States of America.)

conforming to American food habits, which were labelled as follows :

1. An "emergency restricted diet." This diet consisted largely of cereals and was designed to tide very poor and destitute people—e.g. the unemployed—over a comparatively short period of privation.

2. An "adequate diet at minimum cost." This was a more expensive diet, including less

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cereals and rather more milk, meat, fruit, and green vegetables.

3. An "adequate diet at moderate cost." This was roughly similar to 2, but was richer in milk and other nutritious foods.

4. A "liberal diet." In this diet the proportion of cereals was reduced to 100 lb. per year, a quart of milk per day was included, and meat, fruit, and green vegetables were added in maximum quantities.

Diets 2, 3, and 4 were similar in energy value, while the energy value of Diet 1 was slightly less. The cost rose steadily from 1 to 4.

The amount of land *per capita* required (in the United States of America) to produce these various diets was calculated by Dr. O. E. Baker. The acreage was as follows :

Diet.	Acres.
1	1·2
2	1·8
3	2·3
4	3·1

Now these figures, or rather the conceptions underlying them, are of enormous importance. They represent a contribution to population questions as significant as any since Malthus's famous "Essay." According to the Malthusian hypothesis, population increases in geo-

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metrical progression, agricultural production in arithmetical progression. This being so, a point is inevitably reached at which there is not enough food to go round and the only way out of the impasse is a reduction of population, or at least a decrease in population growth, by various "checks." Now in Western civilization the spectre raised by Malthus has been laid; agricultural production has increased at a greater proportionate rate than population and the steady raising of dietary standards until they reach the optimum seems within the bounds of possibility. Most of the countries inhabited by the white races have indeed reached an impasse of a very different nature to that envisaged by Malthus. The population problem which faces the West (one must include here in this term such countries as Australia, New Zealand, and white South Africa) is extremely serious, and during the next decades will increasingly perturb educated men and women. We have before us the prospect of a steady and increasing decline in the birth-rate which must have far-reaching social and economic consequences; e.g. a greater proportion of middle-aged and elderly people, with all this means morally and psychologically; a decline in the demand for goods and services, particularly those required by children (e.g. educational

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services); a retraction rather than an expansion of development in colonies now thinly populated by the white races, such as Western Canada and Australia. There is no reason, of course, why the West should not solve its problem of population decline by deliberate plan and action. In fact, it will probably do so. But the problem is there, and it is essential to realize, in considering what appears to be a problem of over-population in other parts of the world, notably the East, that the time has passed when mere unthinking and undirected restriction of population growth was considered by many as a thing essentially desirable in itself. The broad path smoothed by earnest female propagandists of birth-control may lead to troublesome swamps.

But there are other parts of the world where numbers are still rapidly increasing with no immediate prospect of decline. In 1933, the estimated population of British India was some 273 millions, that of all India including Indian States approximately 350 millions. The Public Health Commissioner with the Government of India has estimated that in 1941, when the next census is taken, the population of India will exceed 400 millions, assuming that existing conditions continue, and there is no reason to suppose that they

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will not. The population of India represents between one-sixth and one-fifth of the population of the world.

The total land area of British India amounts to 667 million acres ; of this total, in 1933, only 232 million acres were cultivated and sown. There were 47 million acres lying fallow, 154 million culturable but uncultivated, 145 million not available for cultivation (desert, etc.), and 85 million consisting of forest. Acreage *per capita* would work out as follows :

	Acres per head.
Total area	2·44
Cultivated area, current fallows, culturable area	1·75
Area actually sown	0·72

Comparing these figures with the American estimates of the amount of land *per capita* required to produce diets of various degrees of excellence, we note that the " area actually sown " in India provides a *per capita* acreage which is about two-thirds that required in the United States of America to produce what is called an " emergency restricted diet." The " liberal " diet of the American workers demands an acreage per head which exceeds that available in India if the whole land area of the country, including vast tracts of desert

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and forest, were brought under cultivation. One must, of course, remember that nutritional requirements are lower in India than in the United States of America, both because of climate and because the average Indian is smaller than the average American. But with all allowances made, one can deduce from the low *per capita* acreage under food crops in India, and the absence of food imports on a large scale, that the diet of the mass of the people is largely composed of cereals, and that there is a low intake of nutritious foods such as milk and milk products, eggs, vegetables, and meat. This deduction is in conformity with our knowledge of the actual state of affairs in India. Probably the majority of the population consumes a diet which is qualitatively inferior to Stiebeling and Ward's "emergency restricted diet."

Given a steady increase in population during the next few decades, what is likely to happen in India? In order that the *present* dietary level may be maintained, the amount of food available must increase proportionately with population growth. It is a matter of controversy whether agricultural production in India is outstripping population or being outstripped by it. There does not appear to have been any appreciable increase in the *per capita* acreage under food crops

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during the last few decades ; a large proportion of "cultivable waste other than fallow" is very poor land which, in the words of Royal Commission on Agriculture in India, "could in no conceivable circumstances be brought under tillage." At the Population Conference held in Lucknow in 1936 (the first of its kind in India) Professor Radhakamal Mukerjee gave it as his opinion that while more waste land might be forced to grow food under an unremitting population pressure, in no circumstances could the soil of the country support more than 440 millions.

The application of scientific methods to agriculture has resulted in increased yields from more productive lands, and the comparative rarity of widespread famine to-day suggests that on the whole the food supply is less insufficient than formerly. But there is no clear knowledge on this last point and the Malthusian spectre still walks. Giving evidence before the Royal Commission on Agriculture in India, in 1927, the Director of Public Health in Madras advised against spending large sums of money on irrigation schemes. These would undoubtedly increase food supply, but the benefit would be only temporary. Increase in numbers would rapidly absorb the extra supply of food, and the

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final result would simply be a larger population with the same standards of life and diet as the present population. Sooner or later scarcity must come. Sir John Megaw has said: "There is every reason to believe that the maximum increase which can be hoped for in the production of the necessaries of life will not keep pace with the growth of the population, so that there is a prospect of a steady deterioration in the state of nutrition of the people."

We must, of course, remember that India is part of the world and that in the world as a whole enormous increases in food production are possible. It is conceivable that a rise in purchasing power, following an increase in industrial wealth, might enable India to feed a much larger population with the help of imported food. The advance of scientific agriculture *might* enable food supply to keep pace with population growth, or outstrip it, until a fall in the birth-rate, such as that which has taken place in all countries which have reached a certain level of development, intervenes to relieve the situation.

Japan, a densely populated country with a rising population, has within recent years tackled her problem of malnutrition with vigour and apparent success. A few ex-

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amples will suffice : the domestic production of eggs increased from 1,620 millions in 1925 to 3,570 millions in 1932. Similarly, the production of wheat, meat, and sugar is rapidly rising, and the growth of the fishing industry has been really remarkable. In 1906 there was only one motor fishing boat in Japan ; all fishing boats in service were open sailing boats or junks ; by 1927 the open sailing boat was disappearing, and nearly 21,000 motor-boats were in use. In 1931 there were 31,000 ; in 1933, 45,000. During the years 1912 to 1927 in Japan population increased by one-fourth, while fish production was trebled. The Japanese administration has set out to improve the nutrition of the people by a deliberate and considered policy, based on scientific knowledge.

The following figures show the trend of birth- and death-rates in India from 1901-33 :

BRITISH INDIA

Period.	Birth-rate per mille.	Death-rate per mille.
1901-10	38	34
1911-20	37	34
1921-30	35	26
1926	35	27
1927	35	25
1928	37	26

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BRITISH INDIA

Period.	Birth-rate per mille.	Death-rate per mille.
1929	36	26
1930	36	27
1931	35	25
1932	34	22
1933	34	22

The birth-rate is not rising in India ; it may perhaps be falling slightly, since no increase has been apparent in recent years in spite of improved registration. But if a fall is occurring it is still slight and will accelerate slowly. Meanwhile the death-rate is unquestionably falling, *pari passu* with the development of public health services. The infantile mortality rate, however, remained more or less stationary during the years 1928-33, fluctuating between 180 and 170 per thousand births. Existing natality and mortality statistics provide no prospect of immediate slackening in population growth. They show, in fact, that the factors which have been associated with rapid population growth elsewhere are present in India.

Such are the bare outlines of the so-called population problem in a vast sub-continent. It is difficult, in fact impossible, to forecast the future trend of events, but clearly there *are* grounds for anxiety. Even if the view

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that India is facing a prospect of increasing food scarcity is rejected, it is obvious that no very extensive improvement on the *quality* of the diet of the people as a whole can take place as long as the *per capita* area under food crops remains very low. The importation of foods and increased yields have, of course, the *effect* of increasing *per capita* area under food crops. But whatever may be the possibilities in this direction, the nutrition worker in India cannot at present envisage India as a well-fed nation according to Western standards. A consideration of the various factors in the situation, of which population is perhaps the most important, makes it clear that the improvement of the diet of the people of India will be a slow and difficult task.

The educated classes in India are becoming aware of their "population problem," which was discussed at length at the first Population Conference in 1936. "Family limitation" and a rising standard of living and education go together. It seems that the former must follow the latter, though indeed it might be argued that India cannot reach and maintain a higher standard of living unless numbers are first reduced. A comment on the population question in India made by the Director of Public Health in Madras, A. J. H. Russell, in giving evidence before the Royal Commission

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on Agriculture (1927), is worth quoting. On being asked, "Have you any solution to offer?" he replied:

"I think the first thing is to spread education in hygiene. I am not going to mention 'birth-control' because that would be impossible in a country like this. But if you educate people in ways of healthy living, that result will inevitably follow. In one group in the city of Madras it has followed already. I examined the birth-rate figures for Madras City in 1924 and 1925 and to my amazement found that the birth-rate among the Brahmins of the city was practically equal to the birth-rate among the Europeans. The birth-rate of other communities gradually rises as one goes down the social scale until you get to the lowest class of all, where it is practically double the Brahmin birth-rate; so that, I think, if you could get education in hygiene spread among the whole population the question of over-population would not arise."

Enough has been said to outline the connection between "population pressure" and diet, and to show into what unexpected directions study of the science of nutrition in its broader aspects leads us. The population problem in India is not unique. The great river valleys of China support incredibly dense populations on a diet of poor quality,

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and probably a similar state of affairs exists in such countries as Ceylon, Java, and the Philippines. In Japan, however, applied science has within recent years changed the aspect of the situation.

It is a curious fact that while in certain parts of the world "population pressure" seems one of the main obstacles standing in the way of dietary amelioration, there are other parts of the world in which a steady decline in numbers, sometimes ascribed to deficient diet, is causing serious anxiety. In certain French colonial territories in Africa and elsewhere there is a definite tendency towards "de-population." Similarly, the native population of certain South Pacific islands has been steadily dwindling during the last fifty years or more. In the Marquesasi, for example, population has declined from 50,000 to about 2,000. We have seen that in India the consumption of a diet of poor quality, and a very low standard of living, are compatible with a high birth-rate and a rapid increase in numbers. Experiments on laboratory animals have shown that fertility is adversely affected by various types of diet deficiency, and a high infantile mortality invariably occurs among ill-nourished peoples. If the diet of the Indian masses were to be suddenly improved with no concurrent

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changes in other habits of life, population growth would be still further accelerated. But the fact that in certain circumstances an ill-nourished people can increase and multiply throws doubt on theories that diet deficiency, quantitative and qualitative, is the primary cause of de-population elsewhere. The whole question requires much further field investigation, to elicit the part played in de-population in various parts of the world by diet deficiency, introduced diseases, e.g. tuberculosis, and psychological factors. It is unlikely that the same underlying causes are operative everywhere.

Perhaps Rivers was right in ascribing the de-population of Melanesia to disgust with an existence which the advent of the white man has rendered intolerably boring. Where there is no vision, the people perish. One might hazard the guess that as long as "native" populations under the white man's control are left in peace to follow their traditional manner of existence, with their family customs undisturbed, secured against such major catastrophes as famine, flood, war and plunder, they will multiply however low their standard of life, however wretched their diet. But if they are forced to work at uncongenial tasks, if young men are separated from their homes and villages for long periods and family life

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is dislocated, if time-honoured customs and rituals are sneered at and discouraged, something snaps. The biological urge towards the continuance of the species is killed. The disheartened victims, slowly, but by no means undramatically, commit racial suicide.

CHAPTER IX

PUBLIC HEALTH NUTRITION WORK

THERE is no more fascinating and stirring story than that of the development of the public health movement—social medicine—during the last century and up to the present time. That development has occurred, on roughly parallel lines, in all civilized countries, but nowhere was the battle more fiercely waged than in England. When John Simon became Medical Officer to the Privy Council in the middle of last century, the English factory town, that horrifying product of the industrial revolution and the *laissez faire* economic philosophy, was a death-trap. The slums to be found within a stone's-throw of sedate cathedral closes in country towns, the picturesque hovels in which villagers existed in poverty and squalor scarcely alleviated by gifts of soup from the vicar's wife, were almost equally dangerous to live in. The germs of cholera, dysentery, and enteric were provided with every opportunity to flourish and multiply. In the manufacturing centres industrial diseases took a terrible toll. Metal-grinders

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died of silicosis before fifty ; pottery workers succumbed to lead poisoning and tuberculosis ; in the sweated industries, such as lace-making and stocking-weaving, low wages, semi-starvation, insanitary working conditions and long working hours soon reduced the strongest to a state of debility and weakness from which there was no recovery. Men, women, and children were all victims of the machine.

Naturally, therefore, the public health movement was first conceived as a campaign against disease, and particularly against "dirt" diseases and industrial diseases. The campaign has on the whole been successful ; the worst of the mess has been cleaned up. Not, of course, entirely cleaned up. The slums are still with us and there are still dangerous industries. But a public health system for disease prevention has been slowly created which has made industrial conditions less intolerably dangerous to and destructive of human life. That system, which is still developing, is a permanent necessity.

But social medicine includes more than the prevention and treatment of disease. It is concerned with the creation of positive physical well-being. The conception that it is the public health worker's task to build a strong and healthy nation is not a new one. School

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medical services, for example, which have existed in England since 1906, superintend the health of the growing child, discover disease in early stages, repair the ravages of parental mismanagement, and help to create stalwart citizens. Maternity and child welfare services are responsible for the health and development of the individual at an earlier stage in the life-cycle and for the well-being of the biologically most important section of the population—women of the child-bearing age. Many leaders in the public health movement—Sir George Newman in England, for example—have been apostles and preachers of health, denouncing and pleading in Annual Reports with missionary fervour. It has now become clear that diet is the most important single factor influencing general health and development, and consequently social medicine is becoming increasingly concerned with food and nutrition. During recent years what may be called “public health nutrition work” has been developing rapidly in most civilized countries.

In the *Report of the Chief Medical Officer of the Ministry of Health (Great Britain) for the year 1933* one finds the following statement :

“ Since its foundation in 1919 the Ministry of Health has always insisted upon the vital importance of Nutrition as a fundamental

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factor in personal and public health. The natural powers of the body to digest and assimilate food and to furnish the blood with sustenance and oxygen are quite as essential to health as the daily supply to the body of nourishing food and fresh air. Hence it has been one of the primary duties of the Ministry of Health to do all in its powers to promote the spread of such knowledge in the science and art of dietetics as will contribute to normal growth, to the development of sound physique, and to the maintenance of resistance to infection and other agencies of disease. Two principal means are available : first, the education of the community in the choice of suitable food ; and secondly, the safeguarding of food from deficiency in composition, from adulteration and from contamination."

It is not to be implied, of course, that the present interest of public health workers in nutrition is entirely a new departure. One could point to examples of successful work in this field accomplished long before "vitamins" became a household word and the nutrition of school children a familiar subject for discussion in legislative assemblies. The following may be given as instances : the control of beriberi in the Japanese navy during the closing years of last century ; measures for the prevention of beriberi in

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Malaya formulated during the first decade of this century ; simultaneous measures in India which resulted in the almost complete disappearance of beriberi from gaols ; the efforts made in Italy, from about 1880 onwards, to eradicate pellagra, which were oriented by upholders of the theory that pellagra is due to eating too much "spoiled maize." The Italian anti-pellagra campaign, while based on a theory of causation no longer accepted, included measures of preventive value. Such were : the establishment of rural bakeries to provide cheap wheat bread to maize-eaters, and of kitchens which supplied soup, bread, and sometimes meat to potential pellagrins and patients in the incipient stage of the disease. One could cite many other instances of early public health nutrition work.

To feed the poor is traditionally among the most virtuous of acts, and until recently perhaps the primary function of charity. Poor and hungry are frequently associated adjectives. But the modern mind cannot complacently accept the fact that a large percentage of the population should be insufficiently or improperly fed. A child suffering from malnutrition is an accusation not of wickedness on the part of the educated and governing classes, but of incompetence. Something, we feel, should be done about it

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without delay. Organized social action, not charity, is called for.

In England the Education Act of 1870 made school attendance compulsory. Sickly, ill-nourished, and emaciated children from the slums crowded into the schools to receive the benefits of education. Such children are very stupid and difficult to teach ; their brains are working with the wrong sort of fuel or with not enough fuel. In 1906 Parliament decreed that undernourished children in schools must be fed, because otherwise they could not take advantage of the education the State was expensively providing for them ; the principle was adopted that school feeding is " educational " in character, and not in the nature of relief.

To-day the feeding of school children is one of the most effective and valuable forms of public health nutrition work. In 1907-8 the number of school meals provided by local education authorities in England was less than 3 millions ; in 1932-3 the number had risen to 62 millions. In addition to meals, children diagnosed as suffering from malnutrition by the school doctors may receive extra milk, cod-liver oil, and malt. A great part of such school feeding is free of charge. Meals are supplied free to children whose parents are necessitous, but if parents can afford it, they

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are expected to pay the whole or part of the cost.

The value of "extra" milk in improving the health of school children has been referred to in an earlier chapter. In 1934 the British Government subsidized a scheme by which elementary school children were supplied with one-third of a pint of milk (about 190 c.cm.) for a halfpenny instead of the usual retail price of one penny. At the same time local education authorities increased the provision of free milk meals. As a result some 3 million elementary school children (out of a total of 5 millions) are now (1936) drinking good milk daily in school. It is hard to think of any other measure likely to have a more beneficent effect on the health and development of the people. In future, it seems, civilization will be short of children; all the more reason, therefore, why the remnant should be fine specimens.

Norway is a land of magnificent children and it is surely no coincidence that very careful attention is given to children's diet in that country. The Norwegian school breakfast may be said to represent the ideal of the nutrition worker. In Oslo and other cities a high percentage of children (mostly children of the poorer classes) on arriving at school are provided with the following :

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400 to 500 c.cm. of fresh whole milk.
2 scones made of whole wheat or rye flour ; whole wheat or whole rye bread *ad lib.* ; a little fat cheese and vitaminized margarine (i.e. margarine equivalent in vitamin A and D value to good summer butter) ; half an orange, or half an apple, or a raw carrot.

Norwegian school medical officers emphasize the advantage which a school breakfast has over a school lunch. Breakfast taken before leaving home for school is usually a hasty meal ; one seems to recall rushing out of the house carrying part of it, to be consumed *en route*. It is more healthy and agreeable to sit down to a quiet meal at school, which must be eaten slowly ; half an hour is allowed for the Norwegian school breakfast. The child begins school feeling pleasantly replete, and it is claimed that the attention of a child in this condition is less inclined to wander. One other important point about this and other kinds of school meals must be mentioned : an opportunity of teaching graceful table manners arises. Children learn that the consumption of a good meal is a ritual to be elegantly and seriously performed.

In May, 1936, the Viceroy of India, Lord

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Linlithgow, inaugurated a scheme for providing "extra" milk to malnourished school children in Simla. He quoted Cory Mann's experiment to which reference is made on page 141. "What, indeed," he said, in discussing the importance of proper feeding in relation to health, "is the use of spending public funds on objects such as education, welfare schemes and the like if the people have not the health and vigour of mind and body to take full advantage of them and to enjoy them? What indeed can we hope from a political constitution unless we apply ourselves without delay and with persistence, vision and courage to the improvement of the physical constitution of the common run of men and women? For, in truth, the response of the individual to the opportunities of life, whether economic, cultural or political, is inevitably inadequate in the absence of that vigour and ambition and of that joy in life which belong to the possession of a healthy and balanced mind linked to a healthy body." This is startlingly true. The subject of school meals and other forms of public health nutrition work may seem trivial. It is not particularly scientific; no profound knowledge of nutrition is required to formulate schemes for improving health by improving diet. But a scientifically minded Viceroy,

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grappling with the enormously complicated administrative and political problems of India, drives home the fact that a malnourished nation is grossly handicapped in all its activities. It may well be that the thing India needs most is more milk for school children.

In Soviet Russia it is decreed that *all* children shall receive one or more solid meals in school. How far this admirable regulation is carried out in practice it is of course impossible to say; there is no doubt, however, that in U.S.S.R. particular attention is given to the health and development of children.

Besides school children of the poorer classes, there are other groups in the population likely to benefit from an "extra" supply of nutritious food. Expectant and nursing mothers, for example. In England and Scotland local authorities are empowered to provide food and milk at less than cost price to expectant and nursing mothers and to children under three (exceptionally, up to five years of age), if the medical officer of a Maternity and Child Welfare Centre certifies that such provision is necessary on grounds of health. Only mothers who cannot afford to buy enough nutritious food for themselves are assisted. In principle, extra milk or food is given on grounds of health and not because of poverty—a distinction very typical of the

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English administrative mind. Cod-liver oil may also be provided under this scheme.

In large cities quite an elaborate organization is needed to supply meals to schools and welfare centres. They are usually cooked in central kitchens and distributed in heat-retaining receptacles by motor-lorry.

The diet of the mother during pregnancy and lactation influences the health of the child—the foundations of health, so to speak, are laid during that period. There is evidence, for example, which suggests that full normal development of the brain and central nervous system cannot take place if the foetal circulation, dependent on the maternal circulation, carries insufficient vitamin A to the embryonic tissues. The future development of teeth and bones is adversely affected if supplies of calcium and vitamin D are deficient. Efforts to improve the diet of expectant and nursing mothers are thus of double value, because both mother and child are benefited.

Infant welfare work is one of the most important branches of social medicine. The remarkable fall in infantile mortality which has taken place in civilized countries has been in considerable measure due to careful supervision of the infant by public health workers. The increasing rarity of rickets may be ascribed to the same cause—in particular to

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the widespread popularization and distribution of cod-liver oil. At welfare centres women are taught how to feed and look after their babies, and the growth and development of the baby throughout the first year or so of life is watched. A principle commonly adopted in infant welfare work is that breast milk is the best (and cheapest) food for growing infants—provided, of course, it is derived from well-nourished mothers—and women are encouraged to feed their babies themselves. If breast feeding is impossible, then ordinary cow's milk, diluted and "adjusted" in various ways to bring its composition nearer to that of breast milk, may be recommended. To-day, however, there is a growing tendency to employ "humanized" dried milks, sometimes fortified with added vitamins, in infant feeding. Ordinary infants do very well on such milks—so well, indeed, that it is difficult for doctors to insist that well-to-do mothers, anxious to resume such valuable social activities as bridge and dancing, should remain on duty in the nursery.

The child who has left infancy behind and has not yet attained the school entrance age is often referred to in public health circles as the "pre-school" child. Maternity and child welfare services, as at present organized, do not follow the child beyond its second year.

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When, at the age of five or six, it enters school, it comes under the observation of the school medical officer. Public health authorities often express concern about this period, during which the child's health may receive no supervision except that provided by parents or family doctors; all good public health workers are convinced of the incompetence in this respect of parents and family doctors. In May, 1936, the Ministry of Health in Great Britain circularized local authorities, urging that more attention should be given to the pre-school child by health services. It was particularly suggested that health visitors, whose main concern is at present with mothers and infants, should make it their business to follow children beyond the "infant welfare clinic" stage. There is no doubt that permanent damage can be done to the health of a child during the pre-school period; a large proportion of school entrants are found to be suffering from physical defects which are the result of neglect during the years previous to admission, and which are discovered only when the time for prevention is past.

Many of these defects are in large measure due to faulty diet, and those who formulate public health schemes for improving the health of the pre-school child must pay the greatest attention to diet. The State super-

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vises the nutrition of the individual from conception until past infancy, and again during the school years of childhood ; it is only sensible that the " pre-school " gap should be filled. In India there is perhaps more malnutrition during this period of life than during any other. The infant may do fairly well as long as it is fed from the breast, but when the time for weaning comes, and it passes from a diet of breast milk to a diet of, let us say, rice and water, a deterioration in its condition rapidly takes place. It needs milk, but cow and buffalo milk is scarce and dear in many parts of India. The problem of improving the diet of the pre-school child in India and the East is a thorny one, but there is no doubt of its importance in the sphere of public health.

From the public health point of view, the diet of the mother and the growing child is of paramount importance. Less attention has been given by public and charitable agencies to the improvement of the diet of adults in general by direct means. But within recent years governments have been concerned with improving the diet of groups fed at the expense of the State, e.g. armies, the inmates of State institutions. A passage from an excellent report of the International Labour Office, *Workers' Nutrition and Social Policy*

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(1936), may with advantage be quoted at this point :

“ Simple arrangements for furnishing regular or occasional food supplies to the indigent poor are a custom of long standing in many countries. Thus there are agencies for distributing Christmas baskets, for providing ‘ Winter Aid,’ for organizing soup kitchens, for maintaining transient shelters, etc. For the most part, the work of such agencies is confined to very special groups : the old, the feeble, the ill, the disabled, the homeless.

“ During recent years, however, and in response to the exigencies of the world-wide depression, a much more significant practice has emerged. Public and quasi-public agencies have undertaken to safeguard the nutrition of unemployed households on relief. They have undertaken to do so by a variety of means : the regular provision of food grants or of free meals ; the issuance of vouchers good for the purchase of merchandise in grocers’ or butchers’ stores ; dietary instruction in connection with cash relief, etc.

“ Speaking broadly, every relief payment to an unemployed worker’s household may be regarded as a grant in aid of his family’s nutrition. Among low income families, it is well known, very high proportions of the total income have to be devoted to the purchase

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of food. When income diminishes materially or ceases entirely, the quantity, quality, and diversity of the diet are likely to suffer at once. In many countries, moreover, cash relief has been supplemented by food grants substituted in part for cash. Thus directly or indirectly the relief organizations have functioned as agents for maintaining standards of nutrition among the large masses of working-class families who, in all countries, have felt the impact of the depression with particular severity."

Governments have long undertaken the duty of ensuring the purity and quality of various articles of food. "Pure food" laws are to be found on the statute book in every civilized country. G. K. Chesterton's wicked grocer who

Crams with cans of poisoned meat
Poor subjects of the King,
And when they die in thousands,
Why, he laughs like anything,

has not been left in peace to enjoy the joke. Regulations concerned with the cleanliness, purity, and freedom from contamination of foodstuffs are of the utmost importance in connection with practical nutrition. Thus, the most enthusiastic nutrition worker, convinced on scientific grounds of the food value of milk, could not preach the doctrine "drink

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more milk" without the assurance that the product recommended could be consumed without danger. Milk is so rich a foodstuff that it is an excellent breeding-ground for bacteria; in the past it has been a principal agent in the dissemination of tuberculosis. The nutrition worker in the East is considerably handicapped by the food adulterator. He may, for example, recommend a diet in which *ghee* (boiled butter) is an important ingredient, included as a source of vitamin A. But *ghee* is often adulterated with vegetable fat, which contains no vitamin A; pure *ghee* may be unobtainable. The statement that a group of children is receiving half a pint of milk per day is difficult to interpret in terms of nutritive value when, for all one knows, the so-called milk may be a bluish mixture of milk diluted with an equal quantity of dirty water.

There are at present in the market a large number of proprietary preparations, many of which are widely advertised, which are stated by their manufacturers to be rich in this or that vitamin or in some other food-factor. As a rule, preparations of this nature produced by firms of good standing are reliable; such firms employ properly qualified scientific workers who superintend the manufacture of their products, which do, in fact, contain what they are said to contain. But there is obvious

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room here for fraud on the part of the unscrupulous, and in various countries steps have been taken for the control of preparations "alleged to contain vitamins." The claims of the manufacturer may be checked in a government laboratory.

A very important branch of public health nutrition work is the education of the public in dietetics. Hunger is instinctive ; all living things are impelled to seek their meat in due season. But there is no reason to suppose that human beings possess an instinct which prompts them to seek the right sort of food. Most of us, it is true, prefer our meals to be tasty and varied and will revolt against a monotonous and unpalatable regime. A varied diet is naturally more likely to be well balanced than a monotonous diet. But we have no deep-seated instinct which warns us that a defective diet is dangerous to health, and informs us of the steps which should be taken to make good deficiencies. If there were such an instinct, rachitic children would crave cod-liver oil, victims of beriberi whole rice or rice polishings, while pellagrins would avoid maize as a Brahmin avoids beef. Actually, the victims of painful food deficiency diseases are usually quite unaware that diet has anything to do with their condition at all, and it has taken long years of patient scientific investiga-

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tion to make clear a connection which, had an efficient "food instinct" existed, would have been at once intuitively obvious.

Harris and his co-workers in Cambridge have carried out a very interesting series of experiments to test the faculty of rats to "choose" the right sort of diet. If animals are depleted of vitamin B₁, and then offered some preparation rich in the vitamin—e.g. yeast extract—they will usually display an avid appetite for the food containing the factor their tissues need. But careful experiments showed that this appetite is the result, not of instinct, but of experience; the animal rapidly *learns* that it feels better when it takes certain kinds of food. When a small animal is depleted of vitamin B₁, the consumption of foods rich in the vitamin brings about an improvement in its condition in a few hours. But if a rat is offered a supplement to a deficient diet which produces no *immediate* improvement, it may ignore the supplement, which it may need as urgently as a vitamin B₁ deficient animal needs that vitamin, and continue to eat the original defective diet. It has had no chance of learning that the supplement makes it feel better. If vitamin B₁ deficient rats are offered a large choice of foods, one of which is rich in the necessary vitamin, they cannot immediately pick out the food they

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require, unless previously educated on this point. Again, if they learn that a food rich in vitamin B₁ brings about recovery, they will, when again brought into a state of depletion, avidly consume the same food even though the experimenter has removed the vitamin from it. No instinct tells them that the food, which tastes the same as ever, is no longer of any value to them.

One may often read, in biographies and diaries, of how travellers and explorers, living on a diet of salt meat and ship's biscuit or something similar, *craved* fresh fruit and vegetables. See, for example, Benjamin Franklin's fascinating account of an Atlantic voyage in 1885. But one must assume that such cravings are largely prompted by *knowledge* of the value of fresh food in the particular circumstances.

In discussing education in dietetics, therefore, we can at once dismiss the idea that such education is superfluous because human beings have instinctive knowledge of what they should eat. The two most potent causes of malnutrition are poverty and ignorance, the emphasis being on the former. Poverty leads to malnutrition chiefly because the quality of a diet is related to its cost and the average income of the poorer classes is insufficient to cover the purchase of an adequate diet, but

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also because it is usually associated with general ignorance, which includes ignorance of how to spend money on food wisely. To ascribe the ill-feeding of the children of poor mothers to "maternal inefficiency" is heartless and on the whole unjustifiable; house-keeping problems on minimum wages and unemployment allowances would baffle Napoleon. But it remains true that in any given group of poor children a most important factor influencing the well-being of the individual child is the "efficiency"—the *character*—of the mother. The fact that certain poor housewives manage to provide their families with a better diet for a given sum than other housewives suggests that the education of young mothers on dietetics might produce useful results.

It is not only the poor, whose choice in the matter of food is extremely limited, who are ignorant and prejudiced about diet. Above the poverty-line a correct diet becomes possible if a little elementary knowledge is available. Plenty of people who could afford to consume an excellent diet, and feed their children on an excellent diet, do not in fact do so. One can readily find, among children of the more prosperous classes, cases of serious malnutrition; this statement is perhaps less applicable to England than to certain other

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countries, e.g. India. The nutrition worker will find plenty to do in educating the educated.

Let us consider some of the channels through which sound knowledge of dietetics can be spread. Central public health authorities can, with the help of "experts," draw up advisory memoranda for the guidance of public health officers, superintendents of residential institutions, and the general public itself. In many countries to-day official or semi-official "nutrition advisory committees" have been called into being, whose functions include the preparation of educational material. The Advisory Committee on Nutrition of the British Ministry of Health has produced some excellent educational pamphlets, including two entitled *Diet in Poor Law Children's Homes*, and *The Criticisms and Improvement of Diets*. The British Medical Association also has issued useful pamphlets on nutrition, including one on the cooking and preparation of food. In 1935, a Technical Commission of the Health Organization of the League of Nations drew up a report entitled *The Physiological Bases of Nutrition*, to which reference has already been made. This report, which defines *optimum* standards, may prove a document of considerable economic and sociological importance.

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For the more direct instruction of the public in rational dietetics, the value of classes in "domestic science" or (to use the American term) "home economics" must be emphasized. School girls in their teens can be taught a little about the subject, but the instruction of older girls of marriageable age is more important. Evening classes in cookery and domestic science are attended mostly by young women at this stage of life, who have just crossed the threshold of matrimony or are about to; at such classes they can learn how to prepare wholesome and palatable meals and something about food values, efficient marketing, and the planning of diets. Some of them may not forget *all* they have been taught when faced with the task of providing for husband and family. Domestic science teaching is most highly developed in industrial countries, but successful attempts have been made, in certain parts of the world, to instruct the wives of small farmers and peasants. The diet of a peasant family may be as ill-cooked and as poor in nutritive value as the diet of a slum family, and it has been found that disgruntled countrymen who have suffered from incompetent catering and cooking on the part of their wives are only too anxious that they should be taught better.

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There are many other methods of imparting dietary knowledge. The educational value of school meals has already been mentioned. A great deal of direct educational work is carried out by doctors, social workers, health visitors, and by special nutrition workers often called "nutritionists" or "dietitians" to whom reference will be made later. Lectures, exhibitions, wireless talks, press articles, etc., may be of considerable educational value.

One difficulty encountered by those who attempt to educate the public in dietetics must be referred to. The ingenuity of the modern advertisement is irresistible; it is hard to convince worried mothers, anxious to do the best they can for their children, that this or that food product, the virtues of which are "scrawled on a five-foot page," has roughly the same nutritive value as a similar quantity of bread or cheese, and that it offers for five shillings the same amount of protein and vitamins as may be purchased at the grocer's, in different form, for fourpence-halfpenny. This is not to imply that various vitamin concentrates, and foods enriched with vitamins and other food-factors, produced by reputable firms, may not be of great value in certain circumstances. The modern type of "tonic" which contains,

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in addition to iron, various vitamins in high concentration is probably an improvement on the old-fashioned type of "tonic" of which the principal ingredients were iron, arsenic, phosphorus, and strychnine. The supplying of vitamins produces obvious effects where there has been a previous lack; but vitamins are active physiological agents and in high concentration may have further effects, possibly beneficial to the general health. Consumed in very high concentration in enormous quantities they may be deleterious, just as is the case with other active physiological agents, but in practice there is no need to worry unduly about vitamin excess.

In general, the nutrition worker prefers, in devising dietaries and making good deficiencies, to rely on natural foodstuffs rather than on special preparations and concentrations. The high cost of the latter prohibits their purchase by the poorer classes whose diet stands in greatest need of improvement.

Many references have been made throughout the book to "nutrition workers." What is a nutrition worker? Actually a great deal of practical nutrition work is carried out by doctors, nurses, health visitors, social workers, etc., who possess a limited but adequate knowledge of the subject. Physiologists,

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physicists, chemists, bio-chemists, physicians, and hygienists make contributions to our knowledge of nutrition. But to-day there is a tendency for nutrition to become a speciality—a full-time job—and with some justification, for the field to be covered is a wide one. The science of nutrition is linked up on the one hand with physiology and delicate laboratory research, on the other hand with medicine, hygiene, economics and sociology. One of the principal tasks of the nutrition worker is to bridge the gap between scientific discovery and its application, a task which often paves the way for further discovery. In a sense he (or often she) is a specialist, but not a specialist who is engaged in learning more and more about less and less. He must, in fact, have at least a nodding acquaintance with many branches of pure and applied science. At the same time he must be something of a humanist, realizing that human beings differ in certain respects from laboratory animals. Knowledge of how people, and particularly poor people, really do live and behave is essential in this field of work. The nutrition worker, in drawing up dietary schedules and making recommendations for the improvement of diets, is guided by certain principles. But his task in this respect is not a standardized one ; the practical problems of

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nutrition are exceedingly diverse. In all attempts to improve diet existing dietary habits must be taken into tactful consideration; people will not easily change time-honoured customs at the behest of "experts." Economic and social realities must never be forgotten; diet is influenced not only by habit and income, but also by facilities for shopping, for cooking and storage in the home, and by a large number of social factors such as hours of work, the distance of the place of work from the home, the availability of domestic help, the employment in salaried work or otherwise of the housewife. How is a poor mother to prepare proper meals for her family if she is out at work all day and has no time to go shopping in the cheapest market? It is futile to theorize about improving national diets and ignore the existence of such practical problems.

It would be advantageous if all public health departments above a certain size could have attached to them workers specially trained in nutrition. In the United States to-day there are some thousands of trained "nutritionists" engaged in public health work (the dreadful word "nutritionist," invented in America, is now several years old; one must perforce use it). The nutritionist is a college graduate (female) who receives a

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training in the fundamental sciences and later "specializes" in nutrition; that is to say, she attends lecture courses, demonstrations, and cooking classes, and by visits to hospitals and schools learns something of the practical aspects of her work. When duly qualified she may be employed in various ways. "The nutritionist acts as a consultant in connection with all public health activities which demand knowledge of nutrition, such as tuberculosis, infant welfare, care of pre-school children, pre- and post-natal work, etc. She responds to requests from prisons, orphanages, and other kinds of residential institutions which ask for advice about the regulation of catering methods on scientific and economical lines. A large part of her work is educational; she prepares propaganda and gives talks and lectures, attempting to reach the community through school teachers, public health nurses and social workers. She lectures to graduate and undergraduate nurses. In addition she replies to requests for information from individuals and groups, and often takes part in health demonstrations and in field nutritional studies."¹

Large modern hospitals in the United

¹ *Nutrition and Public Health*, Et. Burnet and W. R. Aykroyd. Quarterly Bulletin, League of Nations Health Organization, 1935, vol. IV.

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States of America and to some extent in Europe employ "dietitians" to take charge of the catering arrangements for the whole institution and to supervise the preparation of special diets ordered for patients by the medical staff. Out-patient departments may include a special "nutrition" or "diet therapy" clinic in which the dietitian advises patients about their food, translating the recommendations of the physicians into practical instruction in terms of common foodstuffs and available income.

The professional nutrition worker in the United States of America has proved of the utmost value during the "depression" when poverty and destitution replaced easy abundance. The nutritionist played a prominent rôle in the social services, the vast relief organizations, hastily assembled to save the country from the worst effects of widespread unemployment and want. She superintended the distribution of food to miserable and bewildered housewives, and of cod-liver oil to malnourished children. Families on cash relief were taught by ingenious and painstaking education and propaganda how best to lay out their scanty dole on food. Leaflets were thrust at the victims :

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HOW TO SPEND YOUR FOOD MONEY

To get the foods that all the family need, *especially the children*, lay out your money carefully.

If you have very little money for food, divide EACH DOLLAR as follows :

One-fourth or more for milk or its equivalent	25 to 30 cents
One-fourth or slightly less for vegetables and fruit	25 to 30 ,,
About one-tenth for eggs, lean meat, fish.	10 ,,
One-fifth or more for bread, flour, cereals	20 ,,
The rest, about one-fifth, for fats, sugars and accessories	20 ,,

This sort of thing is perhaps a poor substitute for work and a living wage. But at least it helped to prevent a general deterioration in national health. Similar activities, on a smaller scale, were undertaken in other countries. As pointed out in the introduction, one of the reasons why the subject of nutrition has attained its present prominence is that the world has during the last twenty years passed through two periods of privation, one due to war, the other to a planless economic system. If we are to have another war, with destruction of cattle and crops, diminished food supplies, and a deterioration in living standards, the services of the trained nutrition worker will be required with some urgency.

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In certain countries nutrition research and its application are the direct concern of the government. In Soviet Russia, for example, where collective feeding is the rule, it has been an obvious necessity to frame regulations about diet and organize a service of workers whose duty it is to see that the regulations are carried out. The National Institute of Nutrition in Moscow, a research and not an administrative organization, supplies the necessary foundation of scientific knowledge. In the Soviet system the State is, theoretically, responsible for the feeding of the people, just as it is responsible for commerce, education, finance, and medical and sanitary services. The special attention which is being given to the health and development of children has focussed attention on diet, and moreover the Russians have considerable experience of what it means to be improperly and inadequately fed. What results will be achieved by the current methods of collective feeding it is impossible as yet to surmise. Principles which are admirable on paper may not always be put into practice ; the diet schedules which are posted on the walls of workmen's dining-rooms may differ in considerable degree from the meals actually provided by the communal kitchens. But at all events, the Russian experiments in collective feeding are of con-

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siderable interest to the nutrition worker, however much he may prefer to consume his own meals *en famille* and feel that this is the most natural and agreeable way for human beings to dine.

In Japan, where much interest has been taken in nutrition and a good deal of pioneer research has been done, nutrition research centres in the Imperial Institute of Nutrition, Tokyo, which is directly attached to the Ministry of the Interior. Japan is a crowded country with a rising population and a low standard of living, and the Japanese have been quick to realize the importance of their nutrition problem. In the Imperial Institute, research into all branches of the subject is carried out, with the ultimate object of discovering means by which the food resources of the country may be made to cover the requirements of the population. A great deal of attention is given to education and propaganda work, and nutritionists who have studied in the Institute act as advisers to local governments, and help to introduce scientifically sound dietary schedules into schools, hospitals, etc. Dietary education is carried into the villages. Another type of public health nutrition work which is being developed in Japan is the feeding of school children.

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Enough has been said to illustrate the importance of nutrition in relation to social medicine and to outline the developments which are taking place in this field. It seems clear that any public health service which does not include nutrition work in its programme is neglecting one of the most powerful means towards fulfilling the object for which it exists—the creation of a strong and healthy people.

CHAPTER X

PROSPECTS

IN 1935 the subject of nutrition began to receive considerable attention from the League of Nations and the related organization, the International Labour Office. Behind the growing interest of statesmen, economists, etc., in the question is the paradox of poverty and want amidst potential plenty. Two major problems confront our generation: the prevention of war, and the devising of means whereby mankind may benefit from the enormous possibilities of enhanced production resulting from the application of scientific methods to industry and agriculture. The two problems are perhaps more closely connected than appears at first sight. It is at least arguable that the amelioration of social conditions, leading to a more abundant life on the part of the masses, would be a step on the pathway to peace. Prosperity breeds content, aversion to warlike adventures. Or does it? That is a psychological question which can scarcely be discussed in a book about food.

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In the Report of the Director of the International Labour Office to the Nineteenth Session of the International Labour Conference (June, 1935) the following passage occurs :

“ Though there is still considerable controversy among physiologists as to the minimum needs for healthy subsistence and as to the rations of calories, proteins, mineral salts and vitamins required in different climatic conditions, it is not open to dispute that large masses of people are at present underfed or wrongly fed. . . . Every country is faced by a problem of this kind, but its exploration is only just beginning. It may be compared with the problem of medical treatment and maternity care, for which much has already been done wherever a sound system of health insurance has been established. . . . If the cure and prevention of disease is a communal affair, housing and feeding, which are the primary requisites of healthy living, are hardly less so. They were certainly not excluded from the purview of the International Labour Organization by the Preamble to the Constitution, which lays down the ‘ provision of an adequate living wage ’ as one of its objectives and declares it urgent to improve conditions of labour involving hardship and privation.

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“Looked at from another angle, it is evident that a higher and more variegated standard of food consumption would go far to solve the problem of agricultural over-production. . . .

“This question of consumption is not only national but international in its scope. If it is agreed that the only real solution of the problem of economic balance is not through scaling down production but in levelling up consumption, then it follows that the best hope of finding a way out of the present troubles is to raise the standards of the millions who are now underfed, underclothed and under-equipped. The cares of the American, Argentine, Australian, Canadian or Eastern European farmer would be conjured away if the urban population of Europe and America could eat even a little more bread, butter and meat per head. . . . When all other remedies have been clearly seen to fail, it is in this direction that thought will eventually be directed, unless a general regression towards lower standards of living is accepted as the ironical but inevitable outcome of a civilization condemned to decline through the excess of its own creative ingenuity and technical perfection.”¹

¹ International Labour Conference, Nineteenth Session, Geneva, 1935. Report of the Director, pp. 83-4.

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An interesting discussion of the questions raised in these paragraphs ensued at the Conference, in the course of which various delegates stressed the importance of nutrition in relation to agriculture, economic policy, and the purchasing power and health of industrial workers. The Conference adopted a resolution instructing the Labour Office "to continue its investigation of the problem, particularly in its rural aspects, in collaboration with the health and economic organizations of the League of Nations, the International Institute of Agriculture and other bodies capable of contributing to its solution, with a view to presenting a report to the 1936 Session of the Conference."

During the Sixteenth Session of the Assembly of the League of Nations (September, 1935), delegates of twelve countries, including the United Kingdom, Australia, the Argentine, Chile, Italy, and Sweden, addressed a letter to the President proposing that "the question of the relationship of nutrition to the health of the population which has become a social and economic problem of widely accepted significance, and is recognized as having an important bearing on world agricultural problems, should be placed on the agenda of the current Session of the Assembly."

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This was done, and the admirable discussion which followed lasted three days in the Second Committee ; international assemblies throw themselves with relief and enthusiasm into discussions of subjects not obviously and directly connected with peace, armaments, frontiers, tariff walls and other questions which are the despair of intelligent men. In an opening speech, Mr. Bruce, the chief Australian delegate, used the memorable phrase, " marry health and agriculture," which epitomized the subsequent debate. The world as a whole, and certain countries in particular, are capable of producing much greater quantities of nutritious " health-giving " foods if only an effective demand for them can be created ; if, in short, they can be paid for by consumers. On the other side, the world as a whole, and certain countries and social classes in particular, are in need of a richer diet. Further, if the consumption of agricultural products could be raised, the purchasing power of the agriculturist would rise simultaneously, and industry and world trade would be stimulated, with consequent increase of employment. This is surely sound reasoning. If Australians are coining money by selling good butter to populations in Europe and elsewhere who would be the better for more vitamin A, they will be able

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to buy manufactured goods from industrial countries, and ships will be kept busy effecting the exchange.

If steps are to be taken to improve the diet of populations on a large scale, a necessary preliminary is to set up an objective. In what direction should improvement take place? A Technical Commission of the League of Nations, composed of leading nutrition workers from various countries, which met in London in November, 1935, tried to answer this question. Its Report, entitled *The Physiological Bases of Nutrition*, defines in simple language a series of optimum dietary standards, along the lines familiar to all who have any acquaintance with the subject of nutrition. It re-emphasizes the importance of a high milk intake, particularly for children and expectant and nursing mothers; the value of green leafy vegetables, fruit, eggs, and unmilled cereals; the undesirability of a high consumption of milled cereals and sugar. The dietary standard suggested is one which is at present out of reach of the majority of mankind, so that plenty of scope is left for efforts to increase production and consumption. Even in a comparatively well-fed country like England, the general adoption of a diet of the type recommended by the Commission would mean a great increase in the demand for

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dairy products, eggs, fruit, vegetables, etc., and it is obvious that such a demand would bring prosperity to the farmer. If the whole population of the United States were to consume the "liberal diet" described on page 190, and rely entirely on home produce, an extra 340 million acres of American land would have to be brought under cultivation.

To a large extent, as far as the poorest classes are concerned, diet is determined by income, and without increase in purchasing power no great improvement is possible. But purchasing power cannot be raised because we wish it so ; if it could there would be no economic "depressions" and chronic unemployment. Short of miracles, however, various steps can be taken to push food consumption in the right direction. Food prices may be lowered, without hitting the agriculturist, by improving market organization and distribution, by eliminating trade barriers, and by removing indirect taxation on food products. On the other side, methods of raising purchasing power are not unknown. The International Labour Office Report on *Workers' Nutrition and Social Policy* may once more be quoted :

"To influence consumption by increasing the national income involves a stimulation of

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production efficiency and a successful general business cycle policy. At the same time great scope for improving nutrition standards even within the limit of the existing national income is offered by policies tending towards its re-distribution in favour of the lower income classes. Various methods of such re-distribution have been used, differing mainly in the sources of the money to be distributed—credit expansion, the printing press, taxation of various kinds, etc.—and in the form in which the distribution may take place—relief, wage subsidies, pensions, bonuses, etc. With regard to the source of the money, it is desirable that it should neither be derived from other income classes lying near or beneath the borderline of undernourishment (in particular not from indirect or regressive direct taxation) nor act in any way as a deterrent to production or the full use of productive resources. With regard to the form of distribution, those forms might be chosen which react as favourably as possible in the general economic situation and on the total national production. . . .”

So, a little ponderously, the political economist takes the field in the campaign against malnutrition. It is something new that the relation between income, the cost of living, and food consumption and health, and between “minimum adequate wages” and

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“ minimum adequate diets,” should be forced on his attention.

There are, of course, more direct means of influencing food consumption than those outlined in the above passage from the I.L.O. Report. Reference has already been made to *education* in the principles of dietetics, which in certain countries has done much to create a demand for certain foods. In the United States of America, for example, the prosperity of the “ dairy ” states, e.g. Wisconsin, is in considerable measure due to the enthusiasm with which nutrition workers have preached the value of milk and milk products. In countries like England, the direct subsidizing of certain branches of the agricultural industry (e.g. dairy products, eggs, fruit and vegetables) would stimulate production, and lower prices to the consumer’s benefit. An increased national expenditure on unemployment benefit, the supply of milk and nutritious meals to school-children, pregnant and nursing mothers, etc., an improvement in the diet of groups whose feeding is the concern of the State, would ultimately have a beneficial effect on the health of a large section of the population and at the same time put money in the farmer’s pocket. In many countries—alas !—armies form the largest groups fed at the public expense, and armies are mainly

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composed of young men whose health and physique can be improved by satisfactory feeding.

The League of Nations "Mixed Committee on the Problem of Nutrition," which held its first two sessions in February and June, 1936, has the task of formulating and analysing methods of improving diet throughout the world; it is composed of nutrition workers, agricultural experts, and economists. Whatever success may be achieved, its mere existence is of importance. Science has been blamed for many of our present troubles; for perfecting engines of destruction, for scattering abundance in a bewildered world still bound by the tradition of want. But what we need is not less science, but more, and in particular science applied to human life in all its aspects. If some of the intellectual effort which has created the aeroplane and modern physical science can be applied in this direction, we may soon find paths leading to higher levels of prosperity and happiness.

The Chairman of the "Mixed Committee," Lord Astor, concluded his opening speech to the first meeting with the following words: "I believe that our final recommendations can and will make an overwhelming appeal to the commonsense of the world. . . . If starting from the aspect of public health and

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continuing our inquiries through the fields of national agriculture, of world trade, of industrial employment, we come to the conclusion that welfare, using this word in its widest meaning, can be immeasurably raised through the application of the results of science, we shall open up a new era of progress to a suffering world.”

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