



PRIVY COUNCIL

MEDICAL RESEARCH COUNCIL

SPECIAL REPORT SERIES No. 257

A STUDY OF INDIVIDUAL CHILDREN'S DIETS

by

E. M. WIDDOWSON

LONDON : HIS MAJESTY'S STATIONERY OFFICE

1947

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PREFACE

In the majority of the dietetic surveys carried out from time to time the family has been the unit of investigation and, consequently, measurements have been made of the food eaten by parents and children together. The method is useful for some purposes and, by making certain assumptions, it is possible to get some idea of the food eaten by the children. The method does not, however, give any picture of what an individual child eats and does not show the variations between one child and another. Hence it does not provide the information by which it is possible to correlate intake of food with the physical state of the children in relation to age, sex and other factors. Information on these points is obviously desirable, and when, in 1936, Dr. Widdowson proposed to investigate the diets of individual children, the Council welcomed her suggestion. The intention was to obtain an exact knowledge of what food, in kind and quantity, was actually consumed by each child in selected groups. The method employed was to weigh the food eaten over a period of one week by each child studied. At the same time the heights and weights of the children were measured, and frequently also the blood and teeth were examined. To collect these data from over 1,000 children was a formidable task, but it was completed in 1939, a few weeks before the war broke out. The translation of the individual diets into terms of proteins, fats, minerals and vitamins, and the subsequent analysis of the records, would inevitably have taken a very long time, but the exigencies of war have further and very greatly delayed the preparation and publication of the results which are here presented.

The children whose diets were studied by Dr. Widdowson were healthy, and most of them were living at home. At least 20 boys and 20 girls were investigated at every year of age from 1 to 18. The records, therefore, cover the whole range of childhood, and many curves have been constructed showing the effects of age on food habits and dietary intakes. The children came from "middle class" homes, and it is satisfactory to find that their heights and weights were fully up to American standards. Nevertheless, when the children were graded according to the economic circumstances of their parents, there was an unmistakable tendency for the less fortunate financially to be slightly smaller and lighter than the others.

In most dietary surveys the data are presented only in chemical phraseology or in terms of "proximate principles", but in this report the actual foods eaten by the children are recorded in some detail, and many people, particularly those actively concerned with the feeding of children, are likely to find this section of special value. It includes some surprising findings. Who, for instance, would have predicted that the consumption of white bread rose steadily with age, while that of brown bread was the same at all ages studied? And who would have been prepared for the discovery that clear differences existed between the food consumption of the two sexes as early as the ages of 6, 7, or 8?

Among the most striking points revealed by this investigation were the wide individual variations in calorie intake which were compatible with good health and average physical development. In each age group studied there was always one child who ate twice as much as another, and similar differences were found when children of the same height, weight or surface area were compared. Variations of the same relative size have been encountered by Dr. Widdowson in adults, and it is evident that they constitute a warning against legislating for

individuals from a knowledge only of the average. These differences, no doubt, will help to explain why one person keeps fit and puts on weight while another loses weight when issued with the same rations.

It is recognized in the report that the information obtained is not that relating to "requirement" but essentially that of dietary habit. Even after surveying the literature with great care the author has to conclude again and again that no firm figure can be given even for the average person's "requirement" of iron or calcium, or even protein, much less for an individual's requirement, and the variations revealed in the report further emphasize this point. Nevertheless, we are very much better informed about dietary matters than we were at the close of the war of 1914-1918, and our knowledge of the value of particular items of diet has lately been turned to good account by such measures as the provision of cheap milk for children and all the recent extensions of that scheme.

A few children living in "homes" or at residential public schools, some children with parents out of work, and a few diabetics and vegetarians were included within the scope of Dr. Widdowson's studies, and the relevant data, plotted against the general background of the main investigation, are of interest for comparison.

In conclusion, it is pertinent to point out that much of the work reported here was made possible only by the series of analytical investigations into the chemical composition of foods which had been carried out by Dr. McCance and Dr. Widdowson, with support from the Council, since 1925 (see Report No. 235 in this Series, second edition, 1946). Dr. Widdowson had herself taken a prominent part in the latter phase of this work, and it is satisfactory that she should have been able to apply its results in studying the present problem.

MEDICAL RESEARCH COUNCIL,
38 Old Queen Street,
Westminster, S.W.1.

12th February, 1947.

A STUDY OF INDIVIDUAL CHILDREN'S DIETS

BY

E. M. WIDDOWSON, B.Sc., Ph.D.

(from the Department of Experimental Medicine, University of Cambridge)

"And they shall eat bread by weight, and with care; and they shall drink water by measure and with astonishment,"

—Ezekiel 4, 16.

CONTENTS

CHAPTER 1	PAGE
INTRODUCTION	1
Dietary requirements	1
Food intakes: their measurement and significance	2
Previous dietary surveys on individual children	5
 CHAPTER 2	
DESCRIPTION OF THE PRESENT INVESTIGATION	7
The subjects	7
Numbers of children and methods of approach	7
Heights and weights	9
Haemoglobin levels	16
Incidence of dental caries	17
General health	19
Collection of the food records	19
Calculation of the results	21
 CHAPTER 3	
THE CHILDREN'S FOOD	22
Cereal foods	23
Bread	23
Porridge and proprietary cereals	27
Biscuits and cakes	28
Total cereals	30
Dairy products	31
Milk	31
Condensed milk	35
Cream	35
Butter	36
Cheese	37
Eggs	38
Flesh foods	38
Meat	38
Bacon	41
Fish	41
Pastes and extracts	42
Fruit	43
Raw fruit	44
Cooked fruit	46
Tinned fruit	47
Nuts	47

CONTENTS—*contd.*

	PAGE
Vegetables	47
Potatoes	48
Green vegetables	49
Root vegetables	50
Legumes	51
Miscellaneous cooked vegetables	51
Raw vegetables	52
Sugar, preserves and sweets	52
Sugar	52
Preserves	54
Sweets and chocolate	55
Ice cream	56
Beverages	56
Alcoholic drinks	56
Tea and coffee	56
" Bedtime " drinks	57
" Soft " drinks	57
Vitamin and mineral concentrates	58
CHAPTER 4	
CONTRIBUTION OF VARIOUS FOODS TO THE TOTAL CALORIE INTAKE, AND	
THE CONSUMPTION OF FOODS IN TERMS OF MAN-VALUES	59
Proportion of the total calories derived from various foods	59
Food intakes in terms of man-values	61
CHAPTER 5	
CALORIE INTAKES AND CALORIE REQUIREMENTS	64
Historical	64
Variation in calorie intake with age and sex	66
Man-value scales	67
Individual variations in calorie intakes	69
Daily and weekly variations in calorie intakes in the same individual	70
Variation in calorie intake with body weight	74
Calorie intakes per kilogram of body weight in relation to age	75
Variation in calorie intake with height	77
Calorie intakes per inch of height in relation to age	78
Variation in calorie intake with surface area	79
Possible explanations of individual variations	81
CHAPTER 6	
PROTEIN, FAT AND CARBOHYDRATE	83
Protein requirements	83
Protein intakes in relation to age	84
Protein intakes per kilogram of body weight in relation to age	86
Percentage of calories derived from protein	87
Animal protein intakes	88
Fat and carbohydrate intakes	91
CHAPTER 7	
CALCIUM REQUIREMENTS, CALCIUM ALLOWANCES AND CALCIUM INTAKES	96
Calcium requirements	96
Determination by means of skeletal growth rates	96
Determination by means of balance experiments	96
Vitamin D and seasonal effects	97
Chemistry of calcium absorption	98
Practical applications and other considerations	100
Calcium allowances	102
Calcium intakes	103
Calcium intakes and the incidence of dental caries	108
CHAPTER 8	
PHOSPHORUS	108
Phosphorus intakes	110
CHAPTER 9	
IRON	112
Iron requirements	112
Iron allowances and iron intakes	115
Iron intakes and haemoglobin levels	118

CHAPTER 10		
VITAMINS		119
Vitamin requirements		119
Vitamin intakes		121
Aneurin		122
Ascorbic acid		124
Vitamin A		127
Carotene intakes		128
Intakes of preformed vitamin A		128
Total vitamin A intakes		131
Vitamin D		132
Vitamin supplements and vitamin intakes		134
CHAPTER 11		
EFFECT OF LOCALITY UPON THE TYPE AND VARIETY OF FOODSTUFFS CONSUMED, AND UPON THE CHEMICAL COMPOSITION OF THE DIET		135
Comparison of the consumption of milk, fruit and green vegetables in different parts of the country, and of the intakes of calcium and ascorbic acid		135
Effect of various factors on variety in the diet		138
Comparison of the diets of girls attending secondary schools in London and Preston, Lancs		139
Comparison of the diets of boys attending secondary schools in London and Dudley, Worcs		141
Study of the diets of 23 rural Cambridgeshire children		142
CHAPTER 12		
BOARDING SCHOOL DIETS		143
Comparison of the diets of children at eight different boarding schools with each other and with those of children of similar ages living at home		144
Comparison of the diets of public schoolboys at home and at school		151
CHAPTER 13		
SCHOOL MEALS		153
Day nursery school meals		153
Diets of eight children having dinner at a charitable canteen		156
Contribution of school dinners to the diets of eight children attending Cambridgeshire Village Colleges		158
CHAPTER 14		
TWINS		159
CHAPTER 15		
NUTRITIVE VALUE OF VEGETARIAN DIETS		161
CHAPTER 16		
COMPARISON OF THE NUTRITIVE VALUE OF THE DIETS OF THIRTEEN DIABETIC CHILDREN WITH THOSE OF HEALTHY CHILDREN OF THE SAME AGES		163
CHAPTER 17		
COMPARISON OF THE DIETS OF 38 CHILDREN OF UNEMPLOYED FATHERS WITH THE DIETS OF MIDDLE-CLASS CHILDREN		166
SUMMARY		177
ACKNOWLEDGEMENTS		179
REFERENCES		179

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E. M. WIDDOWSON

CHAPTER 1

INTRODUCTION

Dietary requirements

The determination of the food requirements of men, women and children has been the aim of many nutritional investigators since the scientific study of food began. The early workers concentrated chiefly upon calories, and for the most part accepted intakes as being equivalent to requirements. Subsequent investigations have in the main justified this point of view, and the figures for the energy requirements of sedentary workers, and of lumbermen and others, which are quoted in every text book on nutrition, will always remain monuments to this particular technique. The growth of interest in protein and mineral requirements soon revealed the extraordinary variations in the intake of these constituents which might be compatible with average health. Studies on the minimum requirements for these constituents naturally followed. Over short periods of time these could often be determined directly, both in animals and man, by balance experiments, and it soon became clear that the requirement of one constituent might be profoundly altered by the presence or absence of another. Thus the protein minimum was shown to depend upon the adequacy or inadequacy of the calorie intake, and the calcium minimum upon vitamin D.

With the passage of time the term "requirement" has been used and defined in several ways. To the average housewife food requirements are the mixtures of viands which satisfy the appetites of her family and agree with their digestions. To most people, both scientific and lay, the unqualified term "requirement" seems to mean the amount of food, or indeed of any food constituent, which will maintain an individual or a group of individuals in the *status quo ante* over a prolonged period of time. The term "minimum requirement" permits of more precise definition, and may be stated for adults to be the least amount of any dietary constituent necessary to maintain a perfectly healthy individual in equilibrium for a given (usually a short) period of time. For children a separate definition is required. Here the minimum requirement is the least amount of any dietary constituent which will promote satisfactory health and growth.

Optimum requirements for both adults and children are of far greater importance than minimum requirements. Their definition is self-evident, but they are exceedingly difficult to assess. Optimum requirements must exceed minimum requirements by an allowance for foreseen and unforeseen eventualities, but this allowance cannot be determined experimentally. In the assessment of optimum requirements many independent lines of evidence may have to be considered, and the final decision is always a matter of judgment and will vary with the investigator. A minor complication arises from the fact that, whereas the optimum requirements of certain food constituents are truly "optimum" in that an excess is as deleterious as a deficiency, an excess of other food constituents (ascorbic acid, for example) appears to be quite harmless, so that any quantity, within reason, above a certain limiting amount may be regarded as optimal. The difference depends upon the ease with which the body can excrete or metabolize the surplus. While, therefore, there may be, and probably is, an optimum cellular concentration of all constituents derivable from food, this may not in all cases be a matter of nutritional concern once an adequate supply has been assured.

In spite of these difficulties and uncertainties, there is agreement that the minimum and optimum requirements of different food constituents vary with age, sex and occupation, and do not necessarily vary in the same direction. Thus the demand for calories, and probably also for aneurin, rises with age to puberty or early adult life, and thereafter varies with the amount of physical work performed. The need for calcium, on the other hand, is certainly greater during childhood and adolescence than it is after growth has ceased, and is possibly greatest of all during lactation. Women's demands for iron are greater than men's throughout the whole of the child-bearing epoch. Most of the vitamins are needed in larger amounts during childhood than they are in later life, and pregnant and nursing women rank with children in this regard.

Except in so far as hard work is known to create a demand for calories, no one yet has seriously considered to what extent the requirements of one individual may vary from those of another. This is a chapter of nutritional research which has still to be written. The present study may perhaps claim to be an opening paragraph.

Food intakes : their measurement and significance

Since it became fashionable to study nutrition in the "field", a great many dietary surveys have been carried out, and in order to understand their significance it is essential to appreciate what dietary surveys have set out to measure, and how the measurements have been made. The immediate object in all cases has been the measurement of the food of individuals or groups of persons selected for investigation, but the great majority of surveys have been inspired by an interest in food requirements. Indeed, many surveys have been undertaken with the idea that food intakes constitute a measure of food requirements. This is seldom true, except perhaps for calories, for even an apparently freely chosen intake is invariably restricted by convention, taste or economic necessity, and the only requirement assessed is that which maintains the *status quo*. Clearly, this may bear no relation at all either to the optimum requirement or to the so-called minimum requirement. Of late years a number of food surveys have been carried out with the object of comparing the food intakes actually measured with the allowances which have been recommended by different workers. This is legitimate, provided always that the intakes have been accurately assessed, and that it is realized that the recommended allowances are matters of judgment or, let us say, intelligent guesswork, liable to revision by any interested investigator, and are not by any means permanent standards.

It may be stated at once that food intakes, whether of individuals, institutions or families, can be measured with fair accuracy. The method of measurement naturally varies with the material selected, but in all cases the food consumed must be weighed. Fewer assumptions have to be made in studying individuals or closed communities than in studying families. Thus, if any members of the family take meals away from home, the amount consumed by them is a matter of guesswork. Similar difficulties arise if visitors are entertained during the period of investigation. Allowances may also have to be made for domestic animals. Once the total food has been weighed, its composition may be calculated from the most appropriate food tables and the intake expressed either in terms of food, or of proximate principles, minerals and vitamins. If individuals have been studied, the results are then ready to be inspected, compared among themselves, averaged and subjected to statistical treatment, or viewed in the light of suggested requirements. Hitherto, however, dietary surveys have very seldom been carried out on individuals, but mostly on groups of persons in institutions or families. If the group is homogeneous and its numbers are known, once the

food consumption has been measured, the average consumption *per caput* can be found by simple calculation. This method of making surveys and of determining intakes is permissible, although the value of the result is limited by the fact that the individual variations—which are of the greatest importance in medicine—remain quite unknown. If the group is not homogeneous the value of the results is more limited. Let us suppose, for example, that a group of boys at a boarding school has been selected for study, and that their ages vary from eight to twelve years. The results, expressed on a *per caput* basis, have considerably less significance than those obtained from a really homogeneous group, for obviously boys of eight eat less than boys of twelve. The “family” group, consisting as a rule of an adult of each sex and a variable number of children of different ages, presents even greater difficulties—and yet families have been the groups commonly selected for study. To average a family’s food intake on a *per caput* basis is clearly of little scientific value, and there is no way of finding out what proportion of the total each member of the household ate. A guess could be made at it if the average intakes of adults and children of all ages and both sexes in the same social class and locality were known, but if this information were available it would be a work of supererogation to study “family” intakes. It is not even possible to compare the food consumption of one family with that of another unless the numbers, ages and sexes happen to be the same in each. If, however, we assume a “requirement” for adults and for children at each year of age, we can compare the total intake of any family with its calculated requirement. This is indeed the only legitimate way in which family intakes can be used, and for this purpose workers long ago began to make estimates and measurements of the calorie requirements of adults and children of all ages and both sexes. A further convention was then introduced: the calorie requirements of women and children were expressed as fractions of the requirement of a theoretical man, and by dividing the total calorie intake of the family under investigation by the sum of the fractions for the requirements of its members, the family *intake* was compared with its *requirement* in terms of the theoretical man. This at once enabled any one family to be compared with another, for all could be reduced to the same terms. There are, however, many obvious defects in this “family” technique, some of them inherent in it, others due to its abuse. Thus:—

- (1) Apart altogether from the conventions employed, the family method at best only gives average results. Members of the family may not behave in the predicted way, and in such a small group as a family this may completely falsify the conclusions. To cite an extreme instance, if a mother were to starve herself to death for the sake of other members of the family the result might merely be a somewhat subnormal total intake.
- (2) The results as usually calculated are not absolute, but vary with the standards employed. Scales of requirements are always a matter of judgment, and every investigator either selects one of the forty or so already proposed or introduces yet another scale more in keeping with his own ideas. When, therefore, the same family intake is reduced to a unit value—the so-called “man-value” basis—the results may vary by 30 per cent. according to the reducing scale adopted (see p. 67).
- (3) The requirements of women and children were fractionated originally in terms of calories. The fractional scales should never have been used for anything else, for they have no meaning when they are applied to protein, fat, carbohydrate or mineral elements. Fortunately, this error has gradually been recognized, and several scales of requirements for protein, calcium, phosphorus and iron have been drawn up

during the past twelve years. (Stiebeling and Ward, 1933; League of Nations, 1936; Stiebeling and Phipard, 1939; Clements, 1940; McHenry, 1941; National Nutrition Council, 1942; National Research Council, 1943.)

- (4) The usual method of expressing the results of family investigations is unfortunate, for the intakes are given in terms of protein, fat, calcium, etc., consumed per adult man. This may suggest that some person in the family actually ate those amounts, which is not necessarily so. It would be less misleading either to give the results in terms of the total number of grams of food or of proximate principles eaten by the family, and then, in addition, to give the composition of the family, or to express the family intake, not in terms of grams at all, but as a percentage of its estimated requirement. The former would be a true statement of fact in a rather unwieldy form; the latter would give greater facility of expression if only some international scale of dietary requirements existed so that all data could be referred to it. The latter method has been adopted in Canada (McHenry, 1941; Hunter and Pett, 1941; Patterson and McHenry, 1941; Sylvestre and Nadeau, 1941; Young, 1941; Riggs, Perry, Patterson, Leeson, Mosley and McHenry, 1943), and the results of dietary surveys in Toronto and other places have been expressed as a percentage of the Canadian scale of allowances. This is certainly a step in the right direction, but since the Canadian scale is not used outside Canada, the results are of national rather than international interest.

Workers in Australia (Clements, 1940) have devised a rather ingenious method of manipulating the results of large-scale family surveys. All families with the same composition, *e.g.* father, mother and one child aged two, were grouped together, and their total intakes of calories, protein, fat and carbohydrate were averaged. The intakes of all families with a slightly different composition, *e.g.*, two parents and two children, one aged 2 and one aged 4, were then averaged in a similar way, and the difference between the two results gave the composition of the average diet of a 4 year old child. By combining all the families in a number of different ways the average intakes of children of all ages could be determined. This method enables results of a family survey to be calculated without making any of the usual assumptions about man-values (it was itself originally used to evolve another scale of family coefficients), but the method is applicable only if very large numbers have been studied, and it only gives average results.

If information on the consumption of *food* is required, the supporters of the family method must devise a way of dealing with all the various foodstuffs such as milk, meat and bread. Should the amount used by the family be apportioned per head assuming that all the members take equal amounts, or should the intakes be expressed on a man-value basis? If the latter, what scale should be adopted? Clearly a calorie scale is of no use for milk, and in fact a special scale would have to be devised for every food.

All these difficulties, assumptions and conventions seemed so crippling that it was decided some years ago to try if possible to make individual food intakes the basis of some dietary investigations. This was no new idea, for in 1831 John Dalton, founder of the atomic theory, described an experiment he had made upon himself nearly 40 years earlier. He was then a young man thinking of taking up medicine as his career, and as an introduction to the subject he decided to weigh and measure all that he ate and drank for 14 days. "The weights of the individual articles were taken at each meal separately, and entered in a journal, distinguishing fluids from solids A very short time shewed that the daily demand for food, both solid and fluid, was nearly uniform

as to quantity, and that the supply might have been made absolutely so without any inconvenience". He repeated his experiment at two other seasons of the year.

We first applied the individual method to adults in 1935-36, (Widdowson, 1936; Widdowson and McCance, 1936, 1942a; McCance, Widdowson and Verdon Roe, 1938; Widdowson and Alington, 1941) and extended it to children very soon afterwards. Admittedly, an individual survey cannot cover such a large section of the population as a family study, but the present investigation, which is based upon the food intakes of over 1,000 children, provides some evidence as to the feeding habits of middle class families during the years 1935-39. How far these data apply to other periods and social classes still remains to be seen.

Previous dietary surveys on individual children

The aim of all dietary surveys, whether made on individuals or on groups, is to discover what the persons under investigation are in the habit of eating. Their diets must be those to which they are accustomed and which they freely choose. There are many records in the literature of the food intakes of children, who for the purpose of some experiment were living on a prescribed diet or on a diet which was limited in some particular. Such records do not come within the scope of the present discussion.

An excellent summary of the earlier work on dietary studies on individual children is given in the Report of the Committee on Growth and Development at the White House Conference (1932). The first record of such a survey seems to have been that of Hasse, published in 1882. She studied the food intakes of six girls, 2 to 11 years old, four living in Russia and two in Switzerland. These children ate unrestricted home diets, and their food was weighed for 3 or 6 days. Duplicate portions were analysed for protein, fat, carbohydrate and calories. Information is given concerning the amounts of each foodstuff eaten at every meal during the course of the investigation, besides the chemical composition of the diets. It is interesting that these children were eating just about the same quantities of protein, fat and carbohydrate as girls of similar ages, living in the British Isles, have been found to be eating over 50 years later (see Chapter 6, p. 83).

During the next 30 years or so, workers in Germany (Herbst, 1898; Müller 1914; Schutz, 1917) and Finland (Sundström, 1908; Tigerstedt, R., 1911; Tigerstedt, C., 1916) held the field in this line of study. Herbst appreciated how an individual's calorie intake may vary from day to day, and he gave figures to illustrate this. Müller compared the food intakes of 36 children of working class families when they were living at home, and while they were at a holiday camp. Their calorie intakes were a little higher when they were away from home.

The Finnish workers were the first to include mineral constituents in their dietary assays. Sundström analysed duplicate portions of the food of 21 girls and 15 boys for total ash as well as for protein, fat and carbohydrate. R. Tigerstedt (1911) gave figures for the calcium, magnesium and phosphorus in the diets of the children he investigated. C. Tigerstedt (1916) discussed the difficulties and inaccuracies in calculating the composition of diets from food tables. He analysed duplicate samples of the diets of 22 girls and 38 boys, 4-18 years old, for protein, fat and carbohydrate over a period of a week. The children belonged to working class Finnish families and the diets were remarkably low in fat. The individual food intakes varied greatly and seemed to bear little relation to age.

After the end of the first World War the scene of activity in research on this subject moved from the continent of Europe to the United States. Gephart (1917) had already published the results of a dietary survey at a boys' boarding school in New Hampshire. His method of investigation, which was not adapted to the individual, consisted of measuring the total food entering each of the four kitchens, and the kitchen and table waste. Then the amounts of protein, fat, carbohydrate and calories provided by the food eaten in each dining hall were calculated from food tables, and an average value for one boy was obtained. The value of the results is reduced, however, because the boys were of various ages.

Holt and Fales (1921a,b; 1922a,b,c) investigated the food intakes of more than 100 individual children belonging to well-to-do American families for periods of 4 days. The amounts of protein, fat and carbohydrate in the diets were calculated from food tables, and also their calorific value, but average results only are given at each age. The authors differentiated between protein of animal and of vegetable origin, and between starch and sugar, but they did not differentiate between intakes and requirements. These are tacitly assumed to be synonymous, and the series of five papers describing their findings is entitled "The Food Requirements of Children".

During more recent years a number of individual dietary surveys have been made on American children living in institutions and in their own homes, but workers have tended to confine themselves to children of a particular age. Thus, McKay (1926), Winters (1931), Bray, Hawks and Dye (1934), and McKay and Patton (1934, 1935) studied the food intakes of pre-school children, while Wait and Roberts (1932a,b; 1933) investigated the diets of 52 adolescent girls. Only 6 of these were living in their own homes. A study of the diets of boys, aged 11½ to 19 years, at a boarding school in New South Wales, Australia, was made by Wardlaw and White (1940), but only average results for the different age groups are given. Large scale dietary surveys have recently been made in four towns in Canada (Hunter and Pett, 1941; Patterson and McHenry, 1941; Sylvestre and Nadeau, 1941; Young, 1941). The food intakes of 314 families were investigated, and also the diets of a great many of the individual members of the families, including about 500 children. Unfortunately, however, detailed results have not been published.

When the present investigation was begun only two dietary surveys on individual children had been recorded in the British Isles. Bedale (1922-23) carried out an inquiry at Bedales school in Hampshire, during which all the food eaten by 60 boys and girls was weighed for 1-6 days. The amounts of protein, fat and carbohydrate, and the calories, in the diets were calculated from food tables, but a number of cooked dishes were analysed. No information was given about the individual intakes, for the children were divided into three age groups, and the figures for boys and girls averaged together. Cathcart and Murray (1930-31), in the course of their dietary survey at St. Andrews by the "family" method (Cathcart and Murray, 1931), studied the food intakes of each individual member of 5 families. These families were made up of 10 parents and 12 children, 6 boys and 6 girls. The amounts of protein, fat and carbohydrate in the diets were calculated.

There was therefore virtually no information about what British children were in the habit of eating, and in 1935 the time seemed ripe to make use of the individual method to investigate this subject on a fairly extensive scale. The present survey was carried out between 1935 and 1939, and all the data had been collected before war broke out. It is, therefore, essentially "dated" in that it represents results which were obtained at a time and under conditions which are never likely to return. This detracts from the value of the work in some ways, but enhances it in others.

CHAPTER 2

DESCRIPTION OF THE PRESENT INVESTIGATION

The subjects

NUMBERS OF CHILDREN AND METHODS OF APPROACH

435 boys and 481 girls of all ages from 1 to 18 years constituted the basis for the main investigation, and there were at least 20 boys and 20 girls in each of the 18 yearly age groups (Table I). Special groups of children, such as

TABLE I
Age Distribution of Children taking part in the Investigation

Age group	Age in years	Boys			Girls		
		No. in group	Average age years months		No. in group	Average age years months	
1	1-2	20	1	5	23	1	6
2	2-3	23	2	3	21	2	6
3	3-4	20	3	7	21	3	7
4	4-5	23	4	8	20	4	6
5	5-6	28	5	5	20	5	5
6	6-7	24	6	5	25	6	5
7	7-8	21	7	6	22	7	5
8	8-9	23	8	6	20	8	5
9	9-10	21	9	5	20	9	6
10	10-11	25	10	6	27	10	5
11	11-12	27	11	5	30	11	6
12	12-13	22	12	6	31	12	6
13	13-14	21	13	5	34	13	6
14	14-15	36	14	5	38	14	7
15	15-16	22	15	5	41	15	5
16	16-17	27	16	6	36	16	5
17	17-18	32	17	6	31	17	4
18	18-19	20	18	4	21	18	5
Total	—	435	—		481	—	

diabetics and the children of unemployed fathers, brought the total up to 1,028. The diets of these "special" children are discussed separately (Chapters 13, 16 and 17). Parents and children gave their co-operation voluntarily, without reward. Most of the children lived in towns, and more than half of them in London (Table II); but other parts of England, Scotland, Ireland, Wales and the Channel Islands contributed their quota.

TABLE II
Geographical Distribution of Children taking part in the Survey

	Boys	Girls
London	231	250
Southern England (Kent, Surrey, Sussex, Hants., Dorset, Berks., Oxon., Wilts.)	64	34
South-West England (Somerset, Gloucestershire)	10	18
East Anglia (Essex, Suffolk, Norfolk, Cambs., Beds.)	31	31
North-East England (E. Yorks., Northumberland, Durham)	13	4
North-West England (Liverpool and district, Lancs.)	24	120
Midlands	44	6
Ireland	5	5
Scotland	6	5
Wales	5	6
Channel Islands	2	2
Total	435	481

Most of the subjects belonged to the so-called "middle classes". Particulars of the father's occupation were obtained in each case, and on the basis of this and of various other considerations, such as the type of school attended and the appearance of the home, the children have been placed arbitrarily in three social grades. The "professional class" included sons and daughters of doctors, lawyers, solicitors, company directors, and University, public and secondary school teachers. The "upper working class" was composed of children of accountants, bank clerks, shopkeepers and the like. The "artisan class" consisted of children of fitters, skilled labourers, lorry drivers, factory hands and so on. Table III shows the distribution of boys and girls among the

TABLE III
Social Classes of Children taking part in the Investigation

							<i>Boys</i>		<i>Girls</i>
Professional class	..	..	..	..	..	..	197	..	136
Upper working class	..	..	..	..	..	..	179	..	295
Artisan class	..	..	..	..	..	..	59	..	50
Total	..	..	..	..	..	..	435		481

three grades. It will be seen that there are more boys than girls in the first and the reverse in the second. It is improbable that any of the conclusions will have been affected by this difference.

Various methods of obtaining volunteers for the investigation were adopted. The first was what may be described as "private enterprise". This meant asking any and every person that one met whether he or she knew of any children who might be able and willing to take part. About a third of the total children were obtained in this way (see Table IV). The interest of individual

TABLE IV
Means by which Volunteers for the Investigation were Obtained

							<i>Boys</i>		<i>Girls</i>
Through schools	..	..	..	..	..	..	212	..	256
By private enterprise	..	..	..	..	..	..	155	..	156
By advertisement	..	..	..	..	..	..	46	..	46
Through Scouts and Guides	..	..	..	..	..	..	11	..	9
Through hospital out-patient departments	..	..	..	..	..	..	11	..	14
Total	..	..	..	..	..	..	435		481

school teachers (mostly personal friends) proved a more fruitful source of supply. The schools were mainly day schools, though some volunteers from boarding schools were accepted, but, in order to avoid weighting particular groups, only a few at any age from one boarding school were included. A visit was usually paid to the school, and a talk given to the Science Club or classes expected to be interested. Volunteers were then called for, and the scheme was explained to them in some detail. Some of the schools were visited at regular intervals while the pupils were co-operating.

Local groups of Boy Scouts and Girl Guides were approached, and requests for volunteers were inserted in the "Children's Newspaper", "Home and School" and "Parents". Finally, a few children were obtained through hospital out-patient departments. These were not sick children, but brothers and sisters, or sons and daughters, of the patients themselves.

The question arises as to how far the boys and girls, who took part in this investigation, may be considered to be representative samples of British children. It has been suggested that the mere fact that they or their parents were willing

to weigh accurately the weekly intake of food showed that they were not typical of their social classes, but highly selected. How far this is true it is impossible to say, but there is no reason to suppose that these children were better, or worse, fed than other children of the same age and social standing. The numbers were of necessity small, and no claims are made that the findings are necessarily applicable to *all* British children.

It took four years to collect all the data (May 1935–May 1939), and Table V shows the number of children who weighed their food during each of these

TABLE V

Numbers of Boys and Girls who weighed their Food during each of the Four Years of the Investigation

						Boys	Girls
May-December, 1935	..	..	..	..	..	15	53
" " 1936	..	..	..	..	..	132	187
" " 1937	..	..	..	..	..	135	175
" " 1938	..	..	..	..	..	147	53
January-May, 1939	..	..	..	..	..	6	13
Total	..	..	..	..	..	435	481

years. Approximately equal numbers of boys were investigated during 1936, 1937 and 1938, whereas the major part of the girls' data had been obtained by the end of 1937. Table VI gives some information as to the way in which

TABLE VI

Distribution of Food-weighing throughout the Months of the Year

						Boys	Girls
January	..	..	..	..	..	36	27
February	..	..	..	..	..	25	52
March	..	..	..	..	..	38	55
April	..	..	..	..	..	34	58
May	..	..	..	..	..	34	36
June	..	..	..	..	..	29	32
July	..	..	..	..	..	24	14
August	..	..	..	..	..	4	10
September	..	..	..	..	..	23	25
October	..	..	..	..	..	68	53
November	..	..	..	..	..	81	66
December	..	..	..	..	..	39	53
Total	..	..	..	..	..	435	481

the food-weighing was distributed over the 12 months of the year, taking all years together. July, August and September were not so well represented as the other months, but this was only to be expected since most children went for their summer holidays during these months and parents were anxious not to be burdened with food-weighing at this time. Furthermore, since customary diets were the object of the investigation, holiday weighing was definitely discouraged. More boys and girls weighed their food in November than during any other month, because 3 boys' and 2 girls' day schools happened to be co-operating in the investigation during that month.

HEIGHTS AND WEIGHTS

Heights and weights of all children taking part in the experiment were measured during the week in which they weighed their food. Measurements of height were made without shoes to the nearest $\frac{1}{4}$ -in. Weights were taken in indoor clothes but without shoes. This somewhat unscientific method of

recording weight was adopted because it is the conventional one, was easy to carry out, and enabled comparison of the results to be made with those of other authors. Allowances made for the clothes are shown in Table VII. These were based partly upon values given by Woodbury (1921), and partly

TABLE VII
Amounts allowed for Indoor Clothes without Shoes

<i>Height in.</i>	<i>Boys lb.</i>	<i>Girls lb.</i>
Below 39 ..	1	1
40-44 ..	1½	1½
45-49 ..	2	2
50-54 ..	3	2½
55-59 ..	4	3
60-64 ..	5	3½
65 and over ..	6	4

upon actual observations of the weights of children's clothes. Tables VIII, IX, X and XI show the average heights and weights of the boys and girls in each of the 18 yearly age groups, the maximum and the minimum values in each group, and the standard deviations. In Figs. 1, 2, 3 and 4 the averaged heights and weights are plotted against age, and data for American children (Baldwin & Wood, 1923) are given for comparison. The American children were also weighed in ordinary clothing, without shoes, coats or sweaters. It will be seen that the figures for the heights and weights of our children agree very well with those of Baldwin and Wood. They also agree extremely well with other American figures, not shown here, for the heights and weights of 147,000 American children of various walks of life, living in 17 different

TABLE VIII
*Heights of Boys taking part in the Investigation
(Measurements taken without shoes)*

<i>Age group</i>	<i>Average height in.</i>	<i>Maximum in.</i>	<i>Minimum in.</i>	<i>Standard deviation in.</i>	<i>Average height cm.</i>	<i>Standard deviation cm.</i>
1	31.75	34.5	28.0	2.0	80.6	5.08
2	35.25	39.5	32.0	1.7	89.5	4.31
3	38.75	42.0	36.0	1.7	98.4	4.31
4	42.25	45.0	37.0	2.0	107.3	5.08
5	44.5	48.0	40.75	1.8	113.0	4.56
6	46.25	52.5	40.75	2.6	117.5	6.59
7	49.25	53.5	45.5	1.9	125.0	4.82
8	50.75	54.5	46.0	2.3	128.8	5.83
9	53.0	57.25	45.0	2.5	134.6	6.34
10	54.25	59.75	49.5	2.5	137.8	6.34
11	56.75	63.0	51.0	2.6	144.2	6.60
12	58.5	64.5	55.0	2.4	148.7	6.08
13	62.0	66.75	55.5	3.0	157.5	7.62
14	64.25	73.0	56.5	4.3	163.2	10.09
15	65.75	71.5	59.0	3.4	167.0	8.63
16	68.25	74.0	62.0	2.8	173.4	7.10
17	69.25	74.0	63.0	2.4	176.0	6.08
18	68.75	72.25	65.25	1.8	174.8	4.56

States and who were weighed and measured between 1937 and 1939 (O'Brien, Girshick, and Hunt, 1941). (These last measurements were made without clothing, and due allowance was made for this, in accordance with Table VII, before the results were compared.)

TABLE IX
Heights of Girls taking part in the Investigation
(Measurements taken without shoes)

<i>Age group</i>	<i>Average height in.</i>	<i>Maximum in.</i>	<i>Minimum in.</i>	<i>Standard deviation in.</i>	<i>Average height cm.</i>	<i>Standard deviation cm.</i>
1	30.25	36.0	26.0	2.5	76.8	6.35
2	35.75	39.0	31.5	2.1	90.7	5.33
3	38.5	41.5	35.0	1.9	97.8	4.83
4	41.5	47.0	38.0	2.3	105.3	5.84
5	44.0	49.5	41.0	2.3	111.7	5.84
6	46.5	51.75	42.0	2.4	118.1	6.09
7	49.0	52.5	43.5	1.9	124.4	4.83
8	51.0	54.25	45.75	2.2	129.4	5.59
9	52.75	56.5	49.25	1.7	134.0	4.32
10	54.25	57.75	50.25	2.3	137.9	5.84
11	57.5	63.0	51.0	3.1	146.0	7.87
12	59.0	66.0	54.5	3.3	150.0	8.38
13	60.25	64.0	55.5	2.4	153.0	6.09
14	63.5	69.5	59.0	2.4	161.4	6.09
15	63.0	67.75	57.0	2.2	160.0	5.59
16	64.0	68.0	60.0	2.0	162.6	5.08
17	64.25	69.0	60.0	2.5	163.2	6.35
18	65.0	70.0	61.0	2.3	165.0	5.84

TABLE X
Weights of Boys taking part in the Investigation
(Weights include indoor clothes, but not shoes)

<i>Age group</i>	<i>Average weight lb.</i>	<i>Maximum lb.</i>	<i>Minimum lb.</i>	<i>Standard deviation lb.</i>	<i>Average weight kg.</i>	<i>Standard deviation kg.</i>
1	27.0	33.0	19.25	3.8	12.3	1.7
2	31.75	41.5	24.5	3.9	14.4	1.8
3	36.0	42.0	30.0	3.4	16.4	1.5
4	41.0	53.0	30.5	5.2	18.6	2.4
5	45.75	56.5	39.0	4.5	20.8	2.0
6	49.25	67.0	38.5	6.3	22.3	2.9
7	56.25	65.0	46.0	5.3	25.5	2.4
8	58.75	66.5	47.25	5.2	26.6	2.4
9	69.5	79.5	46.0	7.5	31.5	3.4
10	71.5	88.0	59.75	7.7	32.4	3.5
11	81.25	118.0	60.25	13.1	36.9	6.0
12	86.25	117.0	65.0	11.6	39.1	5.3
13	104.25	149.0	80.0	15.2	47.3	6.9
14	113.25	164.0	75.0	22.5	51.4	10.1
15	124.5	151.0	82.0	20.6	56.8	9.4
16	140.5	171.0	102.0	17.1	63.7	7.8
17	151.0	194.0	116.0	17.6	68.5	8.0
18	149.25	176.0	126.0	13.5	67.7	6.1

TABLE XI
Weights of Girls taking part in the Investigation
(Weights include indoor clothes, but not shoes)

Age group	Average weight lb.	Maximum lb.	Minimum lb.	Standard deviation lb.	Average weight kg.	Standard deviation kg.
1	23.5	28.5	18.5	2.6	10.7	1.2
2	31.25	38.75	25.0	3.3	14.2	1.5
3	35.5	44.5	28.0	3.8	16.1	1.7
4	41.0	51.0	31.0	5.7	18.6	2.6
5	45.5	62.0	28.25	8.2	20.7	3.7
6	46.5	51.75	42.0	2.4	23.6	1.1
7	53.75	66.0	38.25	7.1	24.5	3.2
8	63.0	72.5	51.0	6.1	28.6	2.8
9	66.0	103.0	56.0	10.7	30.0	4.9
10	69.5	86.5	55.25	7.8	31.5	3.5
11	82.75	109.0	58.0	13.6	37.6	6.2
12	87.0	120.0	62.5	16.1	39.5	7.3
13	97.75	124.0	64.0	13.6	44.4	6.2
14	114.75	158.0	84.0	16.8	52.0	7.6
15	118.5	157.5	80.5	13.6	53.8	6.2
16	124.5	147.0	91.0	13.4	56.4	6.1
17	127.25	156.0	107.5	14.8	57.8	6.7
18	135.75	176.0	107.0	17.7	61.8	8.1

In Figs. 1-4 are also shown average values for the heights and weights of very large numbers of London elementary school children, obtained by the Board of Education in 1938 (Menziez, 1940). If these figures are compared

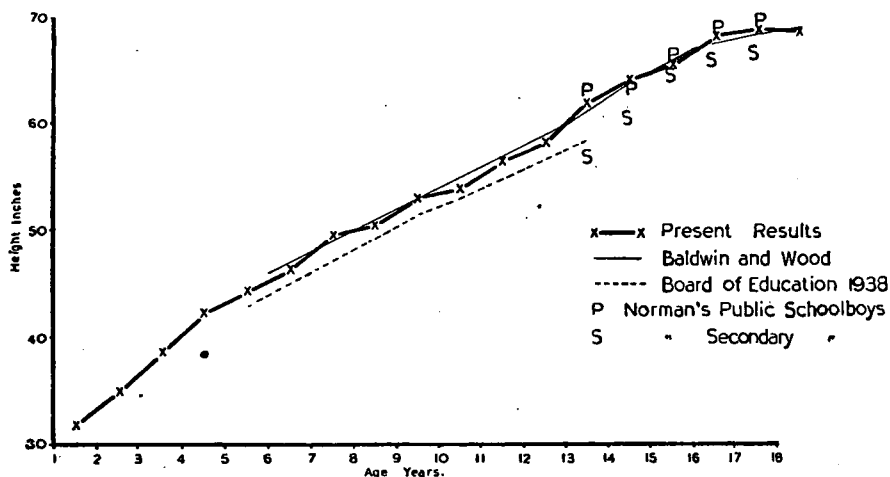


FIG. 1.—Boys' Average Heights.

with those given by the Board of Education (1927) and Tuxford (1939) for the heights and weights of elementary school children in 1910 and 1927, it is evident that elementary school children were taller and heavier at all ages in 1938 than they were in 1910, but that most of this increase has occurred since 1927. Similar increases in height and weight have been observed at a girls' public day school in London (Jacob, 1938), and also among elementary school children living in Toronto (Dominion of Canada, 1942). Even in 1938, however, the average heights and weights of English elementary school children were less than those of the children included in this investigation. Figs. 1 and 3 also include some results obtained by Norman (1939) for public and secondary school boys, most of whom lived in County Durham. The weights and heights of the public

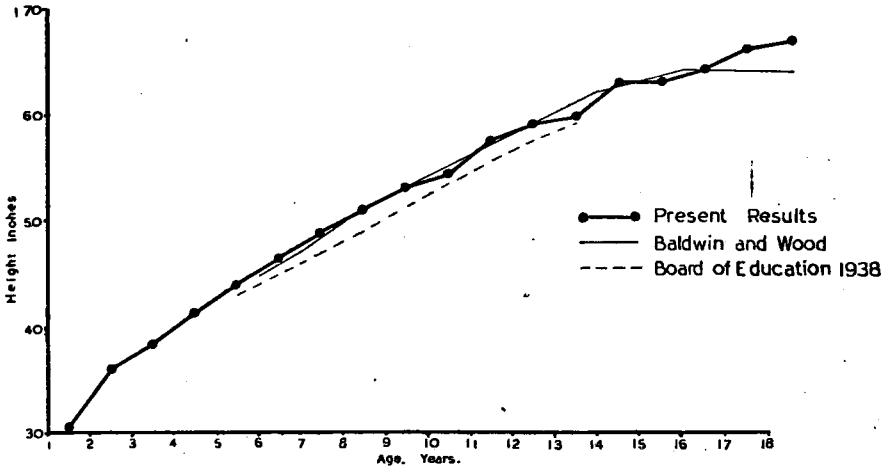


FIG. 2.—Girls' Average Heights.

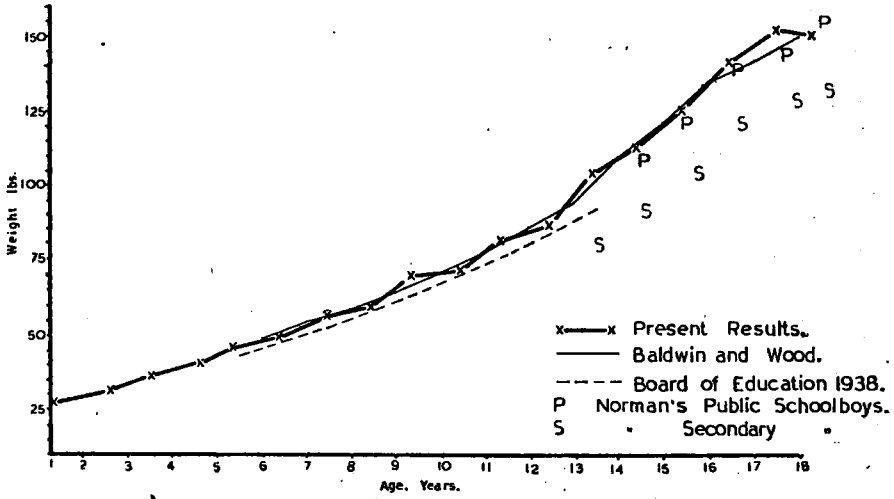


FIG. 3.—Boys' Average Weights.

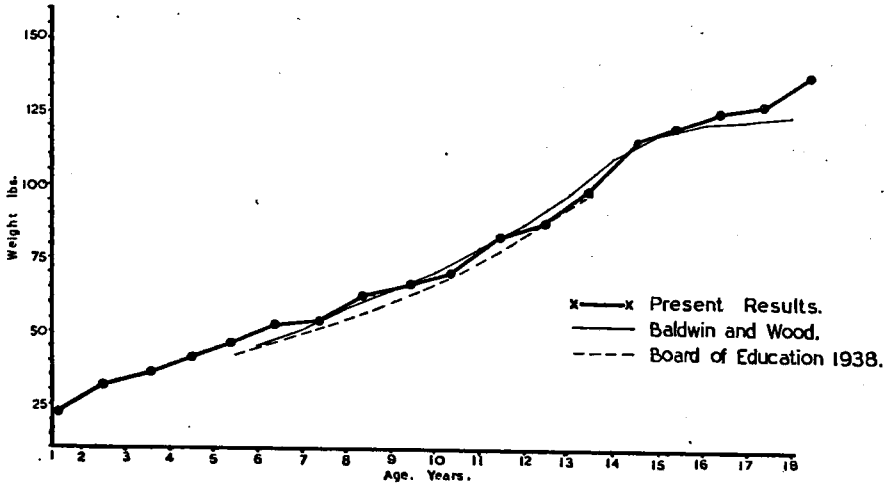


FIG. 4.—Girls' Average Weights.

school boys agree with those of our boys and with those of Baldwin and Wood, while the secondary school boys were smaller at every age. This is surprising, for the great majority of our children of corresponding ages came from secondary schools. Relatively few came from public schools. We have tried to discover whether the heights and weights of our children depended to any

TABLE XII
Average Heights of Boys and Girls at different Socio-Economic Levels (in.)

Age group	Boys			Girls		
	Professional class	Upper working class	Artisan class	Professional class	Upper working class	Artisan class
1	32.0	31.5	30.9	30.6	30.5	30.8
2	35.0	35.7	34.8	36.8	35.1	31.5
3	39.2	39.1	37.7	39.4	38.3	37.2
4	42.9	42.3	42.5	43.6	40.7	39.7
5	44.5	44.4	43.8	45.1	43.5	41.0
6	47.0	45.2	—	47.4	47.0	43.6
7	49.9	49.1	45.5	49.4	49.1	48.8
8	51.7	50.8	49.2	51.6	49.8	52.0
9	53.7	53.3	47.4	53.4	52.7	50.0
10	55.4	53.5	52.4	54.9	54.6	53.1
11	57.0	56.6	56.3	57.6	57.7	56.0
12	59.3	57.8	57.6	—	59.3	58.4
13	63.3	61.3	64.2	61.7	60.6	58.4
14	65.8	60.5	63.2	65.0	63.3	61.0
15	66.7	66.6	62.3	65.6	62.5	61.3
16	68.6	67.6	69.3	63.8	64.1	61.5
17	69.4	69.3	67.1	65.2	64.0	—
18	69.1	69.5	66.9	65.1	64.9	—

TABLE XIII
Average Weights of Boys and Girls at different Socio-Economic Levels (kg.)

Age group	Boys			Girls		
	Professional class	Upper working class	Artisan class	Professional class	Upper working class	Artisan class
1	12.8	11.9	11.2	11.0	10.7	10.4
2	13.8	15.4	13.5	14.9	13.5	11.9
3	16.2	16.6	15.9	16.8	15.9	15.4
4	19.3	17.7	18.3	20.8	17.8	16.5
5	21.2	20.5	19.7	21.5	20.2	17.0
6	23.1	21.2	—	23.9	23.6	23.1
7	25.7	25.8	21.4	24.9	24.5	22.9
8	26.9	26.5	26.1	28.8	27.9	30.0
9	32.2	32.5	23.5	29.6	30.5	25.7
10	32.4	32.5	32.3	31.5	32.6	29.1
11	36.4	36.5	39.7	38.3	38.0	34.2
12	41.1	36.9	42.5	—	39.8	38.4
13	49.0	45.4	57.8	50.7	44.7	39.8
14	53.9	43.1	50.9	57.2	51.6	40.6
15	60.4	57.3	47.6	54.8	54.0	47.5
16	65.6	61.4	69.9	57.7	56.5	50.3
17	69.2	67.7	67.8	59.7	57.0	—
18	68.0	71.2	60.1	59.6	62.9	—

extent upon their social circumstances. The children were divided into their three socio-economic grades, and the average heights and weights at each age were calculated. Tables XII and XIII show the results. If the Tables are inspected it will be seen that the professional class boys had the highest average height in 14 out of the 18 age groups. They never had the lowest. On the other hand, boys belonging to the artisan class had the lowest average height in 14 out of 17 groups, but had the highest twice. (None of the 6-year-old boys belonged to the artisan class.) The results for the girls were very similar to those for the boys. Further, the weights of the boys in the professional classes averaged more than those in the other two grades in 8 out of 18 age groups and

least in only one group. On the other hand, the weights of the boys in the artisan class were lowest in 10 out of the 17 age groups and were highest only 4 times. The girls' weights were much more convincingly in favour of the professional classes. It seems, therefore, on the basis of these admittedly small

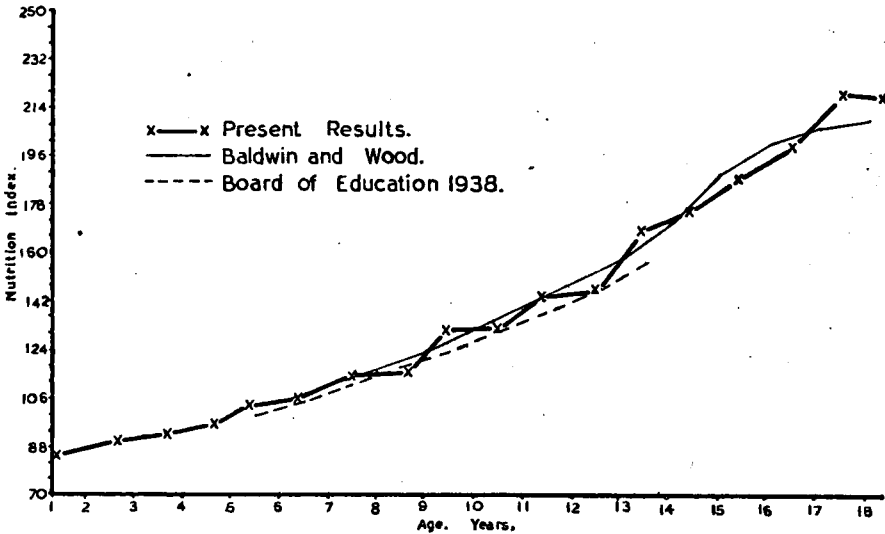


FIG. 5.—Nutrition Index.—Boys.

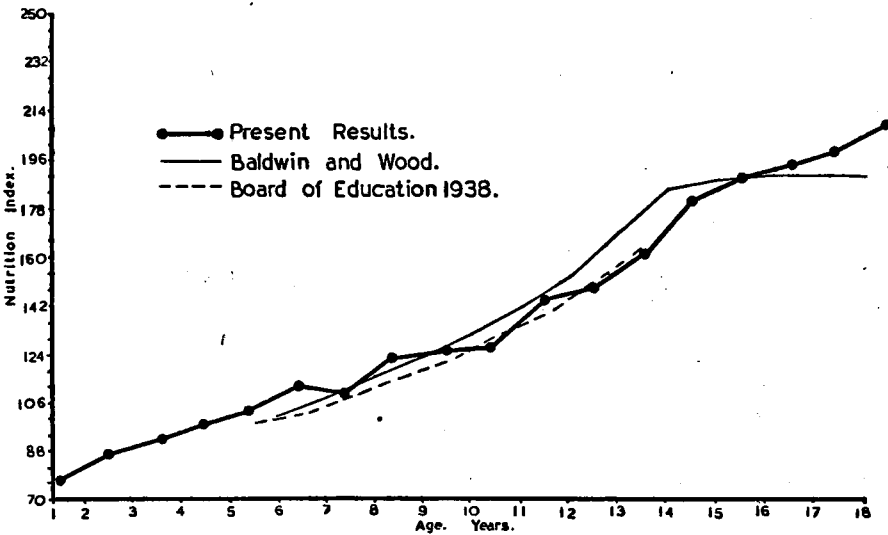


FIG. 6.—Nutrition Index.—Girls.

numbers, that the children's heights and weights did differ in the three socio-economic grades. Both inheritance and up-bringing may have helped to bring this about. The differences in the diets will be discussed in Chapter 11.

Figs. 5 and 6 show the so-called nutrition index of the boys and girls at various ages. The nutrition index has been calculated as the $\frac{\text{weight in lb.}}{\text{height in ins.}} \times 100$. It is of a certain limited value in that it is a measure of weight per unit

of height ; in other words, it gives an indication of whether a child is tall and slim or short and stout. The Baldwin and Wood height and weight values, and the figures published for the heights and weights of English elementary school children in 1938 have been used to calculate the corresponding nutrition indices, and these results are also shown. It will be seen that our figures and those for English elementary school children, weighed and measured in 1938, agree closely with the American ones. The 1910 and 1927 values for elementary school children are very similar to each other, and are considerably below the 1938 figures. Hence, not only were elementary school children shorter and lighter in 1927, but they were also slimmer. While an increase in both height and weight has occurred since then, the increase in weight has predominated.

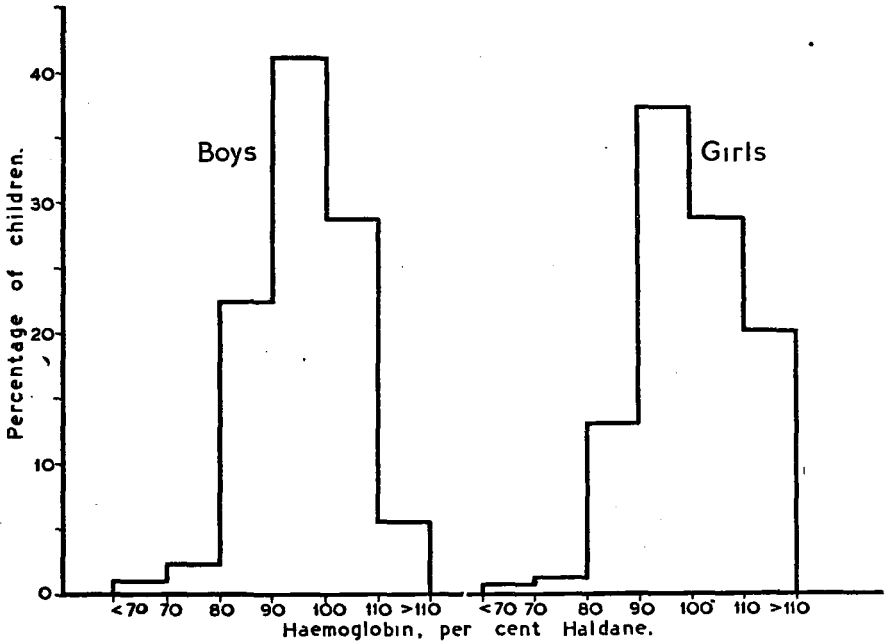


FIG. 7.—Frequency Distribution of Haemoglobin Levels.

HAEMOGLOBIN LEVELS

Haemoglobin estimations were made on 189 boys and 200 girls. The majority of these attended schools which had co-operated in the investigation. The schools were visited, the blood samples taken and the determinations often made on the spot, if a laboratory was available. Written permission to prick the child was always obtained from the parents beforehand. Some blood samples were collected by house-to-house visitation, while some children who lived in London were able to come to King's College Hospital for the test to be made there. Duplicate samples of blood were collected from the lobe of the ear and estimations were made by the Haldane method. All determinations were carried out by the same person. The haemoglobin standard was checked by comparing the answers obtained on a few samples of whole blood with the results of iron determinations. In the light of Gibson and Harrison's (1945) work, it would probably have been better to have checked the haemoglobin standard by determining the oxygen capacity of the blood. The error involved is, however, very small. One hundred per cent. of haemoglobin has been taken here to correspond to 13·8 g. haemoglobin per 100 c.c. of blood. Fig. 7 shows the frequency distribution of the haemoglobin levels for all the

boys and girls who were examined, irrespective of age. Only two had haemoglobin levels below 70 per cent. (9.7 g. haemoglobin per 100 c.c.) and only six more below 80 per cent. (11.0 g. per 100 c.c.). The iron intake of these individual children, and its possible correlation with their low haemoglobin levels, will be discussed later (p. 118). Of the children, 313, or 80 per cent. of the total number, had haemoglobin values of 90 per cent. or over.

By far the larger proportion of the children whose blood was examined belonged to the older age groups; in fact, only 17 boys and 8 girls below 7 years of age were tested. Averages for the younger children at each year of age cannot, therefore, be calculated. Table XIV. shows the mean values for all

TABLE XIV
Average Haemoglobin Levels of Boys and Girls taking part in the Investigation

Age group	Boys			Girls		
	No.	Average haemoglobin		No.	Average haemoglobin	
		g. per 100 c.c.	Per cent. on Haldane scale		g. per 100 c.c.	Per cent. on Haldane scale
1-6	17	12.4	90	8	12.8	93
7-9	27	13.0	94	15	12.6	92
10	13	13.5	98	12	13.5	98
11	18	12.4	90	14	14.4	104
12	10	12.6	92	22	14.2	103
13	8	13.1	95	20	14.3	104
14	25	13.6	99	27	14.0	102
15	14	13.8	100	30	13.9	101
16	18	14.5	105	18	13.8	100
17	27	13.6	99	19	13.6	99
18	12	13.9	101	15	13.6	99

boys and girls between 1 and 6 years, and between 7 and 9 years. It also shows the average values obtained for boys and girls in each of the yearly age groups between 10 and 18 years. These average figures are given to demonstrate the fact that our children, taken as a whole, had haemoglobin values which were similar to those obtained for "normal" children by other workers in various parts of the world (Sobel and Drekter, 1933; Goldhamer and Fritzell, 1933-34; Ross and Summerfeldt, 1936; Sachs, Levine and Griffith, 1937; Faergeman, 1938; Sachs, Levine, Hill and Hughes, 1943; Medical Research Council, 1945).

INCIDENCE OF DENTAL CARIES

Dental caries is probably the most widespread defect of nutritional origin affecting children in this country. It is outside the scope of the present report to discuss all the theories that have been put forward to explain its cause, but it will be generally agreed that diet, and particularly the intake of calcium and vitamin D (M. Mellanby, 1934), and also of fluorine, must play a part in its aetiology.

With the co-operation of Mr. R. E. Clarke the teeth of 183 boys and 207 girls who took part in the main dietary investigation were examined with a probe and mirror for signs of dental caries, and the number of teeth decayed, missing or filled was recorded. Because of the difficulty of interpreting findings on young children, it was decided to confine the analysis of the results to the

153 boys and 193 girls who were over 7 years of age, and these have been divided into two age groups, 7-12 years and 13-18 years. In the younger of these groups the children should, generally speaking, have 24 teeth; between 12 and 14 years the second permanent molars usually erupt, so that from 13 years

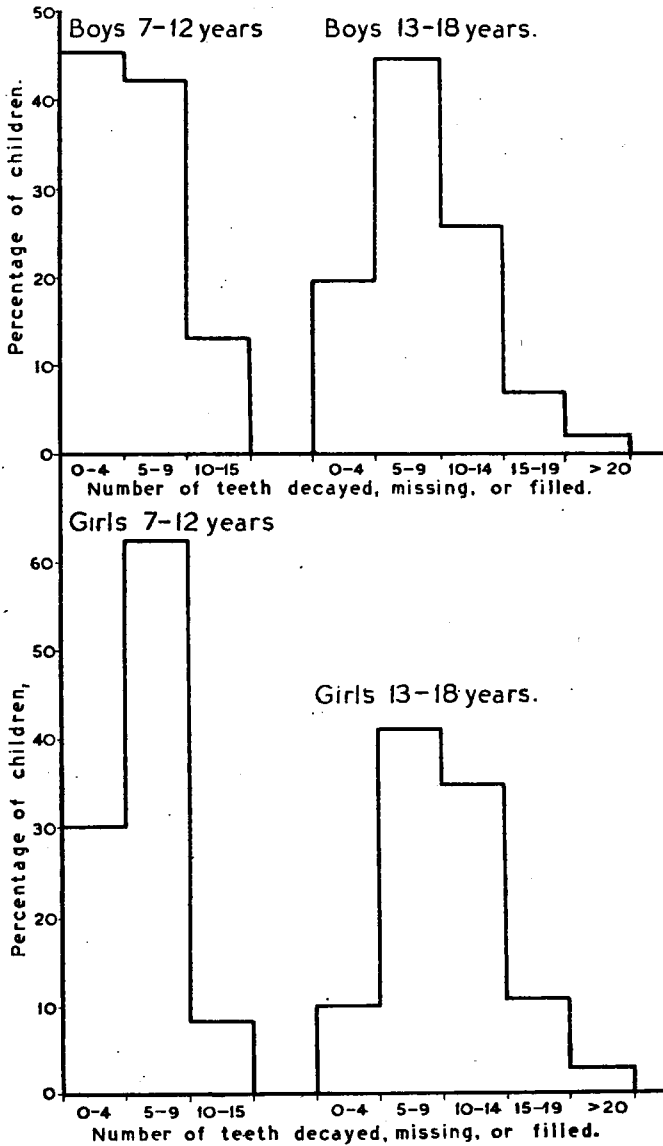


FIG. 8.—Frequency Distribution of the Incidence of Dental Caries.

upwards 28 teeth should be the rule, with the possible addition of the wisdom teeth. Fig. 8 shows the frequency distribution of the number of teeth which were decayed, or missing or filled and therefore presumed to have been carious, at the time of the dietary survey. Most of the children had bad teeth, and on the whole, the girls had worse teeth than the boys. The reason for this variation in the sexes is not known, and it might be worth further investigation.

Of the 53 boys between 7 and 12 years, 3 had no caries, but only 1 of the 61 girls; the same was true of 3 boys, but of no girls, over 13 years of age. The average number of carious teeth in the younger age group was 5.3 for boys and 6.0 for girls. Among the older children the corresponding figures were 8.1 and 9.9 respectively. Two boys and 4 girls in the older age group had 20 or more carious teeth. The possible relationship between the diet of these children and the state of their teeth is discussed on p. 108.

GENERAL HEALTH

We have been criticised for not carrying out a clinical examination of all the children whose diets we investigated. It is extremely unlikely, however, that any gross signs of vitamin deficiency were present, and subclinical deficiencies are notoriously difficult to detect. Investigations that have been carried out on groups of children, similar to those studied here, have always failed to show any correlation between diet and the so-called signs of deficiency disease (Riggs *et al.*, 1943). We have studied the incidence of dental caries in as many children as possible. The children have been shown to be well up to the average as regards heights and weights and haemoglobin levels, and none of them was ill when the dietary record was taken. It seemed unnecessary, therefore, to try to examine all the children clinically.

Collection of the food records

Each subject was provided with a spring butter balance, weighing by $\frac{1}{4}$ oz. up to 2 lb., on which to weigh the food, a sheet of instructions, and a set of forms on which to enter the results. The instructions, given to the subjects, are set out below:—

We are anxious to find out how much is being eaten by healthy growing boys and girls whose parents are sufficiently well off to provide them with plenty of good plain food.

The only accurate way of doing this is by weighing the food actually eaten, and to obtain good results it is necessary to weigh the food every day for a week.

By doing this you are helping medical research which does so much to benefit the health of all.

Instructions

1. Weigh each kind of food separately, just as it is served to you. If raw, say so. If you are eating any food such as fish or chops that contains bones, or fruit with skin or stones, please say whether your weight included the waste, *e.g.*,
Kipper, weighed with bones.
Orange, weighed without skin.

There is no need to weigh the waste, but please weigh any food you leave and deduct it from the food you first weighed out.

2. If you weigh anything on a plate do not forget to subtract the weight of the plate before entering the result on the form.

3. You need not bother to weigh eggs. Just count them and put the number. Sugar may be weighed, or measured in lumps or by the teaspoonful (say whether level or heaped).

4. Please say whether your bread is white or brown.

5. Do not forget to put down all sweets and chocolates under "Extras".

6. Please say whether your fruit was fresh, stewed or tinned in syrup. For stewed and tinned fruit weigh the fruit and juice together.

7. Do not include gravy in the weight of the meat; measure the gravy separately in tablespoonfuls. Please say what kind of meat or fish you eat.

8. It is a good plan to weigh out for yourself at the beginning of the week $\frac{1}{2}$ lb. or $\frac{1}{4}$ lb. of butter and always use from this piece. You need not then weigh the butter as you eat it, but simply put " $\frac{1}{2}$ lb. of butter started" and " $\frac{1}{2}$ lb. of butter finished", when it is so. If any butter weighed out to you remains at the end of the week, say what it weighs.

9. We are very anxious to know how much milk you drink per day and how you drink it, so please weigh the milk if possible or measure it in tablespoonfuls. Say how much milk you drink alone, and how much you put in a cup of tea, cocoa, etc. Do not forget to put down how many lumps or teaspoonfuls of sugar you take in your drinks.

*This indicates how to enter the results and is not meant to be a plan
of an ideal diet*

	<i>Food</i>	<i>Amount</i>	<i>Weighed raw or cooked</i>
<i>Breakfast :</i>	Cornflakes	$\frac{3}{4}$ oz.	
	Sugar	2 level teaspoons	
	1 boiled Egg		
	Bread (white)	2 ozs.	.. Toasted
	Butter started	4 ozs.	
	Milk on Cornflakes and in 2 cups of Tea. (No sugar taken in tea)	5 ozs.	
<i>Dinner :</i>	Irish Stew		
	Mutton weighed with bone	2 ozs.	.. Cooked
	Carrots	1 $\frac{1}{4}$ ozs.	.. "
	Potatoes (boiled)	3 $\frac{1}{4}$ ozs.	.. "
	Gravy	2 tablespoons	.. "
	Stewed Plums weighed with stone	3 ozs.	.. "
	Boiled Custard (made with Egg)	2 ozs.	.. "
<i>Tea :</i>	Bread (white)	3 $\frac{1}{2}$ ozs.	
	Butter from $\frac{1}{4}$ lb.		
	Jam	1 oz.	
	Plain Cake	2 ozs.	
	2 Chocolate Biscuits (cigarette size)	$\frac{1}{2}$ oz.	
	Milk in 2 cups of Tea	2 tablespoons	
<i>Supper :</i>	1 cup of Cocoa—		
	Cocoa	$\frac{1}{2}$ oz.	
	Milk	4 tablespoons	
	Sugar	1 teaspoon (level)	
	2 plain Biscuits (Digestive)	1 oz.	
	1 Apple (weighed with skin and core)	3 ozs.	.. Raw

All the food eaten for one week was weighed. A period of seven days was chosen as being the shortest time in which an investigation of this sort should be carried out (Wait and Roberts, 1932; Koehne, 1935; Leverton and Marsh, 1939; Boulton, 1945; also pp. 22 and 72). Clearly a longer period would have been better, but it would have been far more difficult to obtain volunteers if a further week had been demanded of them. Where possible, the child or the child's mother was interviewed personally both at the beginning and at the end of the week. In many instances, however, this could not be done, and letters were then always sent to the mothers, and the balance was sent by post. Where volunteers were obtained through schools, one or two dozen balances would be left at the school, to be passed on from one child to another during successive weeks. In all such schools success or failure depended upon a teacher's co-operation, and in practically every instance this was enthusiastic and efficient. Special tables, or even rooms, were set aside for children taking part in the investigation, where they could weigh and eat their mid-day meal. Practical lessons were usually given beforehand, showing them how to weigh the food and enter the results.

It will be noted that the children were not personally supervised while the food was being weighed and eaten. It would have been a stupendous task for an investigator to have been present at all the 30,000 meals eaten by the children in the course of the survey. Thus, the accuracy of the record depended upon the parent or child making it. It was found, however, that over-conscientiousness was more frequent than carelessness, and very little difficulty was experienced because of lack of intelligence. The question arises as to how far the amount of food eaten was influenced by the mere fact of having to weigh it. Were particular foods chosen because they were easy to weigh? Were second helpings sometimes refused because they had to be weighed? Were the customary extras between meals, fruit, sweets, etc., avoided during the

experimental week because of the trouble of finding the balance, the form and the pencil? There is no doubt that this did happen to some extent, but there seemed no way of surmounting the difficulty. The disturbance that would have been caused by the presence of an investigator at the meal table, and indeed all the time, would have been a far more serious matter.

Calculation of the results

The records were scrutinized as soon as possible after they had been received so that any queries arising out of them could be answered while the details were still fresh in the co-operator's memory. The completed records contained details as to the amounts of the various foods eaten at each meal during a period of seven days. Portions of a few foods, such as butter, were generally weighed out at the beginning of the week, and used without further weighing until they were finished, and only the total weekly consumption of these foods was known. In the first instance the total amount of each food eaten by each child during the week was calculated, and a daily average obtained. Figures that are given for daily intakes in all subsequent Tables and Graphs (except Tables XLIII, XLIV and Fig. 39) represent average intakes over the whole week, and not the intake on any particular day. This must especially be borne in mind in considering maximum and minimum values. A more detailed analysis of some of the diets has been made, whereby each day has been calculated separately, so giving the variation in the child's diet from day to day. This is discussed in detail on p. 70.

While records of the amounts of the actual foodstuffs are of more interest and importance than the results of calculations of the chemical composition of the diets, a survey of this sort would not have been complete until the results had been expressed in chemical terms. With this in view, it was first of all considered which dietary constituents should be assessed. Calories were of course included, since intake probably comes nearer to measuring requirement for calories than for any dietary constituent. Protein is a dietary essential which is particularly needful for growing children, and calculations of the amounts of protein in the children's diets were therefore made. Fat and carbohydrate are mainly sources of calories, and the relative proportion of one to the other is probably immaterial within very wide limits. Nevertheless they do provide some clue as to national dietary habits, and the amounts of them in the diets were accordingly calculated. The mineral constituents presented rather a different problem. About fifteen of them are present in food, and nearly all are essential for the maintenance of life and health. One cannot be considered to be of more importance than another. Some, however, such as potassium, are present in food in such large amounts and are so freely absorbed that even the poorest diets provide an excess, and there is no fear of a deficiency. This is true also, in temperate climates, of sodium and chlorine. Attention, therefore, is usually focussed upon calcium and iron, which are absorbed with difficulty and may not be present in the diet in sufficient amounts; phosphorus is often included in this category. It was therefore decided to calculate the amounts of calcium, iron, and phosphorus in the diets, with the full realization that most diets contain a supply of the last which is fully adequate. It was clearly desirable also to determine the amounts of the various vitamins that the diets contained, but the necessary data were so fragmentary and contradictory that it was much more difficult to calculate the vitamin intakes with a sufficient degree of accuracy. An attempt, however, was made to assess the children's intakes of vitamins A, B, C and D, but the results must be regarded only as rough approximations.

Calculations of proximate principles, calcium, phosphorus and iron have been made from the tables of McCance and Widdowson (1940). These authors have demonstrated that this is a relatively accurate procedure (Widdowson

and McCance, 1943), provided it is realized that the values obtained for calcium and iron are minimum values. In districts where the water is hard the calcium intakes may be about 100 mg. a day higher than the calculated values, and iron intakes will depend upon the type of cooking utensils used. A number of cooked dishes other than those whose analyses are given in the food tables were eaten. Recipes for these were usually obtained from the mother of the child concerned, and their composition calculated from the composition of the ingredients and a knowledge of the average loss of weight on cooking that particular type of dish. Average figures for the composition of fruit stewed with sugar were arrived at by analysing samples cooked by a number of different people.

The tables of Fixsen and Roscoe (1938 and 1940), Fixsen (1938), and of the Medical Research Council (1945), were used for the calculation of vitamins A, B, and D. Olliver's (1943) figures were used for the vitamin C calculations. It was impossible to calculate the intakes of other vitamins of the B complex because so few foods had been analysed, but such calculations can be made later from the dietary records when sufficient data are available.

CHAPTER 3

THE CHILDREN'S FOOD

" The feeding of Children properly is of much greater importance to them than their Clothing. We ought to take great care to be right in this material article, and that nothing be given them but what is wholesome and good for them, and in such quantity as the body calls for towards its support and growth "

(Cadogan, 1769.)

It has been said that food is an interest in life which begins earlier and lasts longer than any other. But this is an interest in *food*, not in calories or minerals or vitamins, and a great deal of the value of the present inquiry has been the determination of the quantities of various foodstuffs actually eaten by children of different ages during the years from 1935 to 1939. In presenting the results, data obtained from 63 men and 63 women (Widdowson, 1936; Widdowson and McCance, 1936) have frequently been included, and, in the graphs, data for the adult age groups are shown by dotted lines. The adults have been divided into three age groups, as was done when their diets were calculated for proximate principles, calories and minerals in the original publications. It is satisfactory to note that their mean intakes fall into line with those of the children in the present study. In fact, the individual survey seems to offer the only satisfactory method of discovering trends of food consumption and dietary habits, whatever the age of the subjects.

In this chapter the consumption of cereal foods, dairy products, meat, fish, fruit, vegetables, sugar and other food items will be discussed, but first it is necessary to consider the value of the evidence. It might be argued that a week, which was the length of time for which these children weighed their food, was not long enough to give a true picture of an individual's food habits. This matter has been investigated by Boulton (1945), who carried out a study of the diets of 8 children of various ages for 4 successive weeks. She found that, so far as the staple foodstuffs such as bread, milk, meat and potatoes are concerned, the amount consumed was very similar from week to week. When foods which are eaten less frequently, such as liver, or foods with a seasonal incidence, such as strawberries, are considered, a week is clearly too short to characterize an individual's intake. Each case must be judged strictly on its merits. Thus, the figures for liver could probably be used to give some idea of the

amounts of liver eaten at one sitting, and they might provide a curious Minister of Food with a clue to the quantities of liver eaten by his hypothetical "average" child. Again, they might be used to compare the average amounts of liver and meat eaten by children of various ages, but this data may have no meaning for the individual child, who may never eat liver at all. Furthermore, a child might be passionately fond of liver and yet have had no opportunity of demonstrating his capacity for eating it during the week selected for the survey. In the case of popular but seasonal foods, such as fruit, the reservations are rather different. The figures as they stand cannot be used to compare the popularity of, say, strawberries with apples, because strawberries have always had a short season while apples were not really seasonal during the period 1935-39. Therefore, the amount of strawberries recorded as being eaten is probably a measure of the number of children who weighed their food in June rather than of anything else. Nevertheless, the data even for these rarer and more seasonal foods have an interest and value which fully justifies their inclusion. These considerations, moreover, also apply to food constituents such as certain vitamins, which are present only or mainly in particular foods. Thus it will be apparent from Chapter 10 that the intake of vitamin A is closely associated with the consumption of liver and that of D with a fondness or otherwise for the pelagic fish. Data for the intake of these vitamins, therefore, must be scrutinized carefully and only used in a justifiable fashion. In this investigation these precautions have been taken.

Cereal foods

BREAD

"There is nothing parents should more promote in their children than the love of Bread; they should be taught to eat a great deal of it with their Meat" (Nelson, 1753).

There is no doubt that bread has formed an important part of the diet of children for many generations. Since bread is a cheap food, it has always tended to be the mainstay of the poorer classes. In 1892, for example, it was found that the poor children of Bethnal Green were nourished almost entirely on bread. Eighty three per cent. had no other solid food for 17 out of 21 meals in the week (Drummond and Wilbraham, 1939). Among the half-starved children at private boarding schools during the 19th century bread seems to have been the main article of diet, and even at schools where the quantity of food was more adequate it bulked largely on the menu. Children at a "Parish School of Industry", established in Westminster in 1782, had bread at every meal, and each child's allowance was one-fifth of a loaf per day. (Parish of St. James, Westminster, 1797.) If these were quartern loaves, the allowance would have amounted to 13 oz. At another House of Industry, in the beginning of the 19th century (Vancouver, 1808), children of 12-15 had the same allowance of bread as adults (10 oz. a day), children of 7-12 had 9 oz., and those under 7 years, 7 oz. Much earlier records are available for Christ's Hospital, however. In 1678, breakfast every day consisted of 2½ oz. of bread and a "supp of drink". Five ounces of bread were also provided "att every meal, dynner and supper", so the total daily allowance was 12½ oz. (Pearce, 1908). In a report on the diet at Christ's Hospital in 1813, it is stated that "their diet is plain and simple; the allowance of bread is very ample and of the best quality; that of animal food is in quantity moderate, and of culinary vegetables but small; but the great quantity of bread allowed to them renders the latter less necessary, and thus, without material inconvenience, they are dispensed with" (Field, 1813). Friend (1935) calculated that the boys were deriving about half their calories from bread in 1704 and again in 1838. They were eating about 1 lb. per head per day at both those times, and the total energy value of their food seems to have been but 2,000 calories per day. Between 1913 and 1922 the boys were still

eating 0·8–1·0 lb. of bread per day, but, since their total calories had by this time risen to some 2,800 per day, the percentage of calories derived from bread had fallen to about 30 per cent. This increase in total calories may have been due to an increase in the age of the boys, for Charles Lamb went to Christ's Hospital in 1782 when he was seven years old, but by 1905 the age of entry seems to have been raised to nine. From 1922 onwards there was a steady fall both in total bread consumption and in the percentage of calories obtained therefrom, so that in 1933 the figures were 0·65 lb. and 20 per cent. respectively. Widdowson and McCance (1942a) have shown, by an individual dietary survey at two public schools, that the boys at the schools in question were eating about 7 oz. of bread per day in 1936 and 1937, and that it provided 14 per cent of their total calories. In 1942, the bread consumption had risen to 10 oz. per day and provided 22 per cent. of the calories in the diets.

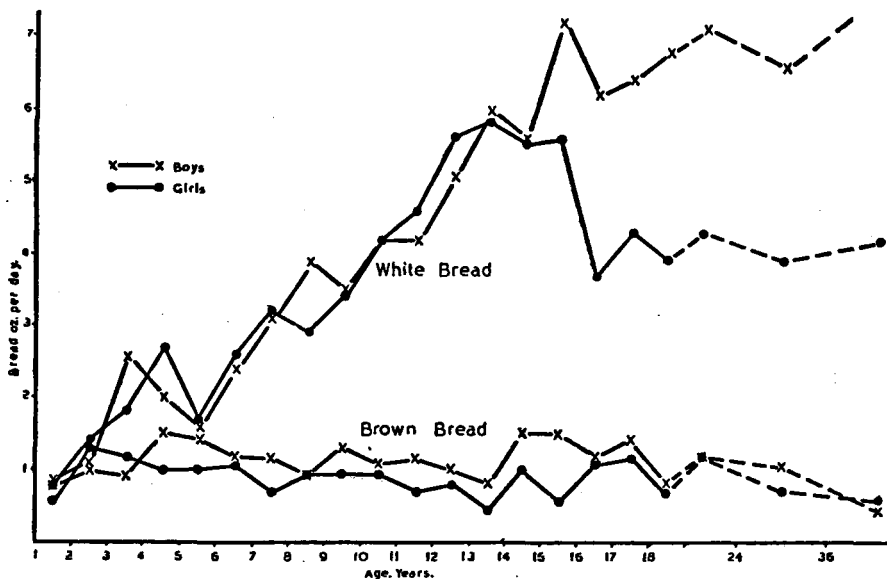


FIG. 9.—Average Consumption of Bread.

Fig. 9 shows the average amounts of white and brown bread eaten by children of different ages taking part in the present investigation. The intake of white bread was just under 1 oz. per day at the age of one year, and there was no difference between the two sexes till the age of 14, by which time the average consumption had risen to about 5½ oz. per day. After this age the boys' intakes continued to rise, and were of the order of 7 oz. per day at 18 years and 6½ to 8 oz. per day in the adult age groups. By 18 years, however, the girls' intakes had fallen to 4 oz. per day, and the women's intakes remained at about that level. At the earliest ages white and brown bread were eaten in similar amounts, but thereafter, while the consumption of white bread rose as already described, that of brown bread averaged approximately 1 oz. per day at all ages. This steady average was brought about in the following way. At the age of one year, 28 per cent. of the children were having brown bread and no white, and 23 per cent. were having white bread and no brown. The remaining 49 per cent. had some of each. By 2–3 years of age the percentage having brown bread to the exclusion of white had fallen to 16, but 89 per cent. of the children were still having some or all of their bread in this form. The relative proportions of brown to white bread gradually decreased so that by eight years of age no child was eating only brown bread and only 60 per cent. tasted it during the week

of study. After eight years of age these proportions changed very little. It would seem that many of the younger children were given brown bread because it was thought to be good for them. As they grew older enthusiasm waned—or possibly the children began to have more say in the matter—and fewer children ate brown bread. Owing to their greater appetites at these

TABLE XV
Boys' Bread Intakes (oz. per day)

<i>Age group</i>	<i>Average intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	1.7	3.2	0.2	0.90	53
2	2.1	5.7	0.1	1.44	68
3	3.5	8.5	1.2	1.83	52
4	3.5	7.2	0.4	1.55	44
5	3.0	8.2	1.1	1.51	50
6	3.6	8.5	1.7	1.55	43
7	4.3	6.5	1.6	1.47	34
8	4.8	9.9	1.5	1.80	38
9	4.8	7.0	2.7	1.12	23
10	5.3	9.3	0.9	2.03	38
11	5.4	11.3	2.2	1.91	35
12	6.1	12.9	2.7	2.29	38
13	6.8	13.6	2.7	2.84	42
14	7.1	14.7	0.8	2.15	30
15	8.7	15.1	3.6	3.38	39
16	7.4	16.6	2.2	3.10	42
17	7.8	15.3	1.5	3.04	39
18	7.6	12.2	3.4	2.42	32

TABLE XVI
Girls' Bread Intakes (oz. per day)

<i>Age group</i>	<i>Average intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	1.4	3.8	0.2	1.01	72
2	2.7	5.4	0.9	1.17	43
3	3.0	8.2	0.9	1.76	58
4	3.7	7.4	1.3	1.62	44
5	2.7	7.1	0.4	1.67	62
6	3.7	7.5	1.7	1.24	33
7	3.9	5.9	0.9	1.35	35
8	3.8	7.8	1.5	1.61	42
9	4.3	7.0	2.3	1.33	31
10	5.1	10.0	1.5	1.79	35
11	5.3	10.2	2.4	2.11	40
12	6.4	10.3	1.8	2.20	34
13	6.2	11.7	2.2	2.37	38
14	6.5	17.9	1.9	2.82	43
15	6.2	10.8	2.3	1.94	31
16	4.8	11.6	1.1	2.12	44
17	5.5	8.3	1.0	1.82	33
18	4.6	7.2	0.8	1.48	32

ages, however, those who did have brown bread easily ate enough to maintain the average intake at about 1 oz. per day. Only one man and no woman of the 126 adults studied (p. 22) ate brown bread to the exclusion of white. Sixty-five per cent. of the men and 54 per cent. of the women had no brown bread at all.

Tables XV and XVI show the average total bread intakes at various ages, the largest and smallest average daily quantities eaten by particular children in each age group, the standard deviations and the coefficients of variation.

Every child ate some bread, but in spite of the proverbial appetite of schoolboys only one boy ate more than 1 lb. per day. He was 16 years old and lived at Bridgend, and his daily consumption averaged 16·6 oz. The biggest bread eater in the whole investigation was a 14-year-old girl from Liverpool, who ate 17·9 oz. per day. Her calorie intake was well above the average for her age. No other girl ate as much as 12 oz.

It is interesting to note that on a freely chosen dietary there were always some small bread-eaters. Every yearly age group, of boys as well as of girls, contained two or more children who ate less than 4 oz. of bread per day. This applied to 26 boys between 12 and 18 years. Generally speaking, these boys tended to have lower calorie intakes than the big bread eaters. Twenty of them were having less than the average number of calories for their age, whereas, of the 15 boys who were eating more than 12 oz. of bread per day, 12 had more than the average number of calories. Of the six boys with high calorie intakes, but who ate only small amounts of bread, four were public school boys home on holiday. Their calories were made up by the substitution of large quantities of cakes, buns and biscuits for the more usual bread, or by the consumption of more than the average amounts of meat, milk and puddings.

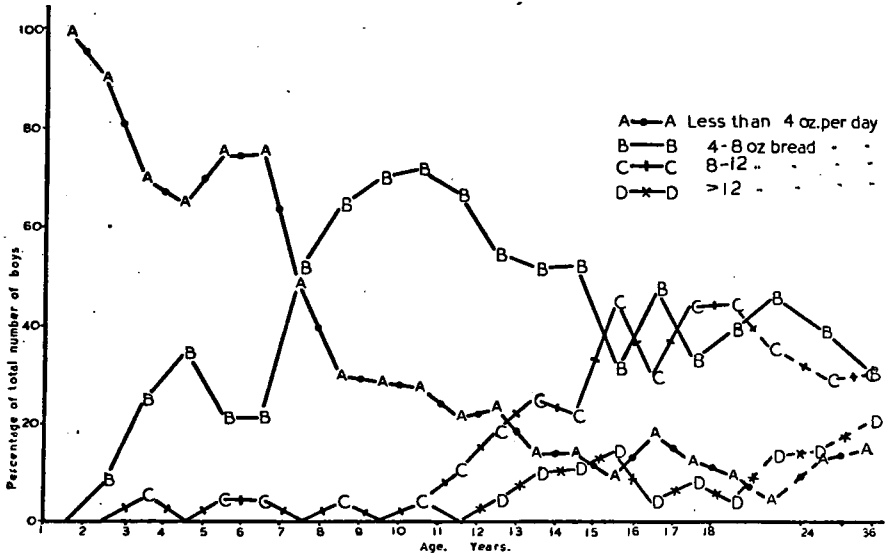


FIG. 10.—Frequency Distribution of Boys' Bread Consumption.

In order to show in more detail the amounts of bread eaten by boys and girls, children of each age have been divided into four categories according to their bread consumption. Those who ate less than 4 oz. per day were placed in category A; those who ate more than 4 oz. but less than 8 oz. per day, in category B; those who ate between 8 and 12 oz. per day, in category C; and the remainder were placed in category D. The percentage of the total number of children in each age group falling into these four categories is shown in Figs. 10 and 11. All the one-year-old children ate less than 4 oz. per day, and, therefore, 100 per cent. of them fell into category A. As their ages increased from one to ten, more and more children ate 4-8 oz. per day and so qualified for category B, while fewer and fewer ate less than 4 oz., and only an occasional child more than 8 oz. Then the proportion of children in categories A and B fell because more and more children ate 8-12 oz. per day. Up to the age of 13 the trends of the boys' and girls' consumption were similar, but thereafter they differed as the boys' bigger appetites became manifest. More boys than girls, between 12 and 18

years of age, ate between 8 and 12 oz. per day. Furthermore, 15 boys but only one girl ate more than 12 oz. of bread per day. Consequently, more girls than boys were classified in categories A and B.

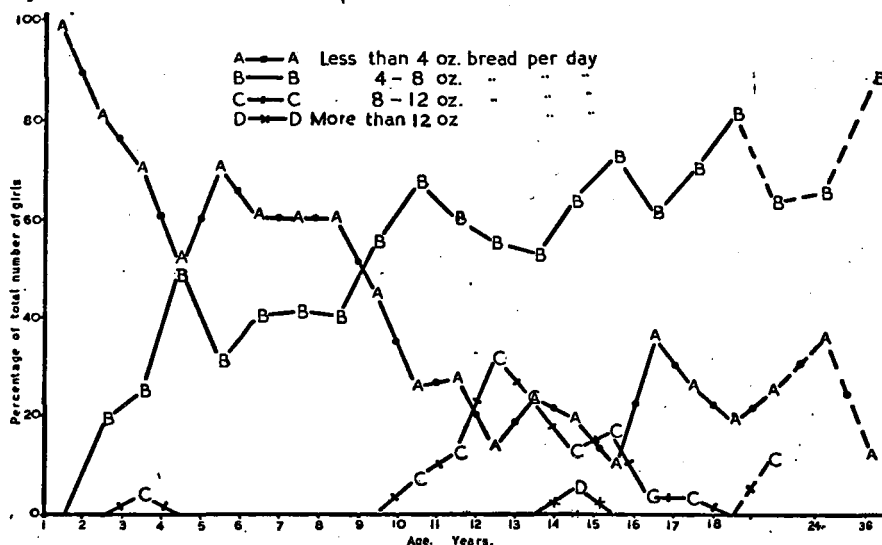


FIG. 11.—Frequency Distribution of Girls' Bread Consumption.

PORRIDGE AND PROPRIETARY CEREALS

More children had proprietary cereals than had porridge. Many had both. More of the younger than of the older children ate breakfast cereals, and, at most ages, more boys than girls. The percentage eating breakfast cereals was of the order of 70 at all ages up to 11, and thereafter it fell to about 45 at the age of 18. Of the total number investigated, 63 per cent. of the boys and 54 per cent. of the girls had cereals in some shape or form. Since many of the children ate none, the amount consumed by the children who did eat them, expressed as averages of the total number of children at each age, tended to be variable and the results have only a limited interest. The amounts of breakfast cereals eaten by the individual children who partook of these foods varied considerably from child to child, but age made curiously little difference to the average amounts consumed. Boys and girls of 18 months were being given about 6 oz. per week, but one child of this age ate 22 oz., mostly as "Farex". Children of 12 averaged 5.7 oz. per week, boys in their teens 5 to 9 oz. and girls of these ages 2.5 to 5 oz. One 16-year-old boy had 4 oz. of "Shredded Wheat" every day for breakfast. Most of the well-known brands of proprietary cereal were

TABLE XVII

Number of Children eating various Proprietary Breakfast Cereals

	Boys	Girls
Total number	435	481
Number eating :—		
" Cornflakes "	163	140
" Shredded Wheat "	61	61
" Rice Krispies "	34	37
" Force "	31	31
" Post Toasties "	25	15
" Grape-Nuts "	24	18
" Puffed Wheat "	14	10
" Weetabix "	9	8
" Puffed Rice "	7	9
" Wheat Flakes "	5	4
" Farex "	5	4

included in these children's diets. Some idea of their relative popularity may be gained from Table XVII, where the number of children consuming each type of cereal is shown. Many children ate more than one variety during the week.

The percentage of children eating porridge varied somewhat erratically from one age group to another, but, taking all the children together, 41 per cent. of the boys and 32 per cent. of the girls favoured this breakfast food. It is interesting that this proportion is no less than that found by Wright (1936) in the course of an inquiry into the food habits of 13,317 school children living in Glasgow and in urban and rural districts of Ayrshire. Thirty-three per cent. of these Scottish children took porridge either for breakfast or for some other meal. If our children's consumption is expressed in terms of raw oatmeal, the children who had porridge averaged a little over 1 oz. per week at 18 months, and only 2½ oz. at 13 years. It is an odd fact that at every age boys tended to eat more porridge than girls, and at 16 the former were averaging 5 oz. of oatmeal a week and the latter only 1 oz. Older boys ate more proprietary cereals than older girls, and this was true also of the adult groups previously investigated.

Only a few children ate porridge on each of the seven days of the dietary survey. Most of those who ate it did so irregularly, many only once. One London boy, aged 16, however, had about 15 oz. of cooked porridge every day for breakfast, eating a total of 106 oz. during the week. His 13-year-old sister, who presumably had the same opportunities but not the same appetite, never ate more than 8 oz. at one sitting.

Proprietary breakfast cereals are an expensive form of calories, and in order to find out whether income and social status had any effect on their consumption the children have been divided into three socio-economic grades as described on p. 8. It was found that among the professional class children 67 per cent. of the boys and 63 per cent. of the girls ate proprietary cereals. Sixty-four per cent. of the boys and 52 per cent. of the girls of the upper working class had them during the week of inquiry, but only 46 per cent. of the boys and girls in the artisan class. Porridge, on the other hand, is a cheap food, and one might expect, therefore, a higher proportion of the poorer children to be eating it. This was not found to be the case. Porridge was eaten by 37 per cent. of the children of the artisan class, by 34 per cent. of the upper working class and by 39 per cent. of the professional class. Crawford and Broadley (1938) in their survey, "The People's Food", also found that slightly more of the wealthy families ate porridge than of those in the working class group. There are probably several reasons why this should be so. Firstly, the preparation of good porridge demands time, careful attention and cooking facilities. The wealthier classes were, at the time of the investigation, more leisured and accustomed to hire domestic services than now, but the working classes usually had not these advantages. Secondly, porridge needs milk which is relatively expensive. Thirdly, porridge is to some extent a traditional food, and those who are brought up on it commonly eat it for the rest of their lives. Families of Scottish origin now living in England tend to continue to eat their national cereal for breakfast. Among the families of Scottish origin living in England there are possibly more in the professional than in the artisan class, and it is suggested that this may help to explain the slightly higher porridge consumption among the well-to-do.

BISCUITS AND CAKES

Biscuits and cakes were popular foods. Almost every child had cake; 72 per cent. of the boys and 77 per cent. of the girls had biscuits. It is probable that all the children ate biscuits or rusks at some time or other, and these figures suggest that many of the children may have had them during 3 weeks out of 4.

Fig. 12 shows the amounts that were eaten by these children, and by the men and women previously studied. The average biscuit consumption of the biscuit-eaters remained remarkably constant from infancy to middle age, and the two sexes ate approximately equal amounts. The high figure in the oldest

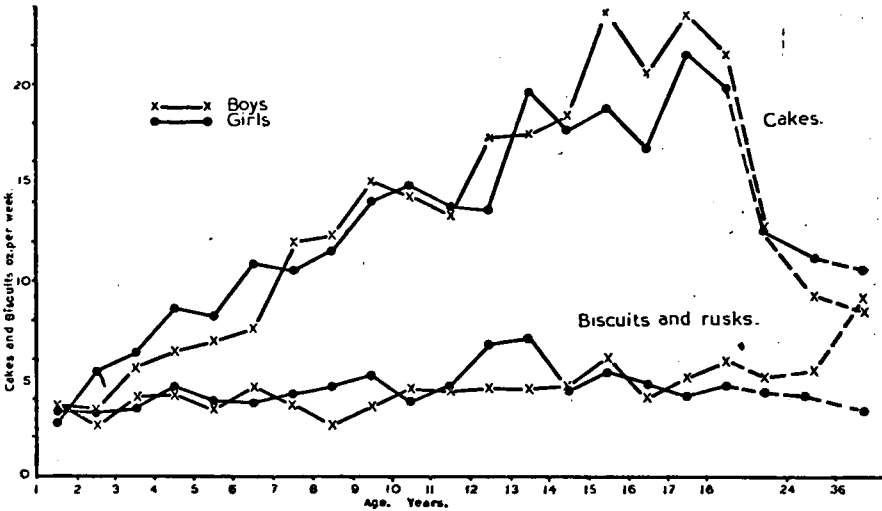


FIG. 12.—Average Consumption of Biscuits and Cakes by those who ate them.

men's group is due to two men out of eight eating very large quantities. Some individual children ate very much more than others, and this is illustrated in Fig. 13. It shows the frequency distribution of biscuit consumption for

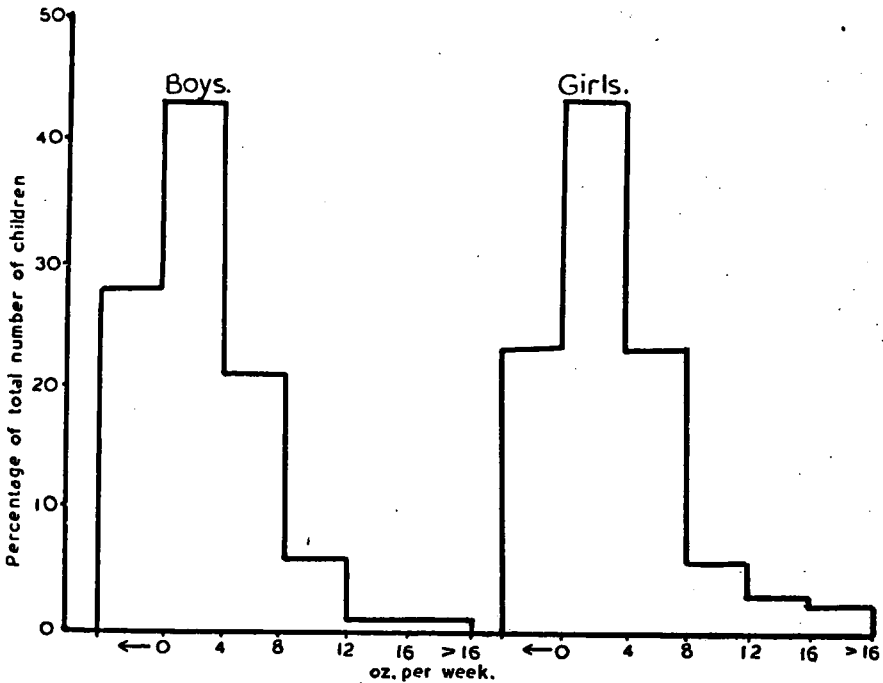


FIG. 13.—Frequency Distribution of Biscuit Consumption.

both boys and girls, taking all the age groups together. Of those who ate biscuits, 58 per cent. had less than 4 oz. a week. Thirty-seven of the boys and 53 of the girls had more than 8 oz., and, of these, 3 boys and 8 girls ate more than a pound of biscuits during the week. The largest weekly consumption was 25½ oz., which was the amount recorded by a 12-year-old girl.

In contrast to biscuits, the average consumption of cakes and buns increased steadily with age. It may seem strange to students of nutrition that children of 18 months should have been fed on cake, but 3 oz. a week was their average consumption at that age and this increased to 18 oz. at the age of 14. Between 14 and 18 years boys ate more cake than girls, and there was a big drop in cake consumption in the youngest adult age group. This decrease continued with increasing age, so that the men and women over 36 years were eating about the same amount of cake as boys and girls of 7 years. One boy of 15 and one girl of 17 ate 3½ lb. during the week, and several others approached this amount.

Proprietary crisp-breads are conveniently mentioned here. Very few children ate them. Fifteen boys and 17 girls took "Ryvita" and 9 of each sex ate "Vitaweat". Two children recorded "Macvita", and no other variety was mentioned.

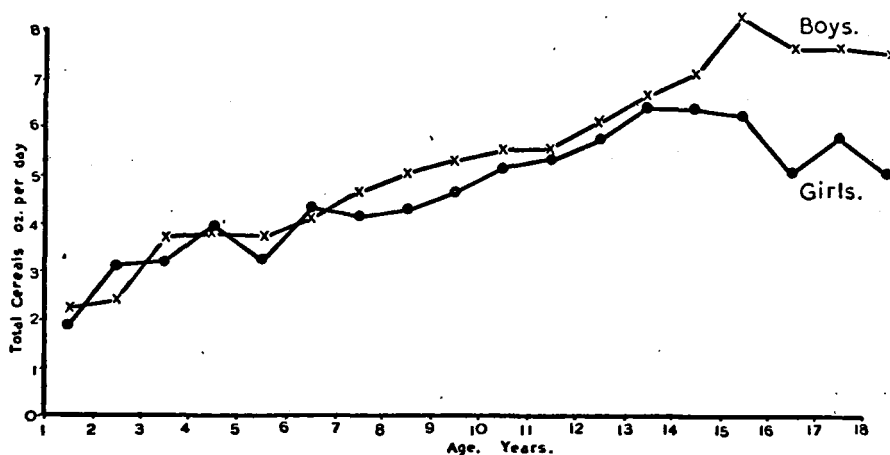


FIG. 14.—Children's Average Consumption of Cereals from all sources. (All the results are expressed in terms of flour, oatmeal, etc., as purchased.)

TOTAL CEREALS

Diets are to some extent characterized by the amount of cereals they contain. Many native diets consist predominantly of a single cereal, but in many ways the total quantity of cereal food is of greater interest than the quantity of any particular one. It would probably be much fairer to use figures for total cereals, instead of those for bread, if the diets of our children were to be compared with those of children living a century or two ago, for in those days they probably had very few cakes or biscuits and certainly no "Cornflakes" or "Shredded Wheat". Fig. 14 shows the average amounts of total cereals eaten by boys and girls of all ages. It will be seen that children between 1 and 2 years of age were eating about 2 oz. of flour or its equivalent per day, and it provided them with nearly 20 per cent. of their calories (see p. 60). At the age of 7, boys were beginning to eat more than girls and at 15 they were eating 8.4 oz. per day. Girls never averaged more than 6.5 oz. per day, and their consumption showed a tendency to fall by the age of 15, and was 5 oz. at the age of 18.

MILK

Dairy products

Milk has attracted more attention among workers in nutrition than any other individual foodstuff—and not without justification—but it is important to realize that it is only during the past 20 years that the value of milk as a food for older children has been generally appreciated. Some primitive tribes, however, who have no access to the milk of domestic animals, suckle their children for a very much longer time than is customary in more civilized communities. Eskimo boys may be fed from the breast till they are 15 years or over (Freuchen, 1936). In 17th century England, milk was regarded as suitable only for young children and very old people and, although there are reports of the boys at Christ's Hospital being given it in the 16th and 17th centuries, by 1704 it seems to have disappeared from their diet. In 1838 it had reappeared again, but the allowance was only a quarter of a pint a day (Friend, 1935). There seems to have been a similar allowance to the children at the Parish School of Industry, established in Westminster in 1782 (Parish of St. James, Westminster, 1797). The children at the Foundling Hospital appear to have fared rather better, for in 1810 they had milk porridge every day for breakfast, and in 1840 those under 9 years of age had three-quarters of a pint of milk a day and those over 9 half a pint (Nicholls and Wray, 1935). In the 18th and 19th centuries the milk sold in the towns was so filthy that it was probably responsible for more disease than health, and it is fortunate that the poor bought so little of it. In country districts in the North, however, milk appears to have been used in quite large quantities. One family in Cumberland, for example, consisting of an agricultural labourer, his wife and five children, aged 6 months to 9 years, drank about 7 pints a day (Eden, 1797.) Some more enlightened people at the end of the last century felt that the children of the poorer classes were stunted in growth because of the lack of milk in their diets, and Wilson (1877) and Dukes (1899) referred to the work of Dr. Ferguson, a factory inspector, who, "after a careful continuous measurement of factory children, came to the conclusion that between 13 and 16 years of age the growth was nearly four times as fast on milk for breakfast and supper as on tea and coffee". In the early part of the present century, milk was still often regarded as a namby-pamby food for growing boys, and it seldom appeared on the menu at boarding schools. Rugby was perhaps an exception, for Dukes (1899), who was physician there during the latter half of the 19th century, was convinced of the value of milk for growing boys. "Milk is the grand type of all diets. . . . Milk should, therefore, always be bountifully supplied for all adolescents as an essential, and part of their staple diet". He advocated $1\frac{1}{2}$ pints a day for all boys between 9 and 19 years of age. It was not until the first World War was over that the nutrition of children, and particularly the importance of milk in their diets, became a matter of general interest. This was greatly enhanced by the work of Corry Mann (1926), who showed that boys living in an institution on a supposedly adequate diet, but with an extra pint of milk a day, gained in one year nearly an inch in height and 3 lb. in weight more than boys on the same diet, but with sugar instead of milk. These results were confirmed a year or two later by a more extensive trial on children living in densely populated districts in Scotland (Orr, 1928; Leighton and Clark, 1929), and among rural children (Clark, 1929). More recent work along similar lines has always given the same results (Riddell, 1935; Milk Nutrition Committee, 1939). Extra milk promotes an increased gain both in height and weight, and an improvement in physique and general well-being. As a result of Corry Mann's observations the "Milk in Schools" scheme was started in 1927 by the National Milk Publicity Council, and later was legalized by the Milk Act of 1934. This made milk available to children at elementary schools and grant-aided secondary schools at $\frac{1}{2}$ d. for one-third of a pint. The scheme was extended to all school children in 1942.

Of the total number of school children (5-17 years) taking part in the present investigation, 109 boys (33 per cent.) and 159 girls (42 per cent.) had school milk. Some of the school children weighed their food during the holidays, however, and hence had no opportunity to have school milk during the week of observation. A few were at boarding schools, which were not entitled at that time to cheap school milk. When these children were excluded, it was found that out of the day school children, who weighed their food during term time, 46 per cent. of the boys and 53 per cent. of the girls took advantage of the school milk and the proportions were roughly the same at all ages. The average amount of school milk drunk by these children during the week was 1.6 pints, or 0.32 pints on each school day. Some children had one-third of a pint twice a day, while others had it only once or twice during the week.

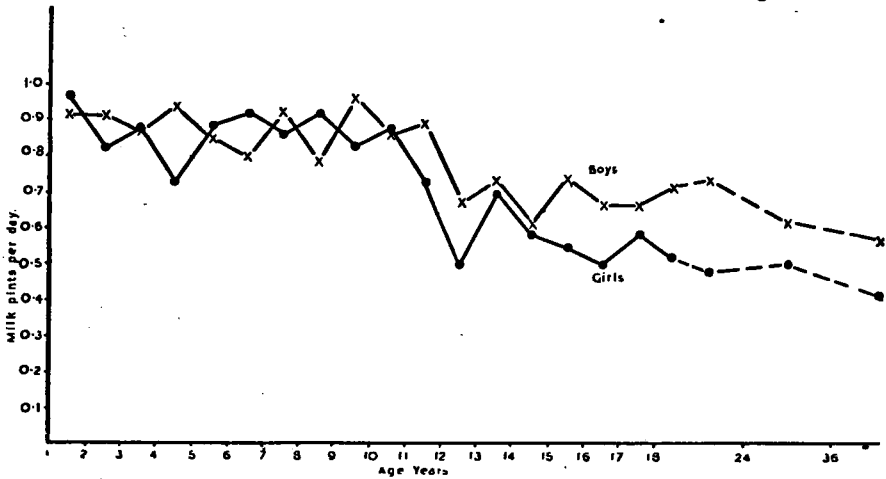


FIG. 15.—Average Consumption of Milk.

Fig. 15 shows the average milk intakes of the children taking part in the present survey, and of the men and women previously studied. From

TABLE XVIII
Boys' Milk Intakes (oz. per day)

Age group	Average intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	18.3	34.1	3.2*	7.4	40.2
2	18.1	30.4	6.8	4.9	27.0
3	17.4	38.7	3.5	6.6	38.0
4	18.4	37.9	6.6	7.8	42.3
5	17.1	28.1	4.7	6.0	35.0
6	16.7	30.4	9.6	6.0	36.0
7	18.2	29.2	11.1	5.1	28.0
8	15.8	29.2	6.2	6.7	42.5
9	18.6	30.4	2.3	6.0	32.2
10	17.3	30.0	3.9	6.6	39.0
11	17.9	37.6	3.4	8.1	45.2
12	13.8	28.5	5.7	5.4	39.0
13	14.7	31.3	0.4	7.0	47.5
14	12.2	33.2	1.6	7.6	62.3
15	14.5	28.5	5.2	5.7	39.2
16	13.2	29.8	1.6	7.0	52.8
17	13.6	31.0	0.0	7.4	54.3
18	14.2	28.2	3.3	6.9	48.5

* Excluding one boy who was allergic to cow's milk, and had none.

1-10 years the consumption of milk by boys and girls remained steady at 0.8-0.9 pints per day. Between 10 and 12 years it fell to 0.6-0.7 pints a day for boys and 0.5-0.6 pints a day for girls, and remained at these levels till 18 years. The men took more milk than the women in all three age groups, and the consumption by both men and women tended to fall as age increased. Further details about the average milk intakes and individual variations are given in Tables XVIII and XIX.

TABLE XIX
Girls' Milk Intakes (oz. per day)

<i>Age group</i>	<i>Average intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	19.5	32.5	6.6	5.5	28.2
2	16.5	25.9	7.7	4.7	28.5
3	17.3	24.7	10.0	4.0	23.1
4	14.6	22.8	8.7	4.5	30.8
5	17.8	29.4	6.4	6.5	36.5
6	18.4	28.6	7.7	5.8	31.5
7	17.2	33.0	10.1	5.3	30.7
8	18.3	28.3	7.6	5.3	28.9
9	16.7	35.3	3.3	7.6	45.5
10	17.4	34.4	5.8	6.8	39.0
11	14.5	30.9	4.2	7.7	53.0
12	10.6	22.1	3.2	5.1	48.2
13	13.3	30.1	2.6	7.6	57.1
14	11.8	32.1	5.4	4.9	41.5
15	11.0	22.8	0.7	5.3	48.2
16	10.6	22.3	1.5	5.2	49.0
17	11.8	30.5	3.3	8.2	69.5
18	10.4	20.1	3.1	4.5	43.3

Fig. 16 shows the frequency distribution of the quantity of milk consumed by individual children. The children have been divided into three age groups, 1-4, 5-11 and 12-18 years, and in the oldest group the boys and girls have been treated separately. Eighty-three per cent. of the children below 5 had between $\frac{1}{2}$ and $1\frac{1}{4}$ pints of milk a day. Two, a boy aged 3 and a boy aged 4, had almost 2 pints, and three had less than $\frac{1}{4}$ pint. One of these, however, a boy aged 1 year 2 months, had "Cow and Gate" dried milk in addition, and another boy, aged 1 year 9 months, was allergic to cow's milk and had no milk at all. He has been omitted in calculating the average. It may be of interest to note, in passing, that both this child's parents were medically qualified. He was being fed on scientific lines and was given 2 oz. of goat's milk cheese during the week, besides calcium and vitamin supplements. He was above the average for his age both in weight and height. In the age group between 5 and 11 years, 72 per cent. of the children had $\frac{1}{2}$ - $1\frac{1}{4}$ pints a day. All had some milk, but 8 had less than $\frac{1}{4}$ pint a day. Three had more than $1\frac{1}{4}$ pints. Of the older boys and girls, 88 per cent. had less than 1 pint of milk a day. One, a public school boy aged 17, had none. His diet was a peculiar one in various other respects and his calorie intake was very low. He was asked to weigh his food for one week during term time as well as for the original week in the holidays, and again he had no milk. He was well below the average for his age both in height and weight.

An attempt has been made to see whether the children who took the most milk were taller and heavier than those who took the least. Rather against expectation, it was found that the child who took the most milk was as often below as above the average weight and height for his age group. Similarly, the child who drank the least milk was just as likely to be above as below his group average.

Previous investigators (Makings, 1935; Orr, 1936; Cathcart and Murray, 1936) have shown that social status and economic circumstances have an influence on the consumption of fresh milk. Accordingly, the children in this survey have been divided into three socio-economic grades as described on p. 8, and the milk taken by the children in each of the three grades deter-

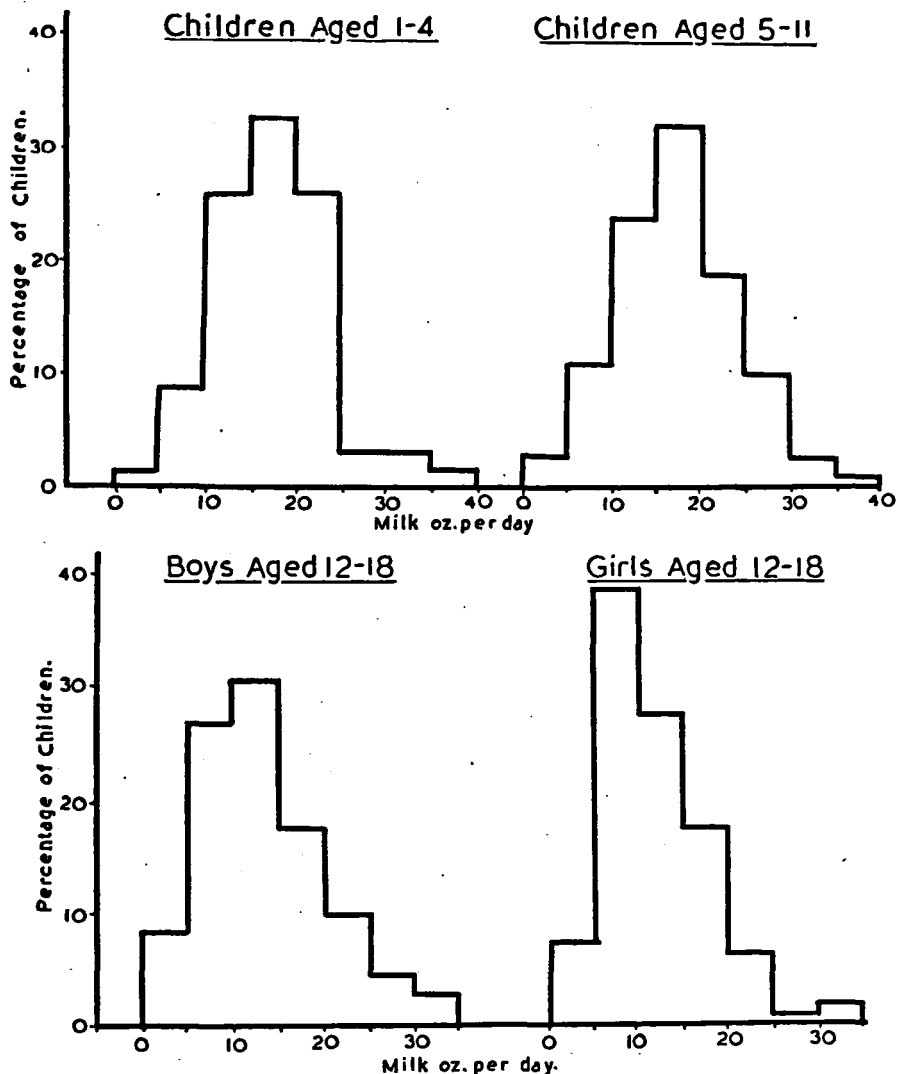


FIG. 16.—Frequency Distribution of Milk Intakes.

mined. Since the mean intake of milk appears to be approximately the same between 1 and 11 years, and again between 12 and 18 years, the children have been divided into three age groups for this purpose—pre-school children (1-4 years) and school children (5-11 years and 12-17 years). Table XX shows the average consumption of milk by children of these ages at the three socio-economic levels. It will be seen that this somewhat arbitrary division does not bring to light any very striking differences in milk consumption. It was

TABLE XX

*Consumption of Milk by Boys and Girls at different Socio-Economic Levels
(Milk intakes in pints per day)*

	<i>Professional class</i>	<i>Upper working class</i>	<i>Artisan class</i>
Boys 1-4 years	0.87	0.87	1.06
Boys 5-11 years	0.87	0.90	0.80
Boys 12-17 years	0.65	0.72	0.64
Girls 1-4 years	0.82	0.91	0.80
Girls 5-11 years	0.86	0.90	0.76
Girls 12-17 years	0.57	0.58	0.54

thought, however, that a larger proportion of the poorer children might be having school milk and that this might be masking the effect of socio-economic level. It was found, on analysing the data further, that this was so. Of the boys between 5 and 17 years attending day school and weighing their food during term time, 66 per cent. of the artisan class group, 49 per cent. of the upper working class and only 19 per cent. of the professional class group took school milk during the week of investigation. In the case of girls the figures were 57 per cent., 49 per cent. and 42 per cent. respectively.

Most children had some of their milk in the form of milk puddings. Table XXI gives some idea as to which were the most usually eaten. Custard made

TABLE XXI

Number of Children eating various Milk Puddings

	<i>Boys</i>	<i>Girls</i>
Total number	435	481
Number eating :—		
Custard-powder custard	256	304
Rice pudding	220	239
Egg custard	86	121
Blancmange	79	90
Junket	44	48
Sago pudding	43	48
Semolina pudding	40	31
Tapioca pudding	27	36
Milk jelly	26	30
Macaroni pudding	19	16
Barley pudding	13	13

from custard powder heads the list. Fifty-nine per cent. of the boys and 63 per cent. of the girls ate it at least once during the week. In spite of the common belief that children dislike rice pudding, this was easily the next in popularity. Fifty one per cent. of the boys and fifty per cent. of the girls ate it. Egg custard, baked or boiled, and blancmange were the next two recorded most frequently. Sago was slightly more popular than semolina or tapioca, and few children ate barley or macaroni.

CONDENSED MILK

Condensed milk was seldom mentioned on the records, though it may sometimes have been used for cooking in place of fresh milk. Twenty-nine children recorded having some, but they took only small amounts of it.

CREAM

Cream was more popular ; about half of the children had some during the week of inquiry. Its consumption was distributed fairly evenly among the younger and older children, and the average amount taken by those who had it was about 2 oz. during the week.

BUTTER

Butter became a popular food among the working classes during the 17th century, but the wealthy despised it and thought it only fit for cooking. It appeared on the Christ's Hospital records as early as 1552. In 1704 the boys were allowed $3\frac{1}{2}$ oz. per head per week, and by 1838 the amount had been increased to $4\frac{1}{2}$ oz. The diet was then changed, and the butter allowance fell to $1\frac{1}{2}$ oz. per week. In the years just before the first World War the consumption had risen to 8 oz. per week and, in 1930, it rose still further to 10 oz. (Friend, 1935).

All but 7 of our children ate butter. The average amounts they spread on their bread are shown in Fig. 17. At the age of one they were eating about $3\frac{1}{2}$ oz.

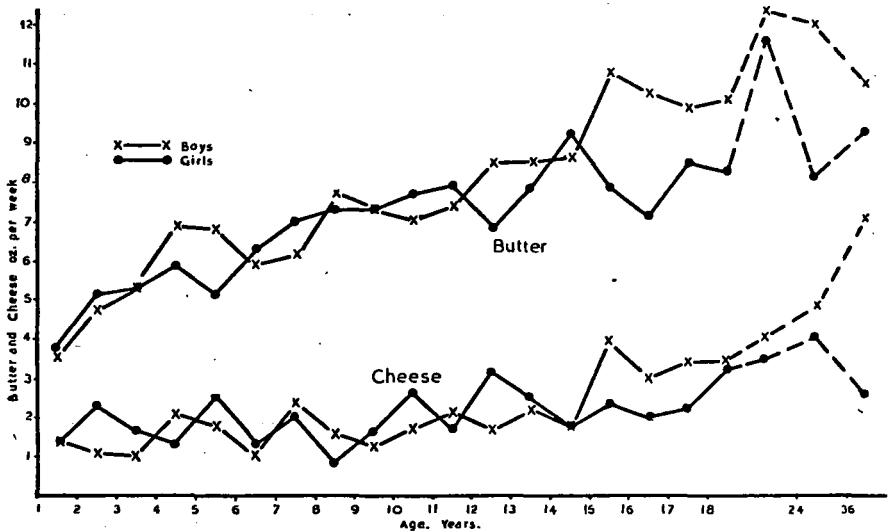


FIG. 17.—Average Amounts of Butter spread on Bread, and Average Consumption of Cheese by those who ate Cheese.

per week. They ate more and more as they grew older, and boys and girls ate similar amounts. At 14 years the butter consumption had risen to 9 oz. per week, but thereafter the boys and men ate more than the girls and women at all ages. The youngest adult groups of both sexes show a sudden increase in consumption which is difficult to explain.

The children who ate most butter were a 15-year-old boy and a 14-year-old girl; they ate 23 and 31 oz. respectively during the experimental week, and the girl was eating half as much butter as bread. This high consumption of butter did not prevent these children eating other fat foods, and their total fat intakes were 249 and 176 g. per day respectively (see p. 93). The boy's diet provided him with 5,395 calories per day, more than any other diet in the whole investigation. The girl had 3,280 calories per day, well above the average for her age. The boy was both tall and heavy for his age; the girl was of average height but rather overweight. Six of the one-year-old children and one 18-year-old boy had no butter. The latter had margarine instead and ate $4\frac{1}{2}$ oz. during the week. Four other children, all boys, recorded having eaten margarine on bread.

Since the figures given above for butter refer only to the quantities spread on bread, an assessment can be made of the proportion of butter to bread that was eaten by children of different ages. The ratio fell from about 1 : 3 at the age of one year to 1 : 5 or 6 at the age of 13—in other words, the children had less

and less butter on their bread as they grew older. The girls' ratio, however, rose again very rapidly after 15 years. This was chiefly because of a decrease in bread consumption (Fig. 9) without a corresponding reduction in the amount of butter (Fig. 17). The boys continued to eat approximately the same proportion of bread to butter up to 18 years, and the consequent difference in the ratio for the older boys and girls was continued in adult life. Women ate more butter than men in proportion to their bread. This may have been because they spread the butter more lavishly, or because they ate less of their bread dry.

CHEESE

While milk and butter have increased in favour as foods for children during the past 100 years, and while the same may be true of cheese in Denmark and Holland, there is no doubt that in Great Britain the amount of cheese eaten by children nowadays is only a fraction of what it was a century or two ago. "Cheese is a kind of Food which Children are naturally fond of; and, if left to themselves will eat it to an immoderate degree" (Nelson, 1753). It was evidently considered desirable to restrain their appetites for it, for the same

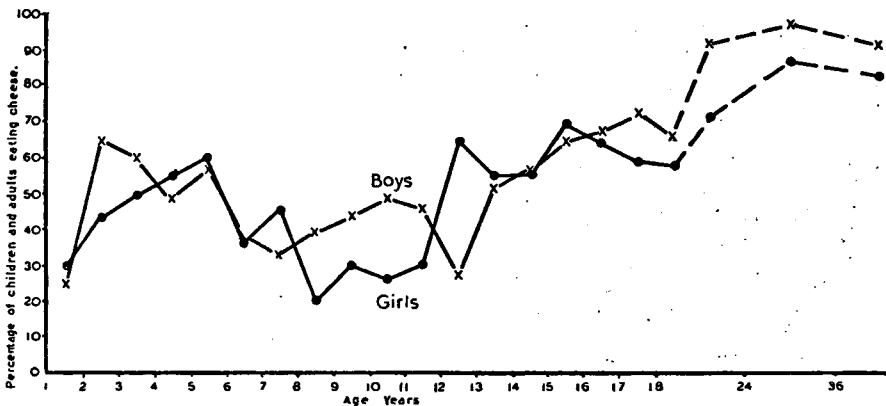


FIG. 18.—Percentage of Children of various ages and of Adults eating Cheese.

author advises "When Cheese comes in turn to the Meal it should be under great Restraint. Suppose, for Example a Child's Supper is to be Bread and Cheese, the Bread should most certainly be considered as the Meal; a very small quantity of Cheese to give it a Relish and convey it down, is all it ought to have. Cheese, tho' nutritious, should never be eat in large Quantity; it gives Children a restless, painful Fondness for what is relishing, and takes off their Appetite from more wholesome, simple diet". From a statement in "Tom Brown's Schooldays" it would appear that whey from the cheese vats was regarded as good for children in the early part of the last century, but not the curds, which were forbidden as unwholesome. A similar idea seems to have been in the minds of the authorities at the Foundling Hospital, for when the rules of the Hospital came up for revision in 1790 "with the idea of securing a more wholesome diet it was resolved that . . . the cheese allowance should be greatly reduced". Twelve years later the allowance was increased once again, and the dietary for 1810 included 4 oz. bread and 1 oz. cheese for supper every evening. By 1840, however, cheese seems to have disappeared from the diet (Nicholls and Wray, 1935).

Those responsible for arranging the dietary at the workhouse in Exeter (Vancouver, 1808) had no doubt about the value of cheese for children, for boys and girls between 12 and 15 years of age were given 1½ oz. of cheese every

evening. Younger children had 1-1½ oz., but they were allowed to exchange it for ½ oz. of butter if they so desired. Cheese was evidently a supper relish at Rugby in Dr. Arnold's day, and Dukes (1899) tells us that cheese was supplied at most schools in his time. The amounts eaten at Christ's Hospital in 1704 (½ lb. a week) and in 1838 (¾ lb. a week) provide a striking contrast to the quantities consumed by public school boys in 1936-39 (Widdowson and McCance, 1942a) or by all the children taking part in this investigation. In the first place, by no means all of our children ate cheese. Fig. 18 shows the percentage of the total number in each age group who took cheese during the week of study. This does not mean that none of the other children ever had cheese, but that they did not have it during this particular week. The graphs for boys and girls are very similar. About 25 per cent. of the one-year-old children ate cheese, and rather more than half the children between 2 and 5 years, but then the proportion fell again and remained low until 12 years, suggesting that the young children were given cheese as being good for them, but that they gave it up as soon as they were old enough to have some say in the matter. After 11 or 12 years the curves tended to rise and to continue to do so.

Fig. 17 shows the average amounts of cheese eaten by children of various ages who ate cheese. It will be seen that these children ate about 2 oz. a week till they were 14 years old, and boys and girls of 14 were having only a fraction more than boys and girls of one. As a general average, the weekly intakes would have been less than 1 oz. From 15 years onwards the boys and men always ate more cheese than the girls and women, but the greatest increase in cheese consumption occurred after 18 years, and then primarily in men. Even the 18 year old boys who actually ate cheese only had an average of 3½ oz. a week.

Nine children had 8 oz. or more of cheese a week. One of these was a vegetarian aged 4 years, and he ate 11½ oz. during the week. Further details about his diet will be found on p. 162. Only one other, a boy aged 17, took more cheese than this 4-year-old boy; he ate 13 oz.

EGGS

Thirty-three boys and 34 girls ate no eggs during the week of investigation. Eggs used in cooking are not considered here, as it was difficult in many cases to be certain whether they had been included in a cooked dish or not. All the rest had eggs, either boiled, fried, poached, scrambled or as omelette, and in all age groups both boys and girls ate an average of about 3 a week. Two 17-year-old boys ate 15, and an 18-year-old boy had 16. These three boys all weighed their food during the winter when home-produced eggs were at their scarcest. Two of them were public school boys home for their Christmas holidays, and the other a secondary school boy living in London. No girl had more than 9 eggs during the week.

Flesh foods

MEAT

We gained our reputation as a meat-eating nation in the 16th century, but meat was for a long time the prerogative of the rich, and the poor ate little or none. In most of the workhouses, at their inauguration in the beginning of the 18th century, meat was served 3 or 4 times a week (Eden, 1797). The poor children at the Parish School of Industry in Westminster in 1782 had 6 oz. of meat four times a week (Parish of St. James, Westminster, 1797); those at a

similar institution in Exeter a few years later were allowed 6 oz. twice a week (Vancouver, 1808). At Christ's Hospital in 1678, meat was evidently served four times a week (Friend, 1935), as it was a century later when Charles Lamb was there (Lamb, 1823). The allowance was very small, less than 3 oz. a week, and according to Lamb "the nurses used to carry away openly, in open platters, for their own tables, one out of two of every hot joint which the careful matron had been seeing scrupulously weighed out for our dinners". It is in fact quite clear from Lamb's essay that the boys never got enough to eat. On "leave" days they were turned out after a breakfast consisting of a quarter of a penny loaf and small beer to fend for themselves till supper. No wonder they envied the "cattle, the birds and the fishes at feed about us". In the early part of the 19th century, it appears that the meat was generally burned, for the children ate off flat slabs of wood—"the pretext for burning the meat being that as the children by the rules of the establishment were not allowed plates, if any gravy existed it would flow out, run over and mess the table". (*Lancet*, 1835). By 1838 meat was served on 5 days a week, and the boys got 4 oz. on each occasion. Between 1913 and 1933 they were supplied with 5-6 oz. of fresh meat a day.

Three girls and four boys taking part in the present investigation were strict lacto-vegetarians and ate no meat, bacon or fish of any kind. All the other children ate some meat, and Fig. 19 shows the average amounts which they

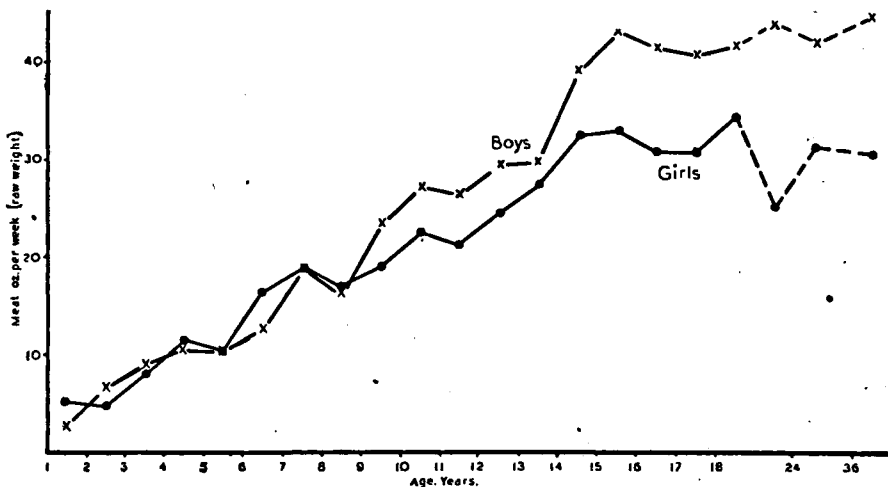


FIG. 19.—Average Consumption of Meat.

consumed. The results are expressed on a raw weight basis, and the figures include all types of butcher's meat, offal, rabbit, poultry and game, but not bacon. Up to the age of 8 the curves for boys and girls run together. Thereafter the boys and men always ate more than the girls and women, and from the age of 11 the differences in this respect between the sexes for each age group are statistically significant except with the 13-year-old children. By the age of 15 the boys were eating about 42 oz. of meat a week, or 6 oz. a day. The older girls ate about 32 oz. a week, or $4\frac{1}{2}$ oz. a day. The maximum and minimum intakes, and the standard deviations and coefficients of variation are shown in Tables XXII and XXIII. One London boy of 17 years of age ate 96 oz. of meat during the week. No one had more than this, but several other boys had nearly as much. No girl had more than 63 oz.

Generally speaking, about three-quarters of the meat eaten was butcher's meat. The remaining quarter was made up of meat in sausages, offal, rabbit, chicken, and, very occasionally, game. Fifty-three per cent. of the boys and 51 per cent. of the girls had sausages at some time or other during the week. The most usual form of offal was liver. Twenty-seven per cent. of the boys and 25 per cent. of the girls ate it, and, as will be seen later (p.128), the amount of vitamin A in the diet depended to a large extent upon whether liver was eaten or not.

TABLE XXII
Boys' Meat Intakes
(oz. per week. Raw weight)

<i>Age group</i>	<i>Average intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	2.4	17.3	0.0	6.7	280
2	6.4	21.0	0.0	5.7	89
3	9.2	19.8	0.0	5.2	57
4	10.3	27.6	0.0	7.3	71
5	10.1	24.5	0.0	6.4	64
6	12.3	28.2	0.0	6.5	53
7	18.7	36.6	4.0	8.8	47
8	16.7	35.1	7.5	6.2	37
9	23.3	48.3	10.5	9.2	40
10	27.2	59.0	3.0	14.6	54
11	26.2	55.5	8.3	11.4	44
12	29.6	64.2	9.5	14.7	50
13	29.9	87.5	11.5	15.3	51
14	38.6	77.5	14.9	14.5	38
15	42.8	73.7	19.4	13.3	31
16	41.2	77.1	10.0	13.7	33
17	40.2	96.5	8.4	19.3	48
18	41.7	71.2	25.8	9.1	22

TABLE XXIII
Girls' Meat Intakes
(oz. per week. Raw weight)

<i>Age group</i>	<i>Average intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	5.4	22.1	0.0	6.3	116
2	4.8	11.6	0.0	3.2	67
3	8.1	19.5	0.0	5.3	66
4	11.2	34.7	0.0	6.7	60
5	10.2	21.7	0.0	5.7	56
6	16.3	27.5	7.3	6.2	38
7	18.4	33.6	0.0	9.6	52
8	16.9	26.3	9.7	5.5	32
9	19.0	34.2	0.0	7.1	38
10	22.3	51.3	11.6	8.8	40
11	21.3	42.0	7.4	7.8	36
12	24.2	51.0	6.3	10.5	43
13	27.8	55.2	10.5	11.4	41
14	32.2	63.0	12.6	11.8	36
15	32.5	53.6	5.0	10.6	32
16	30.4	59.0	7.4	9.7	32
17	30.8	58.0	7.4	12.2	40
18	34.0	56.7	0.0	12.9	38

BACON

Bacon was well known in England in the time of Chaucer, and it has remained a popular food ever since. Children living at home have probably always eaten it, for it could often be obtained even when meat could not. In boarding schools and similar institutions, however, breakfast has usually consisted of porridge or bread and butter, or in the 18th and early part of the 19th centuries, of bread and broth (Parish of St. James, Westminster, 1797; Vancouver, 1808), and bacon does not appear to have been used until the present century.

Not all the children taking part in the present investigation ate bacon. At the age of one year about 20 per cent. of them had it. The proportion increased to 50 per cent. at two years, and it remained at 50-70 per cent. until 13 years. From 14 to 18 years, 90 per cent. of the boys had it and 75 per cent. of the girls.

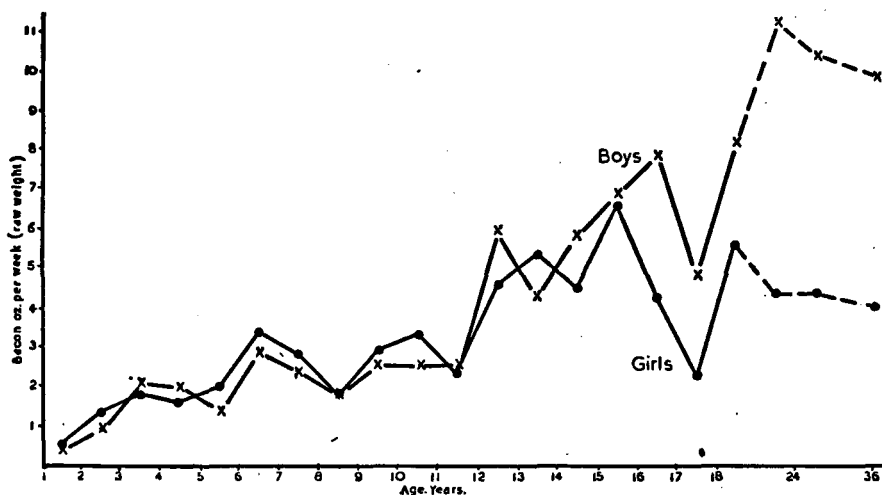


FIG. 20.—Average Consumption of Bacon.
(Those who ate no bacon have been included.)

Fig. 20 shows the average amounts of bacon, expressed on a raw weight basis, eaten by children of various ages. Up to 11 years boys and girls ate approximately the same amounts, and their average intakes at this age were about 2-3 oz. a week. During the next few years the bacon consumption increased rapidly. The curious drop at 17 years is due to the fact that, presumably by chance, only two-thirds of the boys and less than two-thirds of the girls ate bacon. The mean intake of those who ate bacon was only slightly lower than it was at 16 years.

Young adult males ate more bacon than those in any of the other age groups, but men of all ages were eating $2\frac{1}{2}$ times as much as women of corresponding ages. The largest intake recorded in the present investigation was that of a 15-year-old boy. He had fried rashers equivalent to 7 oz. of raw bacon on each of 6 mornings for breakfast, making a total of 42 oz. during the week.

FISH

"Fish is a sort of Diet extremely improper for Children. I would recommend to Parents never to let a Child so much as taste it for the first seven years at least". So wrote Dr. Nelson in 1753. It was not until about 1850 that methods

of storing fish in ice and improved railroad communications enabled fresh fish to be obtained at any distance from the coast. According to Hughes (1857), tea at the School House in Arnold's day was usually brightened by a herring, sprats or something of the sort. Before that time salted and pickled herrings had been popular in England, but any "fresh" fish that reached inland towns was usually rotten before it was sold. There was, therefore, probably some justification for Dr. Nelson's advice.

Above the age of one year 80-90 per cent. of the children of all ages taking part in the present investigation ate some fish. Fig. 21 shows the average weekly

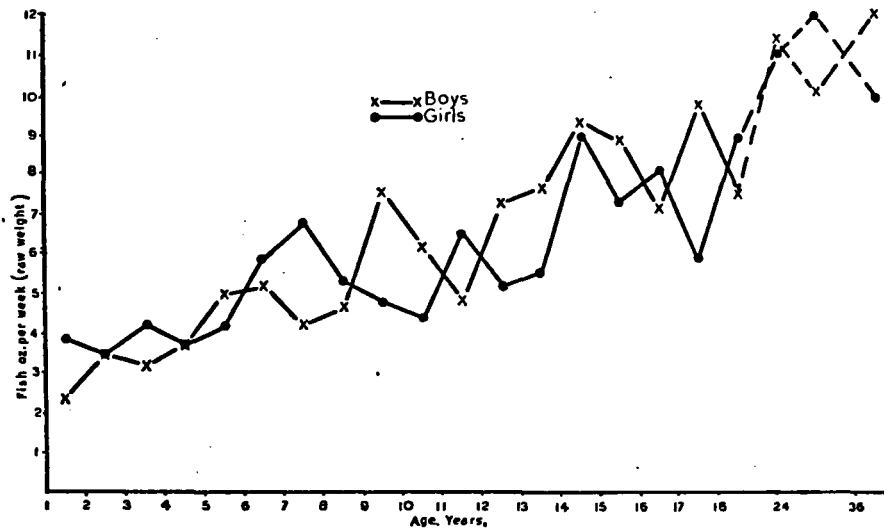


FIG. 21.—Average Consumption of Fish.
(Those who ate no fish have been included.)

intakes. Fish is one of the few foods that was eaten in approximately equal amounts by the two sexes, and this observation on the children is confirmed by results previously obtained for men and women. The curve for fish is rather irregular. The younger children ate about $3\frac{1}{2}$ oz. a week. The amount gradually increased until, at the age of eighteen, 8 or 9 oz. a week were being eaten.

Fried fish was much more popular than boiled, steamed, grilled or baked fish. Fifteen per cent. of the boys and 10 per cent. of the girls had tinned sardines, and 7 per cent. of the boys and 10 per cent. of the girls had tinned salmon. The probability is that most of the children would have eaten tinned fish at some time in the course of a year.

Twenty-six oz. during the week was the highest amount of fish recorded, and this was eaten by a 15-year-old girl, the daughter of a florist in Preston, Lancs. She had fresh plaice, cod, gurnet, hake, herring, tinned salmon and sardines, and these were all eaten either for dinner or high tea.

PASTES AND EXTRACTS

Twenty-six boys and 41 girls had meat paste, and 52 boys and 57 girls had fish paste during their week of food weighing. The amounts eaten were very small, and in most instances they contributed little to the diet. Kipper and bloater paste, however, were probably quite good sources of vitamin D.

Fifteen boys and 10 girls recorded having "Bovril", and 10 boys and 7 girls had "Oxo". It is probable that other children had similar extracts in soups, stews and gravies without being aware of the fact, and so did not mention them by name.

Fruit

An apple a day may keep doctors away, but it was not until the discovery of vitamin C in the present century that the particular dietary function of fruit could be assessed. In the olden days fruit was rarely eaten except during the brief season when it was ripening on the trees. It was very expensive in the towns, and was under a certain disrepute because it was thought to cause fevers. Up to the seventeenth century the only common fruits were apples, plums, cherries and berries from the hedgerows. Many other varieties, pears, apricots, quinces, grapes and strawberries were cultivated in gardens, but most people probably never saw them. Oranges and lemons began to be imported in the 17th century, but it was not until the 18th century that they arrived on any significant scale.

Views on the value of fruit in the 18th century were somewhat divergent. Some doctors still believed in the old theory that fruit was harmful. Others, like William Smith (1776), were more enlightened. He said that fruit was "the lightest, most wholesome food we can eat". Nelson (1753) recommended that it should be given to children, but with great caution. "Children should not be debarred Fruit; but the use of it requires some Attention; 1st, It should always be good in its kind, and ripe. 2dly, Regard is to be had what Sort agrees, and what disagrees. 3dly, some Limitations as to Quantity — Fruit gives some a pain at the Stomach, others not; Apples, Currants and those Kinds, which tho' ripe, have still a degree of Acidity in them, usually agree best. Pears and Plumbs, especially the Orleans Plumb, have a Tendency to bring on Purgings, which sometimes terminate in a Bloody Flux and Death, and therefore should be given to Children with great Caution".

As early as the 17th century the boys at Christ's Hospital were evidently sometimes able to get fruit at their tuck-shop, for in 1684 "Mr. Bennett Smith, and Mr. Court, translator to this House, both living within the bounds of this house, did daily practice" the selling of "drink, bread and fruit within the bounds . . . to the children, as if they had not enough allowed them for their daily subsistence". In 1700 a beadle pleaded for "the same liberty his predecessor had had for his wife to sell apples, gingerbread and other small things at their door". This custom was frowned upon by the Governors, who did their best to put a stop to it. They contended that it was prejudicial to the children's health, but in 1799 the tuck trade became official (Pearce, 1908). It is unlikely that children at most boarding schools in the 19th Century were provided with raw fruit as part of their ordinary diet, though Dukes (1899) sets out the dietary of one boys' public school "where I know the boys are fed according to my ideal of what should be", and this included 15 oz. of fresh fruit a week. Any fruit that the majority of children obtained, however, was an extra sent from home or bought at the school tuck shop.

The present century has seen an enormous increase in the amount of fruit eaten. The *per caput* fruit consumption over the whole country in 1934-35 was nearly double what it had been during the years before the first World War (Orr, 1936). The present investigation was carried out when fruit consumption was probably at its maximum, before the outbreak of hostilities prevented the importation of fruit from abroad.

RAW FRUIT

All but 15 of the children taking part in this investigation had some raw fruit. Table XXIV shows the number of children eating the different kinds.

TABLE XXIV
Number of Children eating different kinds of Raw Fruit

	Boys	Girls
Total number	435	481
Number eating:—		
Apples	342	402
Oranges	299	345
Bananas	290	331
Pears	66	82
Grapefruit	64	77
Grapes	64	60
Dates	54	38
Fresh fruit salad	54	36
Raisins	37	31
Lemon juice	32	22
Strawberries	13	22
Figs	13	4
Cherries	9	9
Raspberries	9	6
Plums	7	15
Peaches	4	8
Pineapple	4	5
Prunes	4	2
Sultanas	3	4
Melon	2	3
Apricots	2	2
Blackberries	2	2
Gooseberries	2	1
Currants, dried	2	0
Currants, red	1	0
Greengages	0	1
Loganberries	1	0
Nectarines	1	0
Olives	1	0
Passion Fruit	1	1
Pomegranate	0	1

Apples head the list, followed closely by oranges and bananas. In the years before the war these fruits were not seasonal in the ordinary sense, and were available practically all the year round, for even the apples were mostly imported. Oranges appeared to be rather more frequently eaten by the younger than by the older age groups, but apples and bananas were equally popular at all ages. On the other hand, more of the older than of the younger children ate grapefruit. It may seem surprising that so few children ate any of the ordinary home-grown fruits, such as plums, strawberries, raspberries and cherries. This is no doubt partly because these fruits have a short season, and also because fewer children weighed their food during the summer than during the winter months (see Table VI). Even at the height of the English fruit season, oranges and bananas appeared to have been preferred, or to have been more easily acquired, than plums, strawberries and raspberries. Fig. 22 shows the average amounts of fresh fruit eaten in the various age groups. Boys and girls of all ages up to 16 ate about 3-4 oz. a day. The older boys and the men ate a little more than the girls and women. There was a wide individual variation in the amount of raw fruit eaten. One boy of two for example, who lived in Jersey, had nearly $\frac{1}{2}$ lb. of oranges and $\frac{1}{2}$ lb. of apples a day, and in fact he had more raw fruit than any other boy. Another two-year-old boy had none at all. A girl of nine had an average of 21 oz. a day, but she was a vegetarian, and she weighed

her food during August. Her breakfast and supper always consisted of home grown fruit and milk. She was one of the outstanding exceptions to the generalization, which has just been made, that little home grown fruit was eaten.

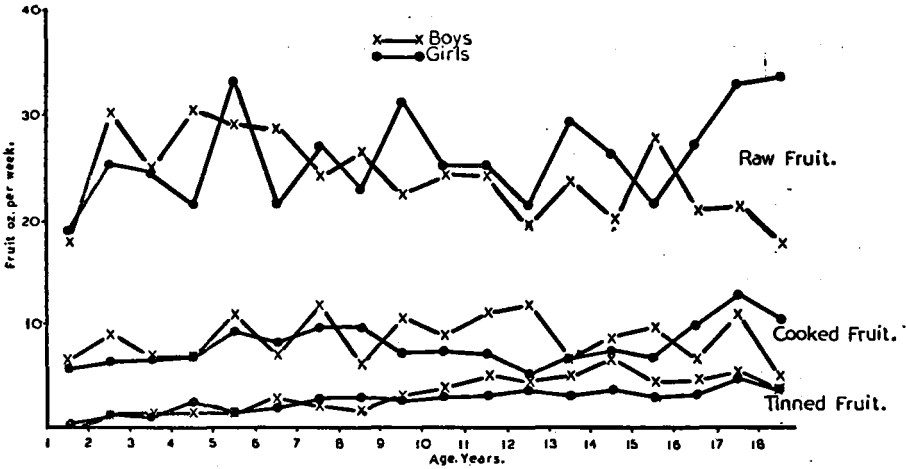


FIG. 22.—Average Consumption of Fruit.

Fig. 23 shows the frequency distribution of the consumption of raw fruit, taking all age groups together. Most children had between 1 and 4 oz. a day. Forty-five boys and 32 girls had less than 1 oz., and 56 boys and 58 girls had more than 6 oz.

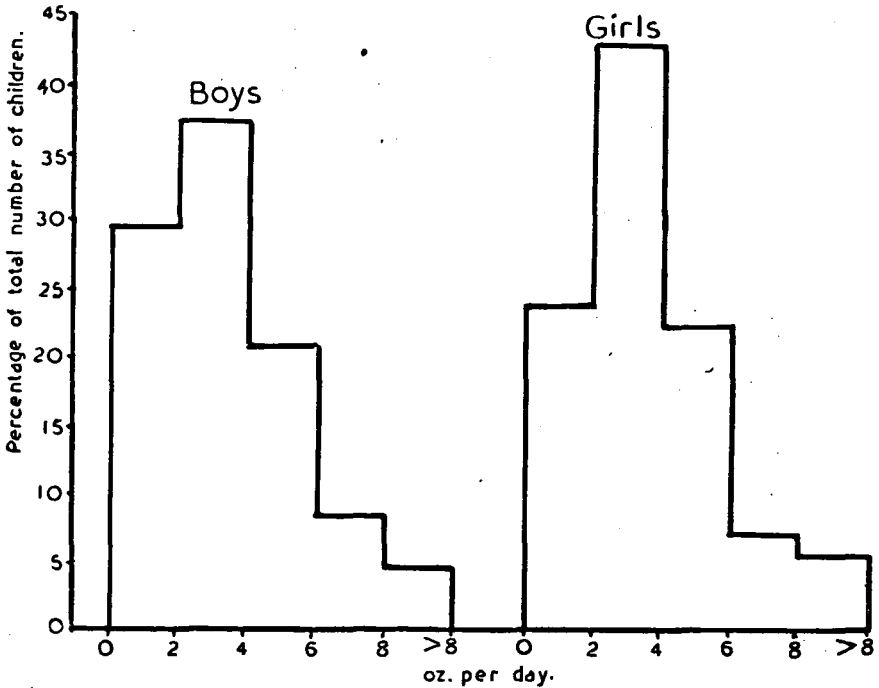


FIG. 23.—Frequency Distribution of Consumption of Raw Fruit.

Since most of the fruit which the children ate was imported, it is not surprising that season made little difference to their fruit consumption. Table XXV shows the average amounts of raw fruit eaten by children who weighed their

TABLE XXV
Seasonal Variation in the Consumption of Raw Fruit

							<i>Boys. Average oz. per day</i>	<i>Girls. Average oz. per day</i>
January	..	..	..	..	..	..	3.2	3.6
February	..	..	..	..	..	..	3.2	3.8
March	..	..	..	..	..	..	3.1	3.6
April	..	..	..	..	..	..	4.3	4.1
May	..	..	..	..	..	..	3.3	3.2
June	..	..	..	..	..	..	3.7	3.8
July	..	..	..	..	..	..	3.8	4.1
August	..	..	..	..	..	..	—	—
September	..	..	..	..	..	..	3.4	3.4
October	..	..	..	..	..	..	3.6	3.8
November	..	..	..	..	..	..	3.1	3.0
December	..	..	..	..	..	..	2.7	3.1

Notes.—The number of children who weighed their food in August was too small to provide a satisfactory average.

food during the different months of the year, and it is clear that there is little or no seasonal variation—in fact, most fruit was eaten during April when there is no English fruit available at all.

COOKED FRUIT

Apples again were the most popular fruit (Table XXVI). Prunes came next, but these were eaten by less than half as many children. Rhubarb has

TABLE XXVI
Number of Children eating different kinds of Cooked Fruit

							<i>Boys</i>	<i>Girls</i>
Total number	..	..	..	..	..	..	435	481
Number eating:—								
Apples	..	..	..	..	..	..	279	292
Prunes	..	..	..	..	..	..	109	103
Rhubarb	..	..	..	..	..	..	63	90
Plums	..	..	..	..	..	..	33	48
Dried apricots	..	..	..	..	..	..	27	35
Gooseberries	..	..	..	..	..	..	20	37
Pears	..	..	..	..	..	..	26	28
Dried figs	..	..	..	..	..	..	28	18
Blackberries	..	..	..	..	..	..	21	23
Dried fruit salad	..	..	..	..	..	..	15	23
Currants, black	..	..	..	..	..	..	12	10
Damsons	..	..	..	..	..	..	8	9
Cherries	..	..	..	..	..	..	4	11
Raspberries	..	..	..	..	..	..	6	5
Currants, red	..	..	..	..	..	..	7	2
Loganberries	..	..	..	..	..	..	5	1
Cranberries	..	..	..	..	..	..	2	2
Greengages	..	..	..	..	..	..	1	2
Nectarines	..	..	..	..	..	..	1	1
Bilberries	..	..	..	..	..	..	0	2
Dried Peaches	..	..	..	..	..	..	0	1

been included here for convenience, and is third on the list—in fact, almost every child whose food was weighed during the rhubarb season had some. More children ate plums cooked than ate them raw. Next to prunes, apricots were the favourite dried fruit. Fig 22 shows the average amounts of cooked fruit

that the children ate and it will be seen that these amounts, like those of raw fruit, remained approximately the same at all ages; the older boys and girls ate about the same amount as the younger ones. Seven and a half per cent. of the total amount of cooked fruit eaten by the boys was rhubarb, and rhubarb formed 11·7 per cent. of that eaten by the girls.

Forty boys and 35 girls had no cooked fruit at all. One boy, of 12 who weighed his food in September ate 56 oz. during the week. These were mostly pears grown in his grandmother's garden.

TINNED FRUIT

The frequency with which different varieties of tinned fruit appeared in the diets will be gathered from Table XXVII. Pineapple was the most popular

TABLE XXVII
Number of Children eating different kinds of Tinned Fruit

	Boys	Girls
Total number	435	481
Total number eating tinned fruit	185	200
Number eating:—		
Pineapple	50	75
Peaches	48	52
Fruit Salad	56	29
Apricots	27	35
Pears	24	28
Oranges	11	25
Grapefruit	12	12
Loganberries	13	6
Raspberries	4	10
Plums	3	8
Strawberries	3	2
Gooseberries	1	4
Cherries	2	2
Damsons	0	2
Youngberries	0	1
Greengages	0	1

among the girls, with peaches second. Pineapple, peaches and fruit salad were eaten by approximately equal numbers of boys. In all, 185 boys and 200 girls ate tinned fruit, and some ate very large amounts. Forty-four and a half ounces during the week was the highest quantity recorded—the amount eaten by a 14-year-old boy. A 15-year-old girl had 42 oz. The average amounts eaten are shown in Fig. 22. The values have been obtained by dividing the sum of the intakes by the total number of children in each age group, and not by those who ate tinned fruit, so that the relative amounts of tinned and of home-cooked fruit that were eaten can be compared.

It is surprising how rarely home-bottled fruit was mentioned—in fact, only two children recorded having had it. Little home-grown fruit was eaten out of season, unless it came out of a tin.

NUTS

Thirty-two boys and 41 girls ate nuts, but the amounts eaten were very small. The average weight of nuts eaten by all children who ate nuts was just under 1 oz. a week. Clearly nuts do not contribute much to the nutrition of British children.

Vegetables

It was not until the 18th century that the practice of eating vegetables with meat became widespread. They were then grown in market gardens round most of the towns, and were very cheap during the first half of the century. Potatoes, carrots, turnips and sprouts were coming into daily use. In the Bristol workhouse, which was opened in 1696, and where 100 girls were

accommodated "we . . . appointed their diets to be made up of such provisions as were very wholesome, afforded good nourishment, and were not costly in price (viz.), beef, pease, potatoes, broath, pease-porridge, milk-porridge, bread and cheese, good bear (such as we drank at our own tables), cabbage, carrots, turnips, etc., in which we took the advice of our physician and bought the best of every sort. . . . We soon found the effect of their change of living. Nature, being well supported, threw out a great deal of foulness, so that we had generally 20 down at a time in the meazles, smallpox, and other distempers; but by the care of our physician, and the blessing of God on his endeavours, we never buried but two". (Quoted by Eden, 1797.) Vegetables are not mentioned in the Christ's Hospital dietary in 1704 (Friend, 1935). In 1762 green and root vegetables were introduced into the dietary of the children at the Foundling Hospital, but in 1840 all except potatoes seem to have been cut out of the diet (Nicholls and Wray, 1935). They were lacking even at the more expensive schools, for John Hanway advocated their introduction at Winchester in 1757 (Drummond and Wilbraham, 1939). During the next century also, no vegetable but the potato seems commonly to have been served, and Coletidge, who spent his schooldays at Christ's Hospital, wrote that "our appetites were damped, never satisfied, and we had no vegetables". (Pearce, 1908.) In the course of the famous inquiry into the prevalence of ringworm at Christ's Hospital in 1829, and the lively controversy which arose over it in 1834 (*Lancet*, 1834), it came to light that "meat is served up with vegetables only about sixty-four days in the year".

POTATOES

"The staple vegetable in this country is the potato, and it is the one of greatest value to the young because they *will* eat it" (Dukes, 1899). The dietary at Christ's Hospital prior to 1838 included 1 lb. of potatoes a week. In 1838 the allowance was increased to 2 lb., and, after bread, potatoes seem to have been the great feature of boarding school diets in the latter half of the 19th century. At the good boarding school referred to by Dukes (1899) the allowance was 59 oz. a week to boys 14-19 years of age. At Rugby in Dr. Arnold's day, baked potatoes were evidently regarded as a favourite form of "tuck". East said to Tom Brown on his first day at school—"You come along down to Sally Harrowell's; that's our School-House tuckshop. She bakes such stunning murphies, we'll have a penn'orth each for tea. Come along or they'll all be gone."

Three of the one-year-old children whose food was weighed for the present inquiry had no potato and two public school boys, aged 14 and 15, ate none. The first of these weighed his food while he was home for his Easter holidays, the second during the summer term at school. The former ate more sugar than any other child in the whole investigation (p. 53), and he also did himself well over cakes, buns and biscuits. Both had considerably more meat than the average amount for their age, but they both ate less bread. Potato was eaten by all the other children and the average daily intakes are shown in Fig. 24. At one year about 1½ oz. a day were eaten. The curves for boys and girls run parallel and close together up to the age of 6, when the average intake was 2.5 oz. a day. From that age onwards the boys ate more than the girls; at 16 years, they were having nearly 6 oz. a day, whereas the girls never took more than 5 oz. a day, and at 17 years their curve shows a sharp decline till, in the "over 36-year-old" group (Widdowson and McCance, 1936), the mean intake had fallen to 2 oz. a day.

These average intakes, particularly of the older boys, are surprisingly small, and had this survey been made during the war, they would undoubtedly have been considerably higher. One 17-year-old boy had 12.7 oz. a day, one boy and one girl had just over 10 oz. All the rest had less. The proportion of the

total calories derived from potatoes is discussed on p. 60. Boiled potatoes were eaten by all except five of the 911 children eating potatoes (Table XXVIII). Fried, baked, chipped and roast potatoes were approximately equally popular, but only 22 children ate potato crisps.

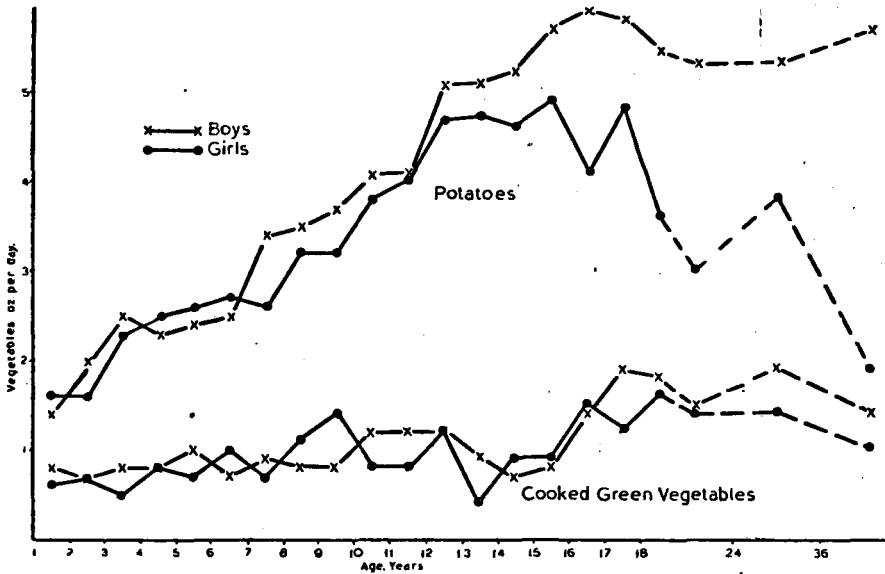


FIG. 24.—Average Consumption of Vegetables.

TABLE XXVIII

Number of Children eating Potatoes cooked in Various Ways

	Boys	Girls
Total number	435	481
Total number eating potatoes	433	478
Number eating potatoes:—		
Boiled	431	475
Baked	99	105
Fried	101	91
Chipped	87	111
Roast	73	108
" Crisps "	10	12

GREEN VEGETABLES

Children, as a rule, are said to dislike green vegetables (Le Gros Clark, 1942), but 84 per cent. of our children ate them, though the amounts they ate were small. Cabbage was the most frequently recorded (Table XXIX), but it is

TABLE XXIX

Number of Children eating different kinds of Cooked green and stem Vegetables

	Boys	Girls
Total number	435	481
Number eating:—		
Cabbage	206	205
Cauliflower	137	139
Brussels Sprouts	125	126
"Greens"	114	121
Spinach	35	42
Celery	13	10
Asparagus	1	7
Sea-kale	1	0

fairly certain that "greens" were sometimes referred to as cabbage, and cabbage as "greens". The figures for spinach call for some comment, for spinach was decidedly a food of the younger rather than of the older children. Thus, of the 267 children aged 6 years and less, 17 per cent. ate spinach. Only 5 per cent. of the 649 over 6 years appear to have had it. It seems to be generally considered by paediatricians and others responsible for the welfare of young children that spinach is a particularly valuable food (see Parsons and Barling, 1933). Admittedly it is an excellent source of carotene, vitamin C and iron, but spinach contains more oxalic acid than any other food (Kohman, 1939), and it is well known that the calcium in it is quite unavailable (Bonner, Hummel, Bates, Horton, Hunscher and Macy, 1938). Davis (1930), in her interesting study of the foods that newly-weaned children chose to eat, found that spinach was always very unpopular, and the present investigation bears this out. It is suggested that many of the younger children were eating it because they were made to do so by well-meaning but misguided mothers.

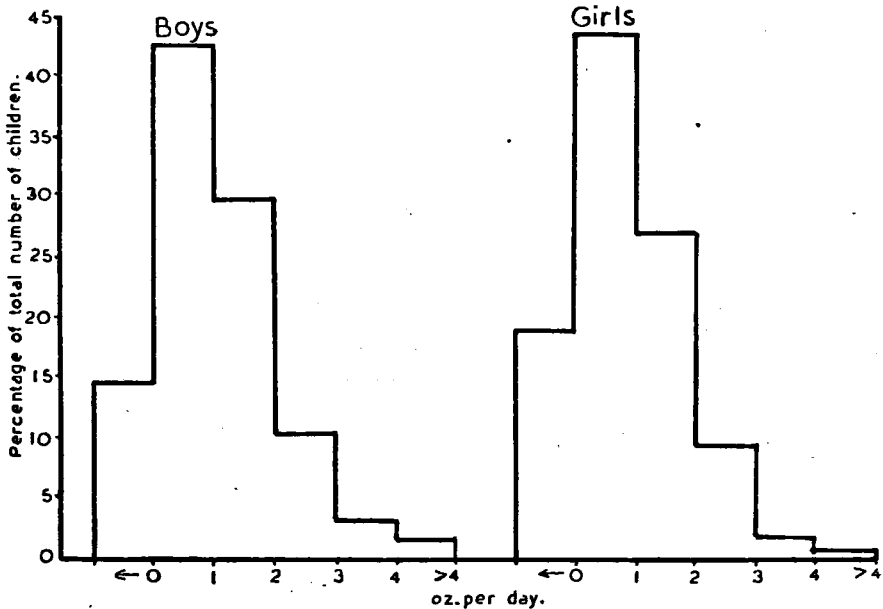


FIG. 25.—Frequency Distribution of Consumption of Cooked Green Vegetables.

The average amounts of cooked green vegetables which were eaten is shown in Fig. 24. Boys and girls ate little more than 1 oz. a day until they were 16 years old. The mean consumption then rose slightly to $1\frac{1}{2}$ oz. and remained at that level till in the oldest adult age group it fell slightly. Fig. 25 shows the frequency distribution of the green vegetable consumption. Most children ate less than 2 oz. a day. Only 7 boys and 4 girls had more than 4 oz.

ROOT VEGETABLES

Many more children ate carrots than any other root vegetable (Table XXX), and in fact carrots were recorded more frequently than any vegetable except potatoes. The explanation no doubt is that carrots were available for most of the year, whereas turnips and parsnips were not. Boys and girls of all ages ate approximately the same amount of root vegetables, and the average for all age groups was about 0.4 oz. a day.

TABLE XXX

Number of Children eating different kinds of Root Vegetables

	Boys	Girls
Total number	435	481
Number eating :—		
Carrots	226	271
Onions	127	147
Beetroot	71	60
Turnips	37	57
Parsnips	38	27
Swedes	15	8
Leeks	6	8
Artichokes	2 ^a	5

LEGUMES

Lamb (1823) speaks of "pease soup—coarse and choking", and split peas were evidently provided at Christ's Hospital even before his time (Friend, 1935). It was found impossible always to differentiate between fresh, dried and tinned peas in the present investigation, so these have all been included together. Peas were the most frequently eaten of the legumes, with tinned baked beans coming second (Table XXXI). Runner and French beans have

TABLE XXXI

Number of Children eating different kinds of Legumes and of Miscellaneous Cooked Vegetables

	Boys	Girls
Total number	435	481
Number eating :—		
Peas, fresh, tinned and dried	128	179
Beans, baked	72	72
Beans, runner or French	44	43
Beans, butter	32	27
Lentils	14	16
Beans, haricot	10	15
Beans, broad	10	3
<hr/>		
Tomatoes	112	136
Mushrooms	14	10
Marrow	5	13
Sweet corn	2	3

been included here for convenience, and they were eaten by most children who weighed their food during the season in which they were available. Of the dried beans, butter beans were more commonly eaten than haricot beans. Very few of the children ever had broad beans, and their short season is no doubt the explanation. The average consumption of legumes (as cooked, and excluding runner and French beans) was less than 1 oz. a week up to the age of 5. Then it rose gradually, and children of 11 years old and upwards were eating about 3½ oz. weekly. Many children had none, and the average over the whole number is considerably reduced by these.

MISCELLANEOUS COOKED VEGETABLES

About a quarter of the children had fried tomato, usually for breakfast. Mushrooms, marrow and sweet corn were eaten by very few (Table XXXI), but this is no reflection on their suitability or popularity as foods for children, for mushrooms were always expensive and the other two are on sale only for a short time each year.

RAW VEGETABLES

More children ate tomatoes raw than cooked (Table XXXII). Two hundred and three boys and 230 girls had some kind of raw green salad, and the average

TABLE XXXII

Number of Children eating various kinds of Raw Vegetables

	Boys	Girls
Total number	435	481
Number eating:—		
Tomatoes	186	192
Lettuce	104	117
"Salad"	78	73
Celery	48	44
Watercress	44	46
Cucumber	23	40
Carrots	25	22
Mustard and cress	11	30
Spring onions	9	9
Radishes	7	6
Cabbage	7	4
Peas	3	2
Beetroot	2	1
Cauliflower	1	2
Swedes	1	1

consumption at all ages above one year was of the order of 2 oz. a week. Lettuce was the most usual raw vegetable; of the others, watercress and celery were about equally popular. Four times as many children ate celery raw as ate it cooked, but carrots were 10 times as frequently eaten cooked as raw.

Sugar, preserves and sweets

SUGAR

Of the total amount of sugar eaten by the children taking part in this investigation, about one-third was recorded as "sugar" and was taken in tea and other beverages, or sprinkled on breakfast cereals or on puddings or stewed

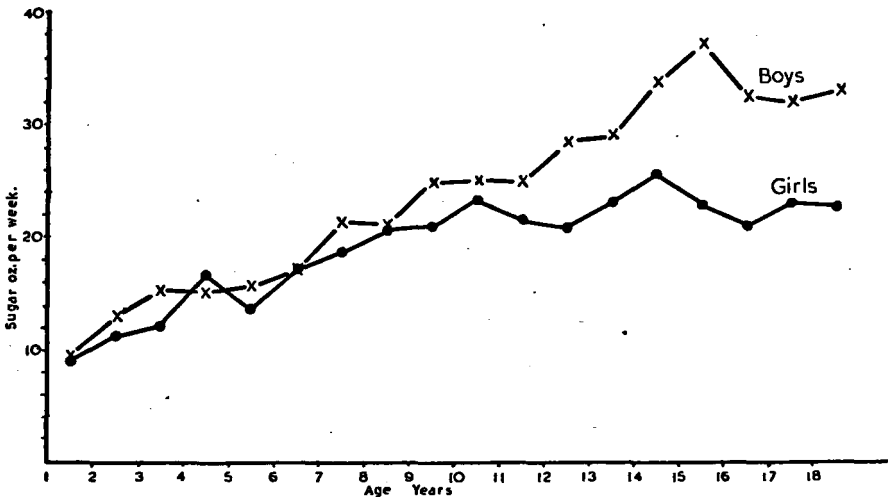


FIG. 26.—Average Total Consumption of Sugar.

fruit. The remainder was eaten in sweets and chocolate, jam and other preserves, cakes, biscuits, puddings and cooked fruit. Fig. 26 shows the intakes of sugar derived from all these sources. All the children ate sugar, and at 9 years of age boys were beginning to eat more than girls; at 15 they were eating nearly twice

as much. One 14-year-old boy, home from a public school for his Easter holidays, managed to get through $3\frac{1}{4}$ lb. during the week, or nearly $\frac{1}{2}$ lb. a day. He was one of the two boys who ate no potatoes. Tables XXXIII and XXXIV

TABLE XXXIII
Average amounts of Sugar which Boys derived from various Sources
(oz. per week)

Age group	Sugar taken as such	In sweets and chocolate	In jam etc.	In cakes and biscuits	In puddings	In cooked fruit	Total
1	3.8	0.5	0.7	1.2	2.2	1.2	9.6
2	4.4	1.8	1.8	1.1	2.4	1.8	13.3
3	4.9	2.9	1.8	1.9	2.4	1.4	15.3
4	4.5	2.3	2.0	2.2	2.8	1.5	15.3
5	3.4	2.2	3.2	2.2	2.9	2.2	16.1
6	4.7	2.7	2.3	2.5	3.4	1.8	17.4
7	6.4	3.2	3.1	3.5	3.0	2.5	21.7
8	7.0	3.4	3.4	3.4	2.8	1.3	21.3
9	6.7	3.6	4.9	4.2	3.5	2.3	25.2
10	6.6	5.0	4.5	4.2	2.5	2.2	25.0
11	7.7	3.2	4.0	3.8	3.0	3.2	24.9
12	9.6	4.0	4.4	4.7	2.9	2.9	28.5
13	9.1	4.8	4.9	4.8	3.7	2.0	29.3
14	11.3	5.1	6.2	5.0	3.8	2.6	34.0
15	13.6	7.3	4.9	6.4	3.1	2.4	37.7
16	14.1	4.1	3.6	5.5	3.2	2.0	32.5
17	8.3	6.1	5.2	6.4	3.2	2.9	32.1
18	11.9	5.1	5.1	6.0	3.6	1.5	33.2

TABLE XXXIV
Average amounts of Sugar which Girls derived from various Sources
(oz. per week)

Age group	Sugar taken as such	In sweets and chocolate	In jam, etc.	In cakes and biscuits	In puddings	In cooked fruit	Total
1	3.9	0.4	0.6	1.0	2.3	1.1	9.3
2	4.0	2.0	1.6	1.8	2.6	1.4	13.4
3	2.9	1.8	1.4	1.8	2.7	1.4	12.0
4	4.1	3.0	2.1	2.7	3.1	1.6	16.6
5	3.0	2.2	2.0	2.4	2.4	1.9	13.9
6	4.1	3.5	2.2	3.2	2.6	1.8	17.4
7	5.1	3.6	2.5	3.1	1.9	2.2	18.4
8	5.5	3.4	3.8	3.5	3.3	2.2	21.7
9	5.7	4.5	2.4	4.2	2.3	1.7	20.8
10	7.7	3.7	3.5	4.1	2.6	1.8	23.4
11	6.6	3.2	4.0	3.9	2.5	1.8	22.0
12	8.1	3.2	2.1	4.1	2.0	1.5	21.0
13	7.9	3.8	1.8	5.6	2.4	1.6	23.1
14	8.1	4.1	3.5	4.9	3.5	1.9	26.0
15	5.9	3.9	3.2	5.2	2.8	1.7	22.7
16	4.4	4.3	2.5	4.8	3.0	2.3	21.3
17	5.5	3.4	2.9	5.9	2.4	3.0	23.1
18	4.3	3.3	4.2	5.6	2.9	2.4	22.7

show the ways in which the boys and girls tended to eat their sugar. The older boys seem to have had a greater fondness for sweet things than the girls, and the amount of sugar they took in addition to what was used in cooking was considerably higher—in fact, boys of 15–18 years ate more than twice as much as girls of similar ages.

PRESERVES

"Jam to-morrow and jam yesterday—but never jam to-day" was certainly not the rule for most of our boys and girls. Fig. 27 shows the total amounts of preserves that they ate. Both curves are rather irregular because individual variations in jam consumption were sometimes enormous. The intake of the girls did not continue to rise after they had reached the age of eight, but that of the boys did so and, at 14 years, it was roughly twice as great as that of the girls. It was not by any means true to say that a big jam-eater was necessarily a big bread-eater. One 13-year-old boy who ate 95 oz. of bread during the week, had no jam at all. He was the son of a chef, and came from a poorer home than most of the children. He usually began the day with fried bread, with or without an egg. He had dinner at midday and ate 3 or 4 oz. of bread with it, and his tea consisted of bread with which he ate fried fish or fish-cakes. In contrast to him another 13-year-old boy, who ate but 29 oz. of bread, disposed also of 29 oz. of preserves. He was a public school boy home for his Easter holidays and he

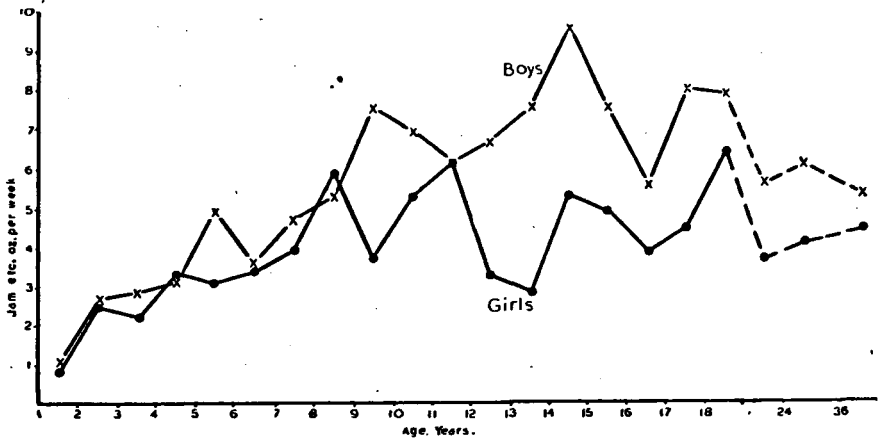


FIG. 27.—Average Consumption of Jam, Marmalade, Syrup and Honey.

was doing himself rather well on about 3,100 calories per day. His tea one day consisted of: honey with comb, $3\frac{1}{4}$ oz.; bread, $1\frac{1}{2}$ oz., and butter, $\frac{1}{2}$ oz. He washed this down with $5\frac{1}{2}$ oz. of Grade A milk, and finished up with $\frac{3}{4}$ oz. of milk chocolate. Jam tarts were a very popular form of food, and they accounted for a significant proportion of the jam that was eaten. A 14-year-old girl was responsible for the highest intake of preserves. She had 36 oz. during the week, as either marmalade for breakfast or jam for tea. An 18-year-old boy had 35 oz.

Table XXXV shows that more children ate jam than any other kind of preserve. Marmalade came next in popularity, followed by syrup, honey, and mincemeat. Only a small number of children ate jelly or lemon curd.

TABLE XXXV
Number of Children having various kinds of Preserves

	Boys	Girls
Total number	435	481
Number having:—		
Jam	324	350
Marmalade	194	217
Syrup and treacle	132	132
Honey	111	90
Mincemeat	54	48
Jelly	23	39
Lemon Curd	20	25

SWEETS AND CHOCOLATE

Food customs have changed in many ways during the past few centuries, but children loved sweetmeats 300 years ago, just as much as they do today. Seventeenth and 18th century books dealing with the upbringing of children usually contain some note of warning with regard to sweets. Thus, John Locke, in his famous Treatise on Education (1695), advised that no sweets or titbits should ever be allowed at odd times: "children should never be allowed to eat or drink between meals, unless it were a piece of dry bread if they complain of hunger". Dukes (1899), with his wide experience of boys' likes and dislikes, said that "most young people have what is called a 'sweet tooth'. To them sweets of all kinds are the most toothsome of all the foods they eat".

Sixty-eight per cent. of the boys and 78 per cent. of the girls ate sweets, and 61 per cent. of the boys and 59 per cent. of the girls had chocolate during the week of food weighing. Forty-three per cent. of the boys and 48 per cent. of the girls ate both. Altogether, 90 per cent. of the children taking part in this investigation ate sweets or chocolate or both. Fig. 28 shows the average

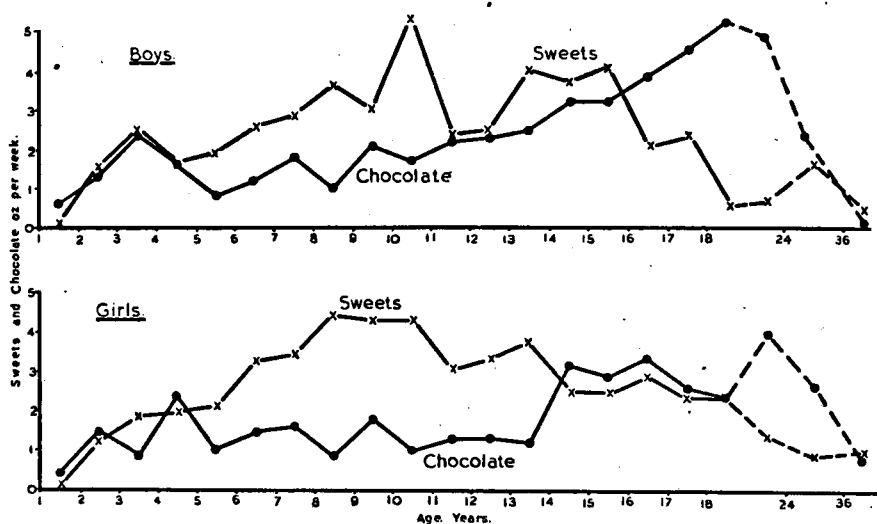


FIG. 28.—Average Consumption of Sweets and Chocolate.

amounts that were consumed. Below the age of five, both boys and girls ate sweets and chocolate in approximately equal amounts. From then until adolescence, if we except the boys of 11 and 12, the quantity of sweets eaten was always considerably greater than the quantity of chocolate. The older children, however, preferred chocolate to sweets, for a greater proportion of the children ate it, and they ate larger amounts, so that its average consumption increased while that of sweets fell off. This was true both for boys and girls, and it was also true of the youngest adult age group previously studied. With advancing years, however, the liking for chocolate declined once more, so that the men and women in the oldest age group were eating little more of either chocolate or sweets than the one-year-old children. Taking sweets and chocolate together, children of two years were having about 3 oz. a week, and those of seven were getting 5 oz. The average remained at about that level till the age of 13. It is worth noting that, weight for weight, this is about equal to

their consumption of green vegetables. Thereafter the boys' intakes of confectionery rose, while those of the girls remained approximately the same. One public school boy, aged 15, fortifying himself in anticipation of the Easter term, ate three times as much as any other in his age group (21 oz. of sweets and 32 oz. of chocolate during the week) and he has been omitted in calculating the average. He was deriving more than 1,000 calories per day from this form of sustenance, *i.e.* about 28 per cent. of his total intake. No girl ate more than 22 oz. of sweets and chocolate combined.

ICE CREAM

Seventy-one boys and 76 girls ate ice cream. The average amount that these children consumed was just over 3 oz. a week, excluding one 17-year-old boy who ate 47.5 oz. This boy weighed his food in January, and, in defiance of the season, finished his lunch and his dinner every day with anything up to 7oz. of ice cream.

Beverages

ALCOHOLIC DRINKS

Perhaps the greatest change that has occurred in children's dietary habits during the past 200 years has been in their staple beverage. "Small beer", which was for centuries the customary drink of children, has been replaced by tea, and also to some extent by milk. Of all the dietary records which were collected in the course of the present investigation, only four included any reference to beer. Three were from boys of 18 and one from a boy of 17 years. One had half a pint, one one pint, one four pints and one eleven pints during the week. In the House of Industry, Exeter, at the beginning of the 19th century, children as young as seven years were allowed a quarter of a pint of beer every evening for supper, and those over 12 usually had half a pint for dinner and another half pint for supper (Vancouver, 1808). At about the same period all the boys at Christ's Hospital were regularly being given a pint of beer a day, and Friend (1935) has calculated that in 1704 they were probably drinking three pints a day, and were deriving nearly half their estimated calories therefrom. By the end of the 19th century beer was evidently "going out" as a school-boys' beverage, for Dukes (1899) tells us that "at the present time, beer is usually supplied at school at dinner and supper for those who desire it. If its use is to be continued at all, it should be taken at dinner only. It is happily, however, used less now than formerly, and the milk which is generally substituted is, on the other hand, a very important item in the child's diet".

One boy of 17 who took part in the present investigation had a glass of sherry, and a girl of 16 and one of 17 had very small amounts of wine. The only other commercial alcoholic beverage that was drunk was cider. One boy of 12 years, two of 17 and one of 18 drank about a pint of cider each, and one girl of 16 had a quarter of a pint. A few children drank home-made beverages such as ginger wine and raspberry vinegar, which may or may not have contained some alcohol. Further details about these are given in Table XXXVII.

TEA AND COFFEE

Tea was by far the commonest beverage. Some of the children began to drink it when they were three years old, and by six or seven years most of them

were having it. One 12-year-old girl from Liverpool had it at every meal during the week. Wright (1936), in his inquiry into the drinking habits of 13,317 Scottish schoolchildren, found that 50 per cent. took tea three or more times a day, and over 90 children drank it five times daily, 30 of them being less than 10 years of age. A number of our children, however, never touched tea and usually drank milk or water at mealtimes. Very few children recorded drinking coffee.

"BEDTIME" DRINKS

Thirty-three per cent. of the children had cocoa, and 18 per cent. drank proprietary beverages, such as "Ovaltine", "Bournvita", "Horlick's Malted Milk" or "Instant Postum". Table XXXVI shows the number of boys and girls recording these different kinds of beverages. Girls evidently liked cocoa-flavoured and malted drinks more than boys, and both sexes drank cocoa more often than all the proprietary beverages put together.

TABLE XXXVI

Number of Children drinking Cocoa and other "Bedtime" Drinks

	Boys	Girls
Total number	435	481
Number having :—		
Cocoa	127	174
"Ovaltine"	23	47
"Bournvita"	14	21
"Horlick's Malted Milk"	8	15
Chocolate	5	7
"Vita-cup"	4	8
"Instant Postum"	7	3

"SOFT" DRINKS

Table XXXVII shows the number of children who had various kinds of "soft drinks". Lemonade was the most popular and about 10 per cent. of the children had it. Orangeade, ginger beer, barley water and lemon barley were drunk by less than 2 per cent. of the children, while other drinks were still less frequently consumed.

TABLE XXXVII

Number of Children drinking various kinds of "Soft" Drinks

	Boys	Girls
Total number	435	481
Number drinking :—		
Lemonade	42	54
Orangeade	11	8
Ginger beer	8	7
Barley water	10	5
Lemon barley	8	5
Grapefruit squash	2	4
Ginger wine	3	2
Mineral water	4	1
Lime juice	1	2
Raspberry vinegar	1	0
Dandelion and burdock	0	1
Passion fruit drink	0	1

Vitamin and mineral concentrates

Table XXXVIII shows the total number of children who recorded having had various vitamin, and mineral, supplements and concentrates. Twenty per cent. of the boys and 16 per cent. of the girls had supplements of vitamins A and D,

TABLE XXXVIII
Number of Children having various Vitamin and Mineral Supplements and Concentrates

	Boys	Girls
Total number	435	481
Number having :—		
Cod liver oil	49	37
Halibut liver oil	12	13
"Radiomalt"	5	11
"Radiostoleum"	3	5
"Adexolin"	2	1
"Ostelin"	1	0
"Robolene"	1	2
"Jecomalt"	1	0
"Halimalt"	0	1
"Numol"	1	0
"Irradex"	2	0
"Glucose D"	8	6
"Haliborange"	5	4
"Syrup Minadex"	1	1
"Farax"	2	4
"Virol"	10	7
"Marmite"	66	69
"Bemax"	7	4
Calcium salts	3	3
Iron salts	1	1
"Parrish's Chemical Food"	2	3
"Yestamin"	0	1

and cod liver oil was the most usual form in which these vitamins were taken. In addition, eight boys and six girls had "Glucose D". The only vitamin C supplements taken were "Haliborange" and "Syrup Minadex". "Marmite" has been included in this table, but whether it should have been is open to question as it was probably used primarily as a flavouring agent rather than as a vitamin supplement. It is likely that a number of children had yeast extracts in soups, stews and gravies without being aware of it, just as they probably had meat extracts but failed to record them.

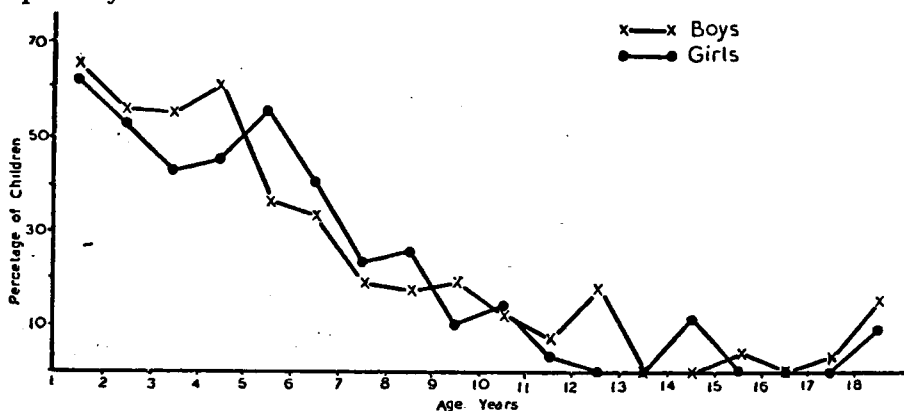


FIG. 29.—Percentage of Children of various ages having Vitamin, and Mineral, Supplements and Concentrates.

The calcium salts consisted of "Sandoz Calcium Syrup" (two children), calcium lactate (two children), and "Serocalcin" and calcium phosphate (one

child each). One boy and one girl recorded having had some kind of iron salt, and two boys and three girls had "Parrish's Chemical Food".

The vitamin and mineral supplements were taken chiefly by the younger children, and Fig. 29 shows the percentage of boys and girls in each age group who had them. In the first age group 60-70 per cent. of the children were having some kind of supplement or other, and up to the age of five about half the children were having supplements, but by seven years the figure had fallen to 20 per cent.; of the children over 11 years of age only some 20 in all—4 per cent. of the total number—were being fortified in this way. The relation of the vitamin supplements to the vitamins in the diets is discussed in further detail in Chapter 10.

CHAPTER 4

CONTRIBUTION OF VARIOUS FOODS TO THE TOTAL CALORIE INTAKE, AND THE CONSUMPTION OF FOODS IN TERMS OF MAN-VALUES

Proportion of the total calories derived from various foods

The contribution that any foodstuff makes to the total calorie intake depends upon the amount of it in the diet, and upon its calorie value. The percentage of

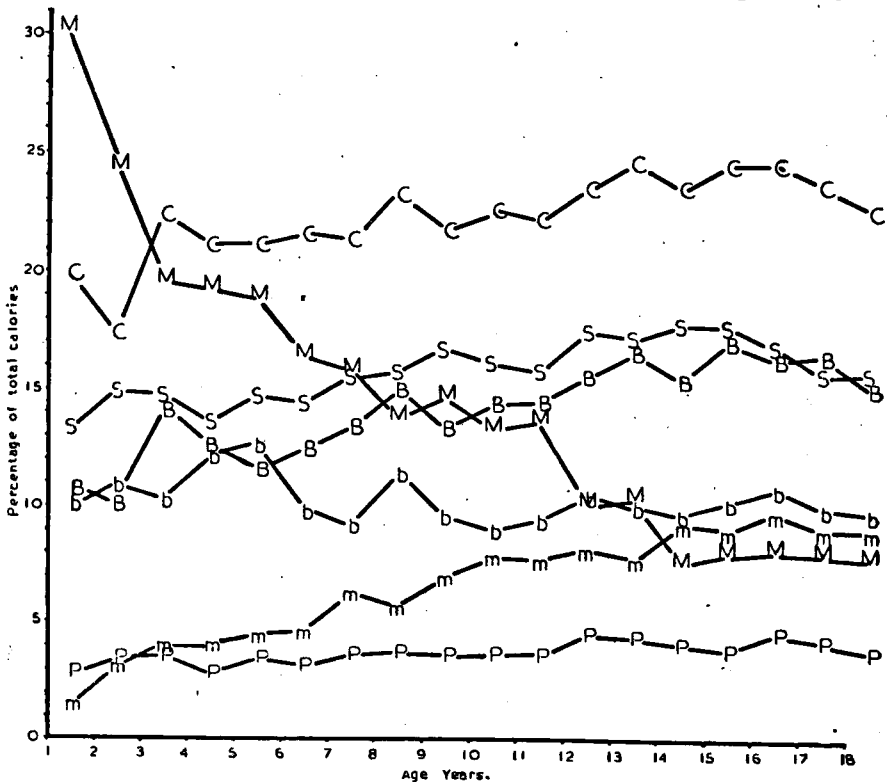


FIG. 30.—Percentage of the Total Calories which Boys derived from Various Foods. M = Milk. C = Total Cereals. B = Bread. S = Sugar. P = Potatoes. m = Meat. b = Butter.

their total calories which children of all ages obtained from seven different sources is set out in Figs. 30 and 31. Young infants derive 100 per cent. of their calories from milk and, as might have been expected, the youngest

children in this investigation obtained more of their calories from milk than from any other food. At one year the proportion was just over 30 per cent., but it fell gradually to about 8 per cent. at 14 years, after which it remained approximately constant.

By three years of age the percentage of the total calories derived from cereals was as high as, or higher than, that derived from milk, and from then onwards cereals provided more than 20 per cent. of the total calories. Both boys and girls seemed to depend upon cereals for about 25 per cent. of their calories when they were 13 years old, but for rather less in their later teens.

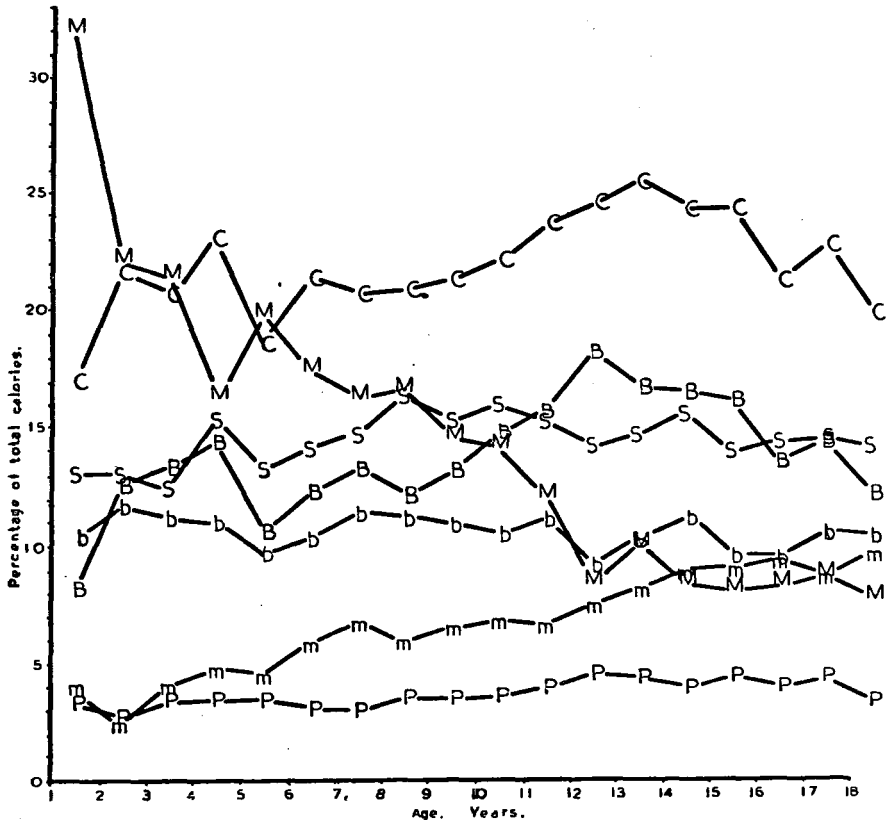


FIG. 31.—Percentage of the Total Calories which Girls derived from Various Foods. M = Milk. C = Total Cereals. B = Bread. S = Sugar. P = Potatoes. m = Meat. b = Butter.

From seven years old upwards the boys obtained more calories from sugar than from anything else except cereals, and between 12 and 15 years of age 17–18 per cent. of their calories came from this source. Girls also derived about 15 per cent. of their calories from sugar, but between the ages of 11 and 16 bread provided rather more. In the oldest age groups of both sexes bread and sugar supplied approximately the same percentage of calories.

Potatoes are popularly regarded as highly calorific, and they are usually avoided by people who want to lose weight. It will be seen that the children in this investigation always derived less than 5 per cent. of their calories from potatoes, and up to the ages of 10 and 11 years less than 4 per cent.

Butter spread on bread provided a surprisingly high proportion of the children's calories, and the younger ones were in fact getting almost as many calories from butter as from bread. The proportion derived from butter,

however, was always about 10 per cent., while the proportion from bread rose, so that the latter provided the older children with $1\frac{1}{2}$ times as many calories as butter.

It will be seen later (p. 95), when the diets are discussed in chemical terms, that fat accounted for about 37 per cent. of the calories in the diets of boys and girls of all ages. One quarter to one third of the total fat intake, therefore, was derived from butter eaten on bread.

The percentage of the total calories obtained from meat increased steadily up to 14 years both for boys and for girls, but it never reached 10 per cent. From 14 years old upwards rather more calories were obtained from meat than from milk.

Food intakes in terms of man-values

It has already been seen how the whole edifice of dietary surveys by the family method is erected upon the rather shaky foundation of man-values. Further, it has been pointed out that, while there may be man-value scales for calories, protein, calcium and iron, no one has yet had the temerity to devise one for meat or milk or potatoes. This investigation provides the first opportunity of doing so, but it must be made clear at the outset that the figures are based upon intakes, not requirements, and they differ in this respect therefore from the accepted man-value scales for chemical constituents. This is correct, for there can be no absolute requirement for any particular foodstuff. The results given here provide a method of calculating how a family's consumption of the principle foods is likely to be divided up among the individual members of the family, and they also make it possible to reduce family intakes of foods to a uniform basis. It must be remembered, however, that these figures apply only to families of the same economic level as those studied here, and that they should be used preferably for diets collected in the decade before the war. They must not, of course, be applied to restricted or rationed diets.

Man-value scales for bread, milk, butter, meat, potatoes and sugar are shown in Figs. 32 to 37. The average intake of each of these foods by the 63 men studied previously (Widdowson, 1936) has been assigned a value of 1.0, and the children's intakes expressed as fractions of this figure.

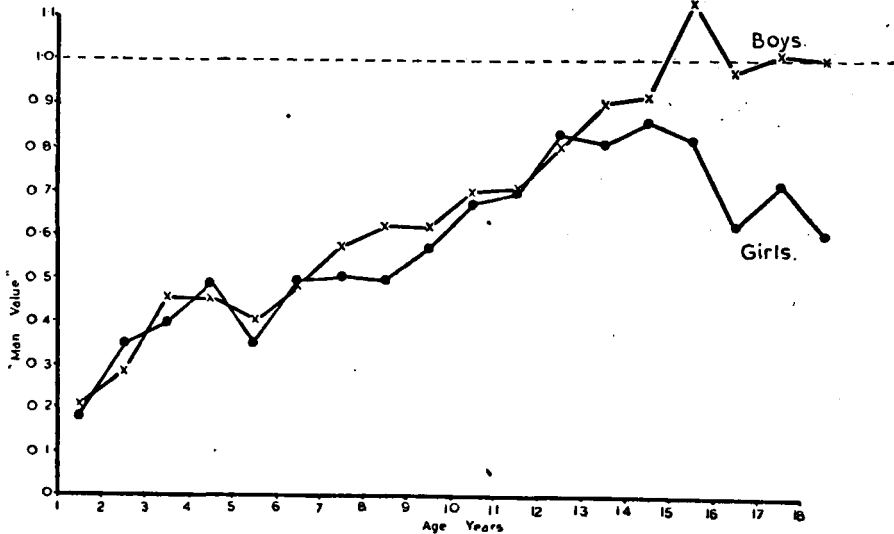


FIG. 32.—Children's Intakes of Bread expressed as Fractions of those of an Average Man.

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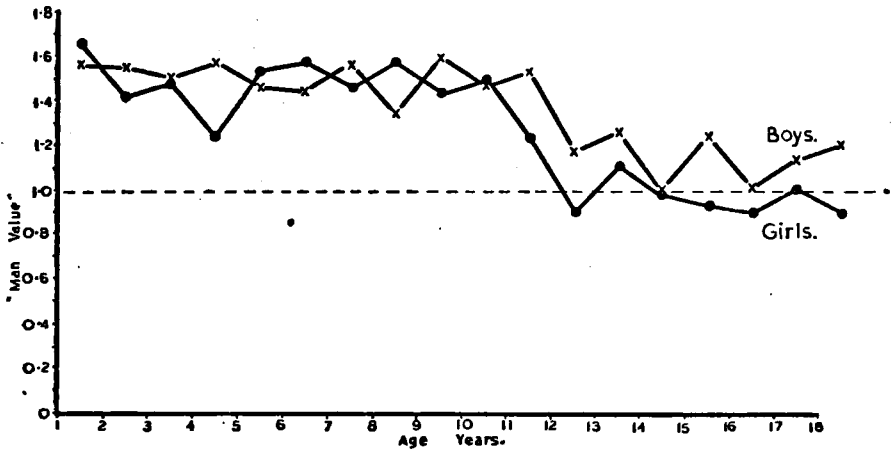


FIG. 33.—Children's Intakes of Milk expressed as Fractions of those of an Average Man.

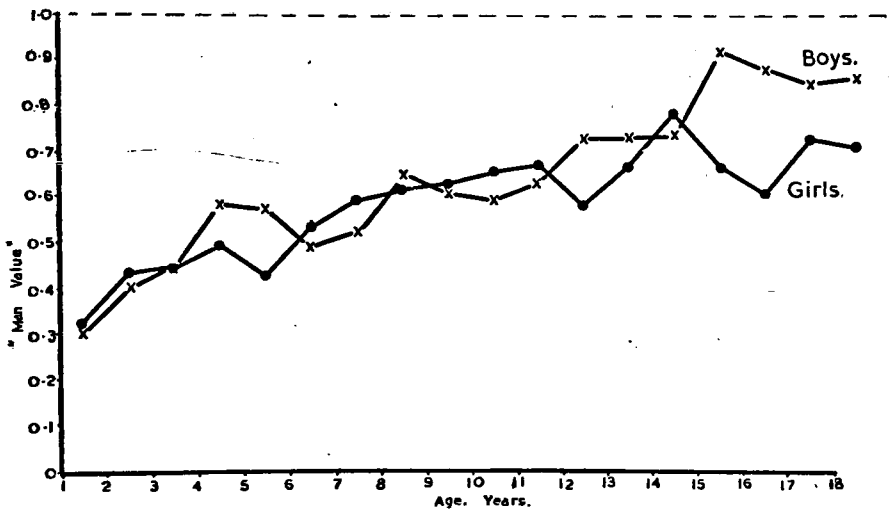


FIG. 34.—Children's Intakes of Butter expressed as Fractions of those of an Average Man.

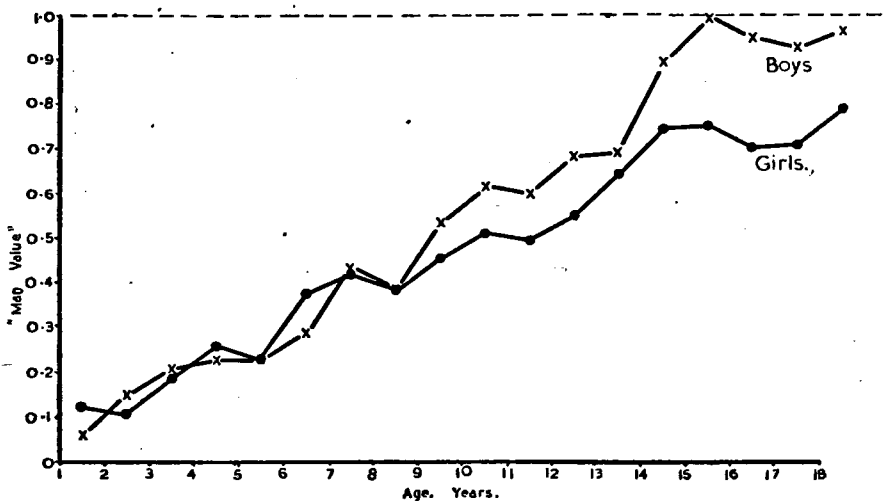


FIG. 35.—Children's Intakes of Meat expressed as Fractions of those of an Average Man.

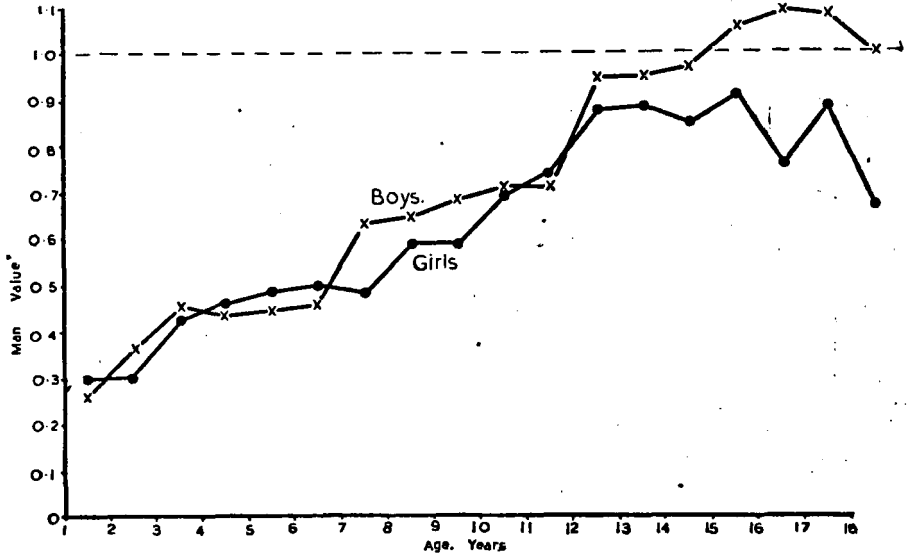


FIG. 36.—Children's Intakes of Potatoes expressed as Fractions of those of an Average Man.

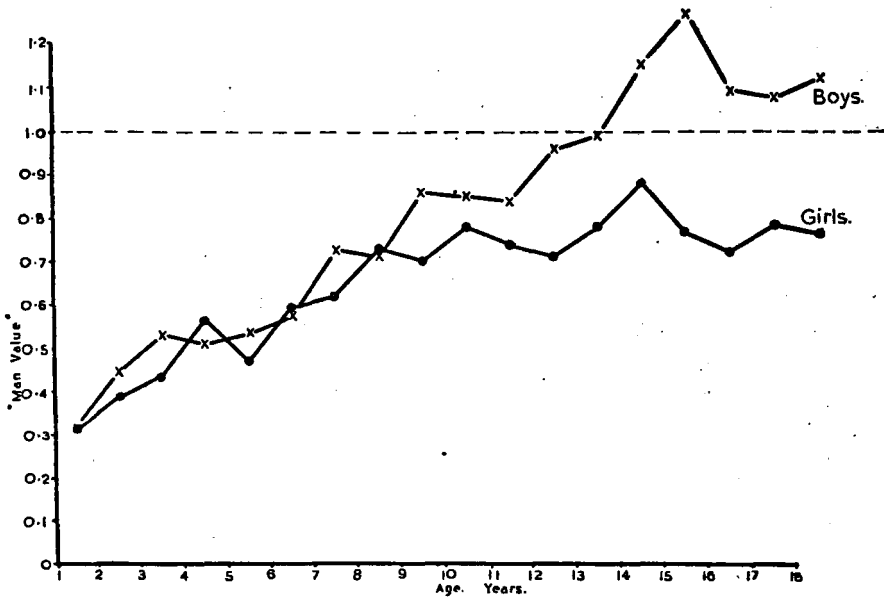


FIG. 37.—Children's Intakes of Sugar expressed as Fractions of those of an Average Man.

The graph for milk is different from all the others in that the man-value decreased as the children grew older, and the figure was greater than 1.0 for all the age groups except the older girls. For all the other foods the man-value increased with increasing age, but it increased at different rates. Thus, children of four years were eating more than half as much sugar and butter as an adult man, but they did not eat half as much meat until they were nine years

old. As will be seen later (Tables XXXIX and XL), the children were taking in 50 per cent. as many calories as the "average" man by the time they were three years old.

Boys of 15 to 18 years of age had a man-value greater than 1.0 for sugar and potatoes and less than 1.0 for butter and meat. For no food except milk did girls of any age ever have a man-value as high as 1.0.

The man-values for bread tended to be lower than those for calories, particularly in the younger age groups. This is really another way of making a point which has just been discussed, namely, that the younger children obtained a smaller proportion of their calories from bread than the older ones. If, therefore, the bread intakes of children were to be calculated on a calorie man-value basis the children would be reckoned to be eating more than they do in fact eat. Suppose, for example, a family consisting of father, mother, 2 boys aged 2 and 11 and a girl aged 6 were found to be eating 2 lb. of bread per day. On a calorie basis (see p. 68) this family would have a man-value of 3.67, and the bread consumption would be calculated as 8.75 oz. per man-value per day. It is more likely that for bread the man-value of the family would have been about 3.08, and the consumption 10.3 oz. per man-value per day—a very considerable difference.

CHAPTER 5

CALORIE INTAKES AND CALORIE REQUIREMENTS

"Growing bodies have the most heat; they therefore require the most food".—Hippocrates.

Historical

The energy requirements of the body are probably better understood than the requirements of any of the specific dietary constituents. Human nutrition became a quantitative science with the invention of the calorimeter, and quantitative work on food requirements began with a study of total energy. No subsequent discoveries have erased one iota from the fundamental importance of this work. Vitamins and minerals are essential, but they can never replace calories.

Just over 100 years ago, two French investigators (Andral and Gavarret, 1843) conducted the first respiration experiments on children. They studied 12 children, 8–16 years old, by attaching a copper mask to the child's face and collecting the expired air in a large glass globe for analysis. Subsequent workers used respiration chambers, which were sufficiently large to accommodate a child, and sometimes even to allow him to take a few steps inside it. In 1895 Sondén and Tigerstedt constructed in Stockholm a much larger respiration chamber than had hitherto been used, and they persuaded boys and girls, 8–15 years old, to sit inside it, reading or eating sweets or apples, while their carbon dioxide output was measured.

Valuable though these experiments were, the results obtained did not in any way represent the heat exchanges of children living normal active lives. Nor did they represent the basal metabolism, for little attention was paid to keeping the subject at complete rest or to controlling the influence of food. Nevertheless they did clearly establish the fact that the energy metabolism

of the growing child is greater, weight for weight, than that of the adult, and that it varies with age. Theoretically, calorimetry is the ideal method for determining energy requirements, but in practice it falls far short of the ideal because no calorimeter has ever been made large enough to allow a child to carry out his normal activities in it. During the present century the use of calorimeters has been directed mainly to the determination of the metabolism under basal conditions. Benedict and Talbot (1921), Boothby and Sandiford (1929), Dubois (1936), Talbot, Wilson and Worcester (1937), Lewis, Kinsman and Iliff (1937), Talbot (1938), Benedict (1938), and Lewis, Duval and Iliff (1943), must be mentioned in this connection. A few workers have compared the basal with the total metabolism of children while the latter were performing a measured amount of work. Thus, Helmreich (1925) measured the energy exchanges of 14 children aged 3-16 years while they lifted their legs alternately, 15 times a minute in rhythm with a clock. He found that this form of exercise increased the energy expenditure of the smallest children, whose legs were shortest in proportion to the trunk, 20-25 per cent., but that of the oldest children, whose legs were relatively much longer, from 80-100 per cent. Taylor and MacLeod (1937) compared the energy expenditure of 6 boys, 9-11 years old, while sitting quietly and while riding a bicycle ergometer. At quiet play the output of energy was 53 per cent. above the basal level, but during cycling the energy expenditure was increased 212 per cent.

In order to measure the energy expenditure under various kinds of activity the Douglas bag method has sometimes been used. This allows of much greater freedom than the respiration chamber, but even here the mere attachment of the mask or helmet to the face, and the large bag on the back must make the exercise abnormal. The best experiment that has been done on children by this method is that of Bedale (1922-23). She determined the metabolism of about 100 schoolchildren for short periods at 25 different activities such as school work in the classroom and laboratory, playing games, eating meals and going to bed. From her results she computed the energy requirements for a typical day for a hypothetical average child. This work is extremely interesting, but the results could never be used as standards for the total calorie requirements of children.

Because of the impossibility of measuring the output of heat under conditions of normal activity, workers have turned their attention to other methods of determining children's energy requirements. Balance experiments have sometimes been used, and an excellent summary of these is given in the Report of the Committee on Growth and Development at the White House Conference (1932). In some, food, urine and faeces were analysed for protein, fat and carbohydrate. In others, foods were completely analysed, but the excreta were analysed for nitrogen only. In others again, the composition of the diet was calculated from food tables and the nitrogen in the excreta determined by analysis. More rarely, a calorie balance was obtained by burning samples of both food and excreta in a bomb calorimeter. Very few of the studies, however, seem to have been made on really healthy children leading their normal lives and eating their fill every day. The classical work of Camerer (1878, 1880, 1882, 1884, 1888, 1892) for example, which was done on his own five children throughout their growth period, does not fulfil these requirements. The children were all underweight, and some of them lost weight and were in negative nitrogen balance during the experimental periods. Similarly, in the more recent study of Wang, Kaucher and Wing (1936a) on 24 adolescent girls, all but one of them were underweight.

In other investigations normal as well as abnormal children were studied, but the diets were generally controlled in some way (Pautz, 1895; Müller, 1907; Herbst, 1912; Ahlqvist, 1916; Rost, Herbst and Weitzel, 1922;

Wang, Frank and Kaucher, 1928 ; Wang, Hawks and Kaucher, 1928). The results of these studies can hardly be used to provide standards for children's calorie requirements since the experiments were usually carried out for short periods of time, and the adequacy or inadequacy of the diets as regards calories was not determined. Macy and her co-workers (Macy, 1942), who have reduced metabolic work on children to a fine art and an exact science, estimated the heat of combustion of food, urine and faeces of 18 healthy children aged 4-12 years over periods varying from 55 to 200 days. The diets were pre-arranged, but the children remained healthy and gained weight normally on them, and they are therefore considered to have been adequate. The average calorie losses through the urine and faeces were 3.6 and 4.2 per cent. of the intake respectively.

Although general impressions as to the energy requirements of children may be gathered from the balance experiments which have so far been carried out, the best information available, has been derived from dietary studies, in which only the intake has been measured. It has become increasingly evident during the past few years that, over a reasonable period of time and among healthy people, calorie intakes are a measure of calorie requirements provided there is no restriction on the total amount of food. Thus, McCance and Widdowson (1946) showed, in an experimental study of rationing, that if healthy adults were deprived of an accustomed source of calories, then appetite and instinct forced them to make good this loss by turning to some other source of supply. This principle was later shown to apply to wartime rationing by a study of women (Widdowson and Alington, 1941) and boys (Widdowson and McCance, 1942a).

Errors inherent in dietary studies made on groups of persons of different sex or varying ages have already been discussed (p. 3). The results of such investigations give no clue as to the calorie intake, let alone the calorie requirement, of an individual. Workers who have made individual dietary surveys on children have so far usually confined themselves to a particular age (see p. 6). The present investigation gives the first comprehensive picture of the calorie intakes of children of all ages studied under the same conditions by one group of workers. The children belonged to families where there was unlikely to have been any restriction on the total amount of food. Their heights and weights were up to the American standards of Baldwin and Wood, and their calorie requirements were probably being met. Their calorie intakes, therefore, seem likely to give as good a measure of their calorie requirements as it is possible to obtain.

Energy requirements depend mainly upon sex, activity, size and age. Activity is difficult to assess, but details as to the sex, age, height and weight of the children taking part in this investigation are available, and the calorie intakes will be discussed in relation to each of them in turn.

Variation in calorie intake with age and sex

Fig. 38 shows the daily calorie intakes of boys and girls in each of the yearly age groups. From the age of three years onwards the boys' intakes were always above those of the girls. The differences were small at first, and were possibly due to chance rather than sex, but for most of the yearly age groups over eight they were statistically significant, and Fig. 38 suggests that real physiological differences probably existed at a much earlier age. Beal, Burke and Stuart (1945) found, as a result of a 3-day dietary study on 160 children aged 1-10 years, that from the age of 5 boys always had a higher calorie intake than girls, and they explained this by the greater activity of boys. Our boys' calorie intakes were highest at 15 and 18 years, when the average value was rather more than

3,400, but the girls reached their maximum of 2,637 a day at 14. It is well known that girls reach puberty earlier than boys, and it is possible that these findings for calorie intakes are in some way correlated with this. The present figures are much lower than the 4,570 and 3,330 calories a day suggested by Orr and Leitch (1938) as the daily requirement of adolescent boys and girls for optimum growth and vigorous exercise. An attempt was made to compare the present findings with previous data for calorie intakes, but at some ages figures for but one or two children were to be found, and, furthermore, the values at some ages were unduly influenced by the work of an investigator in one particular country, while at other ages most of the records were of German, Scandinavian or American origin, and the results were scarcely comparable. It did not seem profitable, therefore, to pursue this matter further. Generally speaking, our figures, both for boys and girls, are higher than those in the literature, but the published work is weighted by the older German and Finnish data. More recent surveys which have been carried out in America on children of particular ages have given results which are in close accord with our own, and this is particularly true of Wait and Roberts' (1932a) study of the calorie intakes of adolescent girls, and of Wiehl's (1944) investigation of the diets of high school students in New York City. McKay and Patton's (1935) values for pre-school

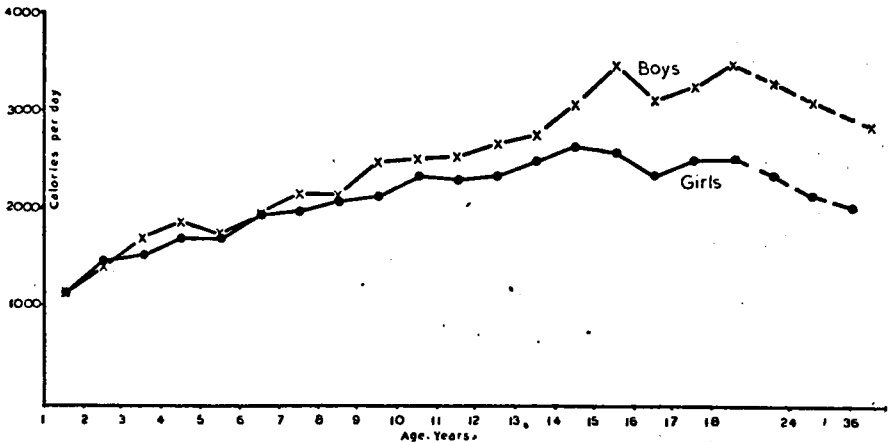


FIG. 38.—Average Total Calorie Intakes.

children are, however, always lower than ours. Their investigations were very carefully carried out on normal healthy children, living in their own homes and whose parents were stated to be above the average as regards the intelligence with which they provided for the needs of their children. McKay and Patton do not state what food tables they used for calculating the calorie values of the diets.

Man-value scales

In view of the dearth of experimental data on children's energy requirements it is not surprising that the scales proposed by different workers for the calorie requirements of children of various ages have been so many and so diverse. von Tyszka (1935) quoted 33 of them, and showed how the calorie intake of a family, divided by its man-value, might appear to be anything from 2,600 to 3,700 calories a day according to the scale of coefficients chosen for the calculations. It is clearly impracticable to compare the present findings with all these scales, nor would it be profitable to do so, but comparisons have been made with some of the more generally-accepted scales and the results are shown.

in Tables XXXIX and XL. Smoothed curves were drawn for the average calorie intakes of our children, of different ages, and from them the man-values were calculated. The conventional value of 3,000 calories a day for the adult man has been taken as unity, since the average calorie intake of 63 men of the English middle class was found to approximate very closely to this figure (Widdowson, 1936).

TABLE XXXIX

Comparison of Present Results for Boys' Calorie Intakes, expressed in terms of Man-values, with Scales Previously Suggested for Boys' Calorie Requirements

Age (years)	Royal Society (1917)	Cathcart and Murray (1931)	Stiebeling and Ward (1933)	League of Nations (1936)	Canadian Dietary Standard (1941)	National Research Council (1943)	Present values
1	0.4	0.3	0.4	0.3	0.33	0.4	0.35
2	0.4	0.4	0.4	0.4	0.47	0.4	0.42
3	0.4	0.5	0.4	0.5	0.47	0.4	0.49
4	0.4	0.5	0.5	0.5	0.63	0.53	0.55
5	0.5	0.5	0.5	0.6	0.63	0.53	0.60
6	0.5	0.6	0.5	0.6	0.63	0.53	0.65
7	0.5	0.6	0.7	0.7	0.74	0.67	0.69
8	0.5	0.7	0.7	0.7	0.74	0.67	0.73
9	0.5	0.7	0.8	0.8	0.74	0.67	0.77
10	0.6	0.8	0.8	0.8	0.74	0.83	0.81
11	0.6	0.8	0.83	0.9	0.80	0.83	0.85
12	0.6	0.9	0.83	1.0	0.80	0.83	0.89
13	0.6	0.9	1.0	1.0	1.07	1.07	0.92
14	0.8	1.0	1.0	1.0	1.07	1.07	1.00
15	0.8	1.0	1.0	1.0	1.07	1.07	1.10
16	1.0	1.0	1.0-1.3	1.0	1.20	1.27	1.10
17	1.0	1.0	1.0-1.3	1.0	1.20	1.27	1.10
18	1.0	1.0	1.0-1.3	1.0	1.20	1.27	1.10
Man	1.0	1.0	1.0	1.0	1.00	1.00	1.00

TABLE XL

Comparison of Present Results for Girls' Calorie Intakes, expressed in terms of Man-values, with Scales Previously Suggested for Girls' Calorie Requirements

Age (years)	Royal Society (1917)	Cathcart and Murray (1931)	Stiebeling and Ward (1933)	League of Nations (1936)	Canadian Dietary Standard (1941)	National Research Council (1943)	Present values
1	0.4	0.3	0.4	0.3	0.33	0.4	0.35
2	0.4	0.4	0.4	0.4	0.42	0.4	0.42
3	0.4	0.5	0.4	0.5	0.42	0.4	0.49
4	0.4	0.5	0.5	0.5	0.55	0.53	0.55
5	0.5	0.5	0.5	0.6	0.55	0.53	0.60
6	0.5	0.6	0.5	0.6	0.55	0.53	0.64
7	0.5	0.6	0.5	0.7	0.67	0.67	0.67
8	0.5	0.7	0.7	0.7	0.67	0.67	0.70
9	0.5	0.7	0.7	0.8	0.67	0.67	0.73
10	0.6	0.8	0.7	0.8	0.67	0.83	0.75
11	0.6	0.8	0.8	0.9	0.75	0.83	0.77
12	0.6	0.9	0.8	1.0	0.75	0.83	0.80
13	0.6	0.9	0.8	1.0	0.83	0.94	0.82
14	0.7	0.83	0.83	1.0	0.83	0.94	0.85
15	0.7	0.83	0.83	1.0	0.83	0.94	0.85
16	0.8	0.83	0.83	1.0	0.83	0.80	0.85
17	0.8	0.83	0.83	1.0	0.83	0.80	0.85
18	0.8	0.83	0.83	1.0	0.83	0.80	0.85
Woman	0.8	0.83	0.83	1.0	0.67-0.80	0.83	0.71

It will be seen that our figures are always higher than those suggested by the Royal Society (1917), and they are higher than Cathcart and Murray's (1931) values for all except the older girls. They are very similar in many respects to the League of Nations (1936) scale, to the National Research Council (1943) scale and to the Canadian Dietary Standards (McHenry, 1941). Our values tend to be lower than either the American or Canadian standards for adolescent children of both sexes, but higher than the American scale in the younger age groups.

Individual variations in calorie intakes

The calorie intakes of individual children will now be considered in more detail. Tables XLI and XLII show the average intakes at each age, the

TABLE XLI
Boys' Calorie Intakes in relation to Age

<i>Age group</i>	<i>Average daily calorie intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	1154	1547	811	210	18.2
2	1406	1929	959	241	17.1
3	1691	2340	1250	316	18.7
4	1939	2574	1210	362	19.6
5	1732	2144	1312	226	13.1
6	1940	2528	1152	340	17.5
7	2178	2827	1644	309	14.1
8	2170	3113	1597	345	15.9
9	2443	2941	1823	257	10.6
10	2501	3533	1596	427	17.0
11	2521	3246	1972	373	14.8
12	2630	3532	2063	434	16.5
13	2756	3611	2150	400	14.5
14	3065	4121	1840	546	17.8
15	3440	5395	2457	646	18.8
16	3105	4341	1363	636	20.5
17	3223	4528	1754	478	14.8
18	3427	5221	2338	703	20.4

TABLE XLII
Girls' Calorie Intakes in relation to Age

<i>Age group</i>	<i>Average daily calorie intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	1152	1631	842	207	18.0
2	1431	2048	1055	252	17.6
3	1533	2328	991	294	19.2
4	1718	2263	1085	318	18.5
5	1708	2288	1300	298	17.5
6	1985	2543	1517	279	14.0
7	1995	2708	1524	283	14.2
8	2086	2971	1482	336	16.1
9	2165	2802	1589	297	13.7
10	2345	3180	1649	376	16.0
11	2292	3725	1585	446	19.5
12	2370	3481	1804	438	18.5
13	2504	3736	1706	452	18.1
14	2637	3617	1901	451	17.1
15	2588	3550	1539	504	19.4
16	2363	3142	1718	389	16.5
17	2513	3318	1620	372	14.8
18	2513	3452	1876	376	15.0

maximum and minimum values in each age group, the standard deviation and the coefficient of variation. It is at once apparent that there were always enormous differences between individuals. In each age group one child ate about twice as much as another, and one 16-year-old boy actually took less than one of the one-year-olds. Similar differences have been found between individual men (Widdowson, 1936) and women (Widdowson and McCance, 1936), and other investigators have also drawn attention to children's behaviour in this respect (Wait and Roberts, 1932a; Bray *et al.*, 1934). Wait and Roberts obtained such wide variations from one individual to another that they concluded that calorie intakes bear little relation to age, and that mean intakes per age are of less significance than is usually thought. It is quite clear that an average calorie requirement can have little meaning when applied without reservation to an individual child or adult. In endeavouring to explain these variations, it has been possible to show that within the age groups there was often a connection between the size of the child and the calories which he or she consumed. Each age group was examined in the following way:—the children who took the most and the least calories, and whose intakes are set out in Tables XLI and XLII, were marked with a + if their weights and their heights were above the average for their age group and with a - if they were below. It was found that of the 36 boys and girls with the highest calorie intakes, 23 were *above* average height and 22 were *above* average weight. Of the 36 children with the lowest calorie intakes, 26 were *below* average height and 28 were *below* average weight.

From the average figures for all the boys and all the girls, irrespective of age, and the corresponding standard deviations, the coefficients of correlation between calorie intakes and heights and weights have also been calculated. Taking all the boys together, the coefficient of correlation between calories and height was + 0.272; for girls the corresponding value was + 0.127. In the case of calories and weight, the coefficients of correlation were + 0.422 and + 0.163 for boys and girls respectively. The standard error for the boys was 0.048 and for the girls 0.046. There was, therefore, a significant positive correlation between calories and height, and between calories and weight; the correlation between calories and weight was the closer of the two for both sexes, the boys' calorie intakes being more closely related to size for age than those of the girls.

Daily and weekly variations in calorie intakes in the same individual

Earlier workers (Herbst, 1898; Wait and Roberts, 1932b; McKay, 1934) have drawn attention to the way in which one individual's calorie intake may vary from day to day. Since the whole value of the present investigation depended upon a week being long enough to give a reasonably accurate picture of an individual's intake, it seemed advisable to explore this point further. Accordingly one boy and one girl were chosen at random from each of the 18 age groups, and the chemical composition of the diets of these 36 children was calculated for each of the seven days during which the dietary investigation was in progress. Tables XLIII and XLIV show their calorie intakes on the seven successive days, the intakes on Sundays being printed in heavy type. Two of the children, the boy of 14 and the girl of 11, did not state which day of the week was which. It will be seen that there is a huge variation, particularly for some of the children, and it is quite irregular. Some, *e.g.* the girls of 5 and 11, ate most at the beginning of the week of weighing, while others, *e.g.* the boy of 18, ate most at the end. Others again, *e.g.*, the 10-year-old girl and the 17-year-old boy, ate most in the middle. Three boys and three girls ate most on Sunday, and three girls, but no boys, ate most on Saturday. Wait

TABLE XLIII

Variation in Individual Boys' Calorie Intakes from Day to Day

<i>Age (years)</i>	<i>Day 1</i>	<i>Day 2</i>	<i>Day 3</i>	<i>Day 4</i>	<i>Day 5</i>	<i>Day 6</i>	<i>Day 7</i>
1	1326	955	988	943	1001	1275	820
2	1452	1373	1518	1398	1420	1658	1321
3	1272	1284	1298	1174	1221	1252	1250
4	1626	1692	1337	1591	1849	1468	1714
5	2242	2341	2439	1919	1520	1555	1554
6	1800	2302	2454	2715	2470	1621	2206
7	2107	1831	2365	2098	1920	2455	1936
8	3178	2986	3026	3552	3321	2706	3056
9	2493	2444	2431	2665	2652	2940	2635
10	2727	3590	2619	2790	4226	3410	2923
11	2223	2484	2250	1531	1686	1819	2340
12	3046	3394	2473	2777	3088	3272	2863
13	3070	3375	3040	2870	3305	3135	3145
14	3082	3192	3108	3284	3627	2011	2818
15	2190	2890	2890	2550	2190	2535	2651
16	3222	3160	2933	3885	3015	3905	3530
17	3403	4492	4578	4062	4538	3977	3248
18	3359	3158	3604	3530	3401	4805	4810

Note :—Heavy type denotes the calorie intake on Sunday.

TABLE XLIV

Variation in Individual Girls' Calorie Intakes from Day to Day

<i>Age (years)</i>	<i>Day 1</i>	<i>Day 2</i>	<i>Day 3</i>	<i>Day 4</i>	<i>Day 5</i>	<i>Day 6</i>	<i>Day 7</i>
1	896	1460	1220	1093	1616	1060	1094
2	1337	1547	1638	1506	1376	1315	1358
3	1743	1785	1632	1650	1915	1853	1680
4	1629	2062	2029	2000	2015	1921	1620
5	2050	1454	955	1420	957	1213	1264
6	1438	1568	1312	1746	1537	1691	1938
7	2260	1889	2190	2504	2185	2187	1860
8	2248	1890	1951	1886	1941	1491	1660
9	2349	2634	2519	2414	2158	2432	2248
10	3137	2754	3002	3541	3182	2295	2763
11	2691	2341	1771	1852	1901	1742	1824
12	2927	2429	2462	2722	2582	2233	2444
13	3249	3129	3592	1885	2014	2861	2678
14	3590	2890	2635	2945	2568	3185	3185
15	3082	2605	2727	3397	2632	2679	2952
16	3055	2482	1940	2835	2715	2455	2225
17	2174	2979	3119	2374	2214	2417	2354
18	2671	2179	2564	2984	2894	2809	1407

Note :—Heavy type indicates the calorie intake on Sunday.

and Roberts (1932b), who found fluctuations very similar to these, suggested variations in activity, dislike of the food on some days, and a particularly high or low intake on the previous day as possible causes. They found that most children tended to eat more at the week-end than on school days; this variation was not clearly demonstrated in the present survey (see Tables XLIII and XLIV). Wait and Roberts emphasized the importance of carrying out dietary surveys for a minimum period of a week, and insisted that shorter periods might give very fallacious results.

McKay and Patton (1935) made a very detailed study of the day-to-day fluctuations in the calorie intakes of nine pre-school children at different seasons of the year, and they came to the conclusion that calorie intakes of individual children varied to a greater extent from day to day within each week than they did from season to season or from one year to the next. The factors which they suggested might influence a child's calorie intake were:—(1) the previous intake of calories, the highest calorie intake following or preceding the lowest in 36 per cent. of their cases, (2) the type of food served, (3) the onset of colds, or excitement and emotional strain, (4) the time of the week, the first part of the week seeming to be more conducive to high calorie intake than the end of the week, and (5) the season, calorie intakes during summer and autumn being less varied than during other seasons.

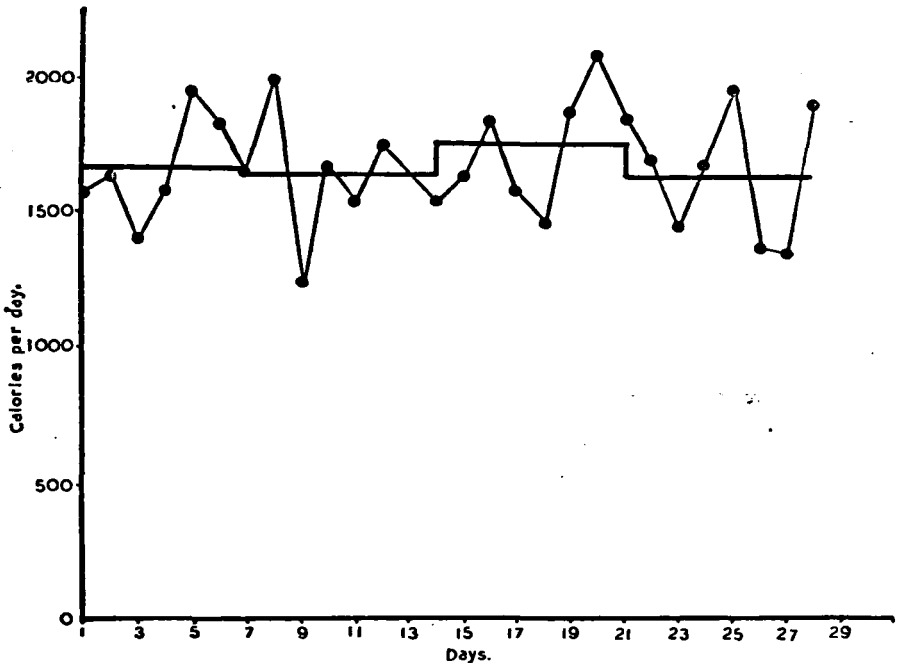


FIG. 39.—Daily and Weekly Variations in the Calorie Intake of a 4-year-old Girl.
(From Boulton, 1945.)

Several of our children had their highest calorie intake on a day immediately before or after a day on which they ate very little. The boys of 14 and 18, and the girl of 13, should be noted in this respect. The causes of these fluctuations were probably as varied as the calorie intakes themselves, and a much more detailed study, designed for the purpose, and on children of all ages, would be necessary before any broad generalizations could be made.

In view of these day-to-day fluctuations, the question arises as to whether an individual's calorie intake is sufficiently constant from week to week for the purposes of the present investigation. For one reason or another, a few girls weighed their food twice, at intervals of about a year. Of these, one was 16 and three were 17 on the first occasion and their average daily calorie intakes were then 2,601, 3,050, 2,601 and 2,542. These girls had reached the age when calorie intakes are not affected by growth (see Fig. 38). On the second occasion the corresponding values were 2,326, 2,853, 2,673 and 2,480. It is evident that in every case the second week was not very different from the first, and either could have been taken as a measure of the girls' intakes.

Boulton (1945), in her study of the diets of eight individual children during four successive weeks, found that their calorie intakes varied from day to day in much the same way as those illustrated in Tables XLIII and XLIV. When the seven days of each week were averaged, however, the figures for the four weeks agreed very closely. One of her graphs, showing the calorie intake of a four-year-old girl, is reproduced in Fig. 39, and her weekly averages for all the eight children are set out in Table XLV, together with the standard deviations and

TABLE XLVII
*Average Daily Calorie Intakes of Eight Individual Children
over Four Successive Weeks. (From Boulton, 1945.)*

Name	Sex	Age (years)	Average daily calories for four successive weeks	Mean for whole period	Standard deviation	Coefficient of variation
J.R.	F	1	1271 1073 949 1136	1107	134	12.1
M.K.	F	2	1293 1140 1067 1014	1129	121	10.7
J.B.	F	3	1171 1150 1046 1061	1107	63	5.7
R.F.	M	4	2063 1994 1896 2023	1994	71	3.6
E.S.	F	4	1661 1630 1766 1626	1671	65	3.9
R.S.	M	8	2170 2461 2546 2273	2363	172	7.3
L.S.	F	17	1811 1629 1841 2105	1847	196	10.6
S.C.	F	17	2438 2412 2567 2710	2532	137	5.4

coefficients of variation. If these are compared with the corresponding figures in Tables XLI and XLII, it will be seen that where calories are concerned the variation of one individual from week to week is very much less than the variation from one individual to another. It may be concluded that a fair estimate of a person's intake is obtained from a study lasting for one week. How far this applies to the separate dietary constituents will be discussed later.

Variation in calorie intake with body weight

Body weight is an obvious basis for expressing calorie intakes and calorie requirements. Camerer (1896) concluded, from his studies on his own children, that energy requirements of children increase steadily with body weight, irrespective of age, and other workers (Holt and Fales, 1921a) have thought likewise. Accordingly, the children taking part in this investigation were divided into 18 groups according to their body weights, 8 lb. being taken as the group unit of weight, and the average calorie intake of each weight group has been calculated. In group 1 were placed all the children weighing 20 to 28 lb., in group 2 those between 28 and 36 lb., and so on to group 18, which was made up of children weighing from 156 to 164 lb. The results of this classification are set out in Fig. 40, and it is at once apparent that, weight for weight as well

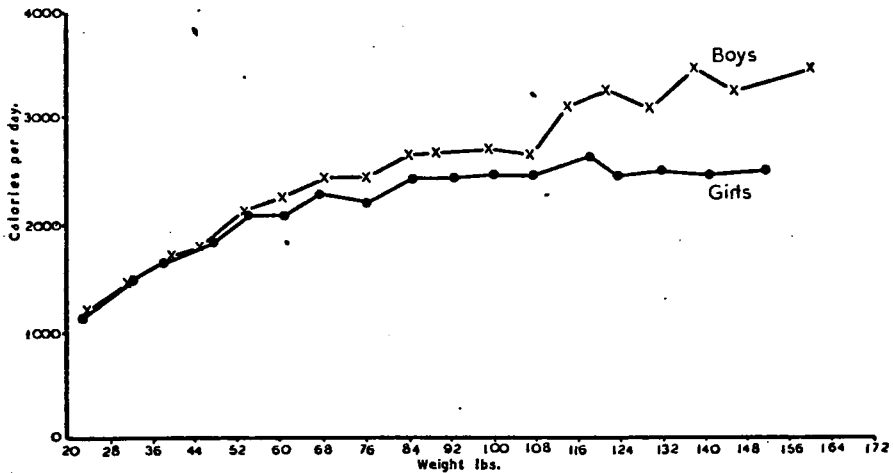


FIG. 40.—Total Calorie Intakes in relation to Body Weight.

as age for age, the older boys had much bigger appetites than the girls, and the differences began to show when the children were 52 lb. in weight, *i.e.* about seven years of age. Further details of the results are given in Tables XLVI

TABLE XLVI

Boys' Calorie Intakes in relation to Body Weight

Body weight (lb.)	No. of boys	Average daily calorie intake	Maximum	Minimum	Standard deviation	Coefficient of variation
20-28	13	1207	1718	811	270	22.4
28-36	38	1439	2284	923	346	24.1
36-44	47	1744	2574	1210	330	18.9
44-52	37	1809	2409	1152	302	16.7
52-60	29	2180	2812	1760	270	12.4
60-68	36	2285	3184	1611	358	15.7
68-76	32	2467	3230	1596	354	14.3
76-84	29	2458	3178	1840	304	13.2
84-92	24	2662	3527	2207	360	13.5
92-100	10	2726	3437	2214	323	11.9
100-108	16	2734	3301	1363	466	17.1
108-116	4	2653	3018	2317	259	9.8
116-124	16	3172	4015	1754	528	16.7
124-132	19	3262	4121	2338	535	16.4
132-140	18	3121	3629	2394	364	11.7
140-148	25	3508	5395	2457	742	21.2
148-156	18	3303	4282	2388	495	15.0
156 and over	24	3501	4587	2712	550	15.7

TABLE XLVII
Girls' Calorie Intakes in relation to Body Weight

Body weight (lb.)	No. of girls	Average daily calorie intake	Maximum	Minimum	Standard deviation	Coefficient of variation
20-28	24	1177	1631	842	235	20.1
28-36	35	1481	2328	1055	311	21.0
36-44	33	1657	2263	991	271	16.4
44-52	32	1842	2503	1269	288	15.7
52-60	29	2112	2971	1439	325	15.4
60-68	45	2139	3165	1524	390	18.3
68-76	34	2296	3725	1794	374	16.4
76-84	26	2219	3481	1585	405	18.3
84-92	19	2452	3291	1713	431	17.6
92-100	18	2438	3087	1986	336	13.9
100-108	30	2491	3474	1539	417	16.8
108-116	38	2471	3333	1620	421	17.1
116-124	47	2633	3745	1718	507	19.2
124-132	29	2491	3318	1583	419	16.9
132-140	18	2569	3528	1973	457	17.8
140-148	11	2503	3617	1775	467	18.7
148 and over	14	2545	3452	2053	388	15.3

and XLVII, where it will be seen that there was as great a variation in calorie intake from one individual to another in the same weight group as there was in the same yearly age group. The maximum was usually about twice the minimum, and the coefficient of variation was of the same order as it was when the children were classified according to age (see p. 69). These results confirm those of Wait and Roberts (1932a), who found that an adolescent girl's calorie intake could not be predicted from her weight with any more certainty than it could from her age.

Calorie intakes per kilogram of body weight in relation to age.

Since individual calorie intakes did not seem to be proportional to either age or weight, each considered separately, calories were next studied in

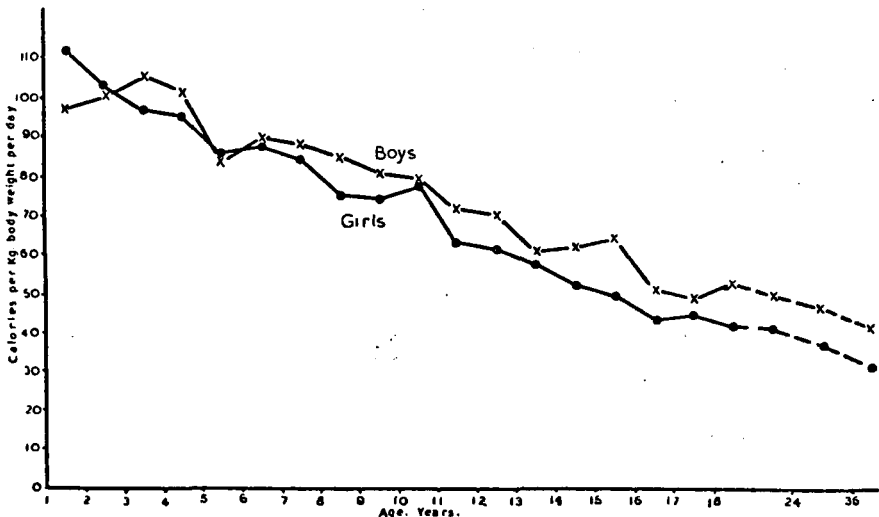


FIG. 41.—Calorie Intakes per Kilogram of Body Weight in relation to Age.

relation to these two factors together. The energy requirement of an individual is frequently expressed as calories per kilogram per 24 hours, and the calorie

intakes of all the children included in this investigation were calculated on this basis. Weights, naked, were used, and these were obtained by deducting the weights allowed for clothes in Table VII (p. 10). The averaged results are shown in Fig. 41. The values for boys and girls were 100-110 calories per kg. at the age of one, and they fell to between 85 and 90 at the age of seven. Thereafter the figures for the boys always exceeded those for the girls. At the age of 16 the boys were getting 50 calories per kg. and the girls 43.

Tables XLVIII and XLIX show the maximum and minimum values as well as the average at each age, and the standard deviation and coefficient of variation. Still the individual variation is as wide as ever, and it should perhaps be noted how much more variable the calories per kg. are in some age groups than in others.

TABLE XLVIII
Boys' Calorie Intakes per Kilogram of Body Weight

<i>Age group</i>	<i>Average daily calorie intake per kg.</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	97.4	135.0	69.9	16.2	16.6
2	100.4	145.0	81.0	14.8	14.6
3	106.0	158.0	70.0	25.4	24.0
4	102.1	143.5	62.5	23.5	23.0
5	84.0	117.5	68.1	11.5	13.7
6	90.0	131.0	53.0	18.2	20.2
7	88.0	109.5	74.5	9.1	10.3
8	85.4	136.0	62.3	15.5	18.2
9	80.7	90.0	70.2	5.9	7.3
10	80.2	115.0	66.5	32.4	40.3
11	71.7	99.5	53.5	11.2	15.6
12	70.2	103.0	55.0	12.3	17.5
13	60.9	80.0	36.0	9.0	14.8
14	62.0	87.2	44.2	10.6	17.0
15	63.9	85.0	45.1	8.7	13.7
16	50.8	69.0	30.7	8.7	17.2
17	48.9	72.2	22.4	9.0	18.3
18	52.6	83.8	37.0	10.3	19.5

TABLE XLIX
Girls' Calorie Intakes per Kilogram of Body Weight

<i>Age group</i>	<i>Average daily calorie intake per kg.</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	112.3	145.0	82.8	14.8	13.1
2	103.9	147.0	72.5	18.8	18.1
3	97.5	157.0	72.7	21.2	21.8
4	95.5	140.0	60.0	20.6	21.5
5	85.3	133.0	60.5	20.0	23.4
6	88.5	113.0	58.0	14.9	12.3
7	84.6	110.5	50.2	12.0	14.2
8	75.6	124.0	50.5	14.4	19.1
9	74.9	105.0	47.1	13.6	18.2
10	77.0	118.0	55.5	14.6	18.9
11	63.0	112.5	40.0	10.5	16.7
12	62.0	96.0	41.2	14.0	22.5
13	57.7	81.0	33.5	14.8	25.7
14	52.0	68.8	32.8	8.5	16.3
15	49.5	74.1	27.6	11.4	22.9
16	43.0	60.7	26.6	8.4	19.5
17	44.6	61.0	30.7	8.0	17.9
18	41.9	51.9	29.8	5.8	13.8

Variation in calorie intake with height

From calculations based on all the available evidence up to 1932, members of the Committee on Growth and Development at the White House Conference (1932) came to the conclusion that calories were more closely related to height than they were to age or weight. Fig. 42 shows how the averaged calorie

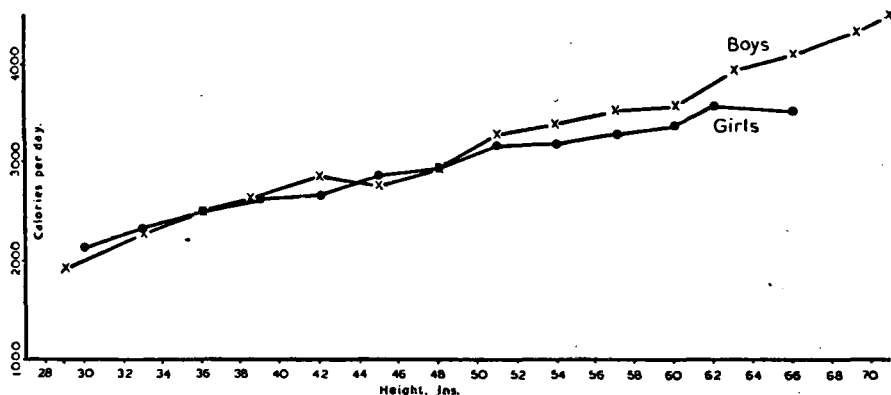


FIG. 42.—Total Calorie Intakes in relation to Height.

intakes of the boys and girls were related to their height. For this purpose the children were divided into 15 groups, each separated by three inches. At first sight it might appear that the curves for boys and girls diverged somewhat later when the calorie intakes were expressed in relation to height, than when they were expressed according to age or weight. The average age at which this sex distinction first occurred, however, was not very different no matter which classification was adopted.

In order to discover whether the calorie intakes of our children were more closely related to height than they were to age or weight, the standard deviation in each height group has been calculated, and also the coefficient of variation.

TABLE L

Boys' Calorie Intakes in relation to Height

Height (in.)	No. of boys	Average daily calorie intake	Maximum	Minimum	Standard deviation	Coefficient of variation
Under 32	6	938	1032	811	68	7.3
32-35	18	1292	1718	933	232	18.0
35-38	23	1490	2340	1152	334	22.5
38-41	15	1654	2321	1257	307	18.6
41-44	28	1853	2508	1250	314	17.0
44-47	34	1778	2574	1312	291	16.5
47-50	27	1963	2546	1152	274	14.0
50-53	39	2278	3184	1644	348	15.4
53-56	37	2403	3131	1845	352	14.6
56-59	39	2547	3635	1596	404	15.9
59-62	29	2589	3475	1840	327	12.7
62-65	25	2964	4528	2191	473	16.0
65-68	37	3128	4121	1363	611	19.5
68-71	54	3327	5221	2394	569	17.1
Over 71	25	3531	5395	2753	578	16.4

TABLE LI

Girls' Calorie Intakes in relation to Height

<i>Height (in.)</i>	<i>No. of girls</i>	<i>Average daily calorie intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
Under 29	6	1011	1206	842	143	14.2
29-32	9	1156	1631	850	249	21.6
32-35	12	1261	1458	1055	122	9.7
35-38	18	1487	2328	1174	293	19.7
38-41	26	1604	2263	991	332	20.7
41-44	20	1643	2026	1154	239	14.5
44-47	24	1816	2543	1269	339	18.7
47-50	28	1983	2971	1524	300	15.2
50-53	37	2197	3725	1589	397	18.1
53-56	41	2201	3165	1649	328	14.9
56-59	44	2250	3481	1583	392	17.4
59-62	48	2378	3291	1539	400	16.9
62-65	99	2582	3745	1775	410	15.9
65-68	57	2532	3528	1095	470	18.5
Over 68	11	2753	3617	2053	517	18.8

The results are shown in Tables L and LI, together with the mean figures and the maxima and minima. Again the maximum was usually twice the minimum, and the coefficient of variation was of the same order as it was when the children were classified according to age and to weight. From these data, therefore, there is no indication that calories are related to height any more closely than they are to age or to weight; indeed, from what has been said on p. 70 the relation would appear to be less close.

Calorie intakes per inch of height in relation to age

When the calorie intakes were expressed per inch of height for each yearly age group, the results shown graphically in Fig. 43 were obtained. The results published previously for men and for women have also been calculated on the basis of calories per inch and they have been included on the graph. It will be seen, if comparison is made with Fig. 41 that, whereas calories per kg. decreased steadily as the boys and girls grew older, calories per inch showed some rather interesting variations. Starting at 38 calories per inch for girls, the figure showed a tendency to rise to the age of 10, and to fall in the later teens and after maturity. At the age of 1-2 years boys' calories per inch were only 36, but they showed an unmistakable trend upwards to somewhere in the region of 48 or 49 at the age of 16. By the time of maturity the calories per inch had begun to fall rapidly, but even in middle age they were still higher than they had been at one year. The Growth and Development Committee of the White House Conference in 1932 predicted that all these trends and changes would be found when sufficient data were forthcoming. Indeed, from a study of all the literature which was available at that time on individual calorie intakes at different ages they calculated that for boys the calories per inch increased with age from 35 at two years to 55 at 17 years, whereas for girls 39-40 calories per inch could be used as a rough estimate of the energy needs at all ages between 6 and 16, while before and after these ages 35-37 calories seemed to be nearer the

correct amount. The actual values obtained here were somewhat higher, except for the older boys, but the general trend of the curves is exactly as was foretold.

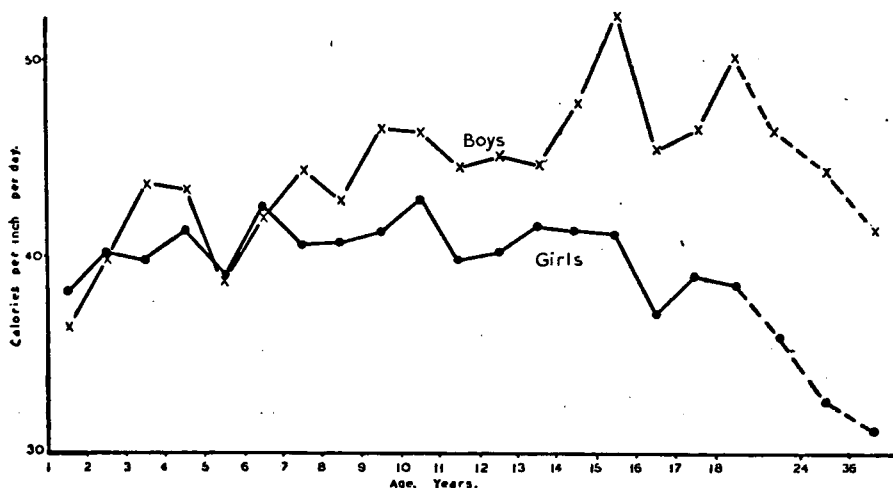


FIG. 43.—Calorie Intakes per inch of Height in relation to Age.

Variation in calorie intake with surface area

It is generally accepted that the number of calories required for basal metabolism increases in proportion to surface area rather than in proportion to body weight, and surface area is usually made the basis of expression when calorie requirements for basal metabolism are discussed (Boothby and Sandiford, 1920, 1929; Dubois, 1936). It seemed reasonable to suppose, therefore, that total calorie intakes might bear a closer relation to surface area than to either weight or height. Fig. 44 shows the average calorie intakes of our children in

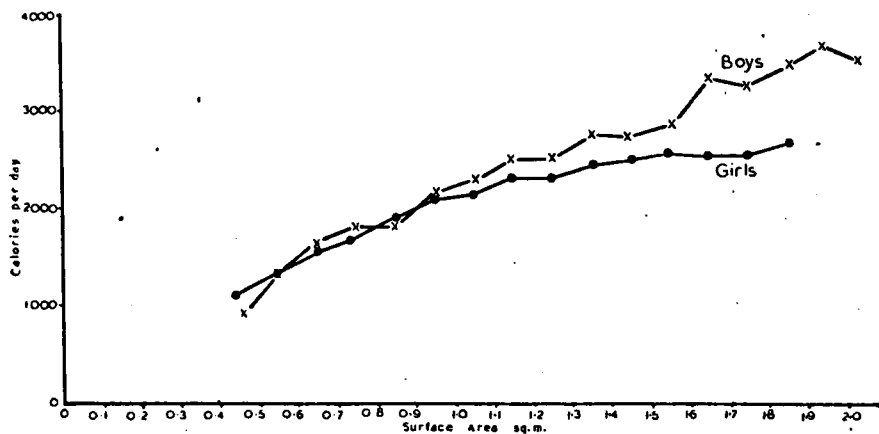


FIG. 44.—Total Calorie Intakes in relation to Surface Area.

relation to their surface area, and Tables LII and LIII record the individual variations when the calories were expressed on this basis. The coefficients of variation are little if any smaller than they were when age, weight and height groupings were used, and the maximum and minimum figures are equally far apart. It must be concluded, therefore, that total calorie intakes do not bear any closer relation to surface area than they do to weight or to height.

TABLE LII
Boys' Calorie Intakes in relation to Surface Area

Surface area (sq. m.)	No. of boys	Average daily calorie intake	Maximum	Minimum	Standard deviation	Coefficient of variation
0.4-0.5	8	971	1095	811	84	8.7
0.5-0.6	28	1384	2284	933	286	20.6
0.6-0.7	30	1627	2340	1202	305	18.7
0.7-0.8	37	1806	2574	1309	335	18.5
0.8-0.9	33	1821	2409	1152	271	14.9
0.9-1.0	38	2191	3113	1644	323	14.7
1.0-1.1	37	2304	3184	1611	330	14.3
1.1-1.2	28	2512	3230	1596	334	13.3
1.2-1.3	39	2509	3527	1840	343	13.7
1.3-1.4	14	2798	3475	2294	346	12.3
1.4-1.5	16	2782	3301	2191	315	11.3
1.5-1.6	19	2944	3764	1754	453	15.4
1.6-1.7	22	3341	4121	2338	510	15.3
1.7-1.8	33	3220	5221	2388	607	18.9
1.8-1.9	33	3427	5395	2641	553	16.1
1.9-2.0	13	3608	4589	2712	572	15.9
2.0-2.1	5	3514	4043	2989	462	13.1

TABLE LIII
Girls' Calorie Intakes in relation to Surface Area

Surface area (sq. m.)	No. of girls	Average daily calorie intake	Maximum	Minimum	Standard deviation	Coefficient of variation
0.4-0.5	16	1114	1463	842	214	19.3
0.5-0.6	25	1371	2012	1055	202	14.8
0.6-0.7	30	1584	2288	991	310	19.5
0.7-0.8	24	1633	2026	1154	217	13.3
0.8-0.9	35	1891	2543	1269	292	15.4
0.9-1.0	33	2126	2971	1524	338	15.9
1.0-1.1	43	2147	3165	1482	329	15.3
1.1-1.2	35	2293	3725	1760	383	16.8
1.2-1.3	25	2317	3481	1713	458	19.8
1.3-1.4	27	2429	3291	1895	332	13.7
1.4-1.5	50	2499	3474	1539	430	17.3
1.5-1.6	63	2587	3745	1718	483	18.7
1.6-1.7	47	2505	3528	1583	411	16.4
1.7-1.8	17	2547	3318	1775	398	15.7
1.8-1.9	11	2635	3617	2053	505	19.2

Fig. 45 shows how the calories per square metre of surface area varied with age, and Boothby and Sandiford's (1929) values for basal metabolism are also given. It will be seen that, whereas the calorie intakes rose as the surface area increased (Fig. 44), calorie intakes per square metre of body surface fell as the children grew (Fig. 45). They fell, too, rather faster than the calories required

for basal metabolism, so that the latter's contribution to the total calories rose from 53 per cent. at six to 58 per cent. at 17 years of age. Above the age of six, boys' calorie intakes per square metre of body surface were always greater than girls', but the basal metabolism accounted for the same fraction in both sexes. It has been suggested that there is a sex distinction in the basal metabolic rates at an even earlier age (Dubois, 1936), and if this is so it seems quite likely that there would be differences in total calorie intakes per square metre of body surface. Our results would not be incompatible with this.

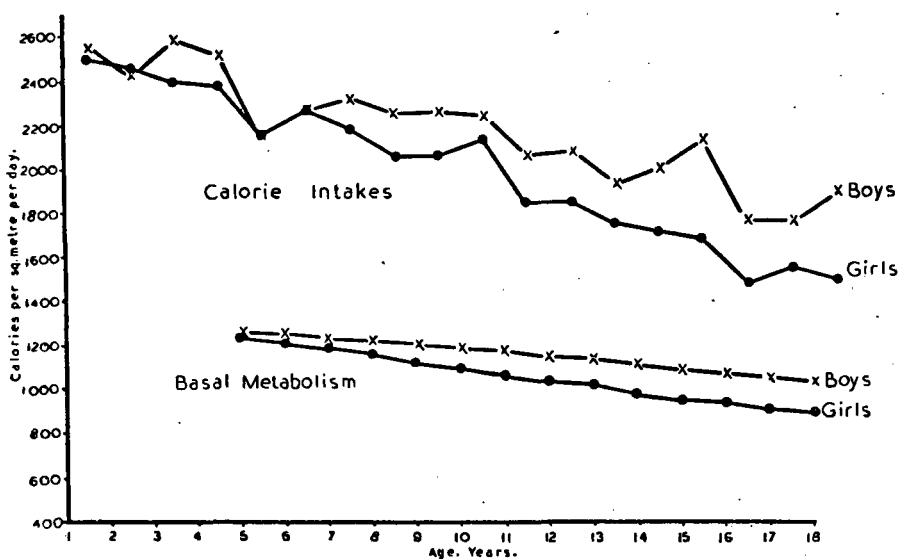


FIG. 45.—Calorie Intakes per Square Metre of Surface Area in relation to Age. (Values for basal metabolism from Boothby and Sandiford, 1929).

Possible explanations of individual variations

Large variations in calorie intake from one child to another have been found whether the children are grouped according to age, weight, height or surface area. Their recognition seems to be of genuine importance to nutrition. Of their reality in both sexes and at all ages there can be no reasonable doubt, but their cause is, as yet, unknown. Dukes (1899) was familiar with the phenomenon, for he says that "different individuals require different amounts of food, and this point is scarcely ever regarded. Some children are capable of consuming, and do not seem to thrive without, a large quantity of food, while the same amount to another would prove a positive poison, and cause ill-health and disease". It is true that the amount of physical work performed influences the calorie intake, and that, on average, manual labourers eat more than sedentary workers, but studies on individual men and women (Widdowson, 1936; Widdowson and McCance, 1936) showed clearly that physical work is not the whole explanation, for a sedentary worker may eat more than a manual labourer of the same age and size. Similarly, although there was some correlation between size and calorie intake, this did not necessarily apply to the individual, and a small boy was often eating more than a big one. It seems to be well established that infants may show considerable fluctuations in their basal heat production from day to day, and one child may differ widely from another (Benjamin and Weech, 1943). The basal metabolism of older children and adults does not vary like this, and variations in their calorie intake cannot be accounted

for by differing basal requirements. It has been shown that by chronic under-nutrition the level of the metabolism can be lowered, and that the organism can maintain itself in metabolic equilibrium with a relatively low calorie intake (Benedict, 1922; Helmreich, 1924), but there is no reason to suppose that any of our children were chronically underfed, and the boy or girl with the lowest calorie intake was just as likely to belong to the highest as to the lowest of our socio-economic groups.

It has been suggested that some people digest their food more efficiently than others, and that different losses in the faeces may account for the varying calorie requirements. Jiménez Díaz and Romeo (1944) have helped to disprove this theory, for they have shown that thin people utilize just about the same proportion of the calories in their food as do those who are fat. Furthermore, the losses of nutriment by the bowel only amounted to 4 per cent. of the energy intake in a group of 18 children, 4-12 years of age, (Macy, 1942), and from the values for standard deviation that are given it is estimated that the range was of the order of 3-6 per cent. Losses in the faeces may vary by 50 or 60 calories from one individual to another, but intakes vary by 1,000 calories or more.

Again, it has been suggested that the solution of the problem lies in the specific dynamic action of foodstuffs. Lusk (1931) has shown that the maintenance of body weight demands 1.3 times as many calories in the form of protein as it does in the form of fat or carbohydrate. A person eating large amounts of protein, therefore, might be expected to need more calories than one who lived largely on fat and carbohydrates. The children who ate most protein, however, did so because they ate the most food, and the specific dynamic action of the extra protein consumed could not possibly have been held to account for the additional calories. To take an example, the biggest protein eater in the whole investigation was a 17-year-old boy, who had 142 g. a day. His daily calorie intake was 4,528. In contrast to him, another 17-year-old boy had exactly half as much protein and 1,754 calories a day. The specific dynamic action of the extra 71 grams of protein that the first boy ate could only have accounted for 67 of the 2,774 calories that the first boy ate more than the second—an insignificant number.

A more feasible explanation of the differences in calorie intakes and requirements from one individual to another seems to be that some are very much more efficient machines than others, and that two people will expend different amounts of energy in performing the same piece of work. This is really a well known fact, for the basis of training for a feat requiring muscular strength lies partly in teaching the efficient use of the available muscular power.

It must be admitted that the present study has been unable to bring to light the laws which relate to the height, weight, size and surface area of any one person to his calorie intake or calorie requirement. It is still not possible, therefore, to predict the food requirement of any individual child or adult from a study of his physical characteristics. Paton and Findlay (1926) appreciated this difficulty twenty years ago, and they came to the conclusion that diet is not the all-important factor in determining growth which it is often supposed to be. Nevertheless, these authors did suggest that below a certain energy intake there is a correlation between the size of the child and the calorie value of the diet. The findings for children of unemployed fathers described in Chapter 17 would bear this out. On the other hand, the present work has revealed the fact that these individual differences among healthy people really exist, and it has, therefore, formulated the problem which future students of individual physiology will have to solve. It is clear that much more research lies ahead of us before we can begin to understand why one person can live on half the calories of another and yet remain a perfectly efficient physical machine.

PROTEIN, FAT AND CARBOHYDRATE

Protein requirements

While calorie intakes may under favourable conditions be taken as a measure of calorie requirements, protein intakes cannot be used in a similar way, and protein requirements, therefore, must be assessed by other means. Metabolism experiments have frequently been used as a measure, but there is a very definite limit to the number of experiments which can be performed, and a single metabolism experiment can only demonstrate the requirements of a particular child at a given age and under clearly defined conditions. No two children are likely to have exactly the same protein requirements, and the requirements of any one child will vary from one age to another. Hence, many experiments would be needed to get anything like a comprehensive idea of children's protein requirements. The number of experiments necessary would be increased still further by the fact that the nature of the protein under investigation and the nature of the rest of the diet both alter the protein requirements very materially. Nevertheless, metabolism experiments are the best guide we have, and the present findings for protein intakes will be discussed in relation to them.

Much of the work on the nitrogen metabolism of children has been directed towards the elucidation of the factors that influence nitrogen retention. Protein intake (Ruatsalainen, 1921 ; Nelson, 1930 ; Parsons, 1930 ; Petrunkina, 1934 ; Wang, Hogden and Wing, 1936 ; Maronay and Johnston, 1937 ; Hawks, Bray, Wilde and Dye, 1942), and the total calories in the diet (Giffhorn, 1913 ; Ruatsalainen, 1921 ; Bartlett, 1926 ; Hubbell and Koehne, 1934 ; Wang, Hogden and Wing, 1936), seem to be the most important factors, but ketosis (Giffhorn, 1913 ; McQuarrie, 1929), the amount of sugar (Talbot and Hill, 1914), and the acid-base balance of the diet (Davis, 1935) cannot be disregarded.

In assessing protein requirements from nitrogen metabolism experiments it must be borne in mind that a positive balance of itself is no indication that the optimum protein intake has been reached. Even on an inadequate diet a child will probably retain nitrogen because a positive nitrogen balance is essential for growth. The minimum protein requirement of children may be defined as the minimum intake that will furnish maximum storage. Increasing the protein intake above that level will not improve the nitrogen retention, but decreasing it will make the positive nitrogen balance less.

One striking point that emerges from a study of nitrogen balances in children is that wide variation in storage occurs in individuals on identical intakes (Porter, 1939). Macy, Hunscher, Hummel, Bates and Poole (1936), from a consideration of the data accumulated from 375 balance experiments on 20 healthy children, found that with identical food intakes there were marked differences in the amount of nitrogen stored by individual children of similar size and age, all in an equally satisfactory nutritional state as judged by rigid medical examinations and physical growth records preceding and during the period of observation. These workers concluded that there are factors other than growth that determine the nitrogen retention. Average figures for requirements may be wide of the mark when applied to an individual, but when numbers of children are being considered, they probably approximate to the truth. From the reported results of nitrogen metabolism experiments on normal healthy children living on diets adequate in calories, it seems that children below school age require 3-4 g. of protein per kg. body weight per day to produce maximum storage (Daniels, Hutton, Knott, Wright, Everson and Scouler, 1935 ; Roubstein, Birger and Freid, 1936 ; Moltschanova, Invenskaja, Ryskina and

Polteva, 1936; Hawks, Bray and Dye, 1938; Hawks *et al.*, 1942). School children appear to require 2-3 g. per kg. (Wang, Hawks and Hays, 1928; Bjeloussoff, 1935; Moltschanova, Porvikova, Kotschegina and Schkral, 1935; Wang, Hogden and Wing, 1936). Bartlett (1926) and Parsons (1930), working on diabetic children aged 4 to 14 years, found that positive nitrogen balances could be obtained on diets containing about 1 g. protein per kg. body weight, and they concluded from this that 1 g. per kg. was sufficient to meet the protein requirements of children in that age category. These authors did not take into account, however, the possibility that greater retentions might have been obtained had the protein intakes been higher. The children might well have grown more, and retained more nitrogen if they had been given more protein in their food. (See Chapter 16.)

Protein intakes in relation to age

Various scales have been put forward for the quantities of protein which children of various ages should have for optimum growth. Some have been expressed on a man-value basis, but only those which give separate scales for

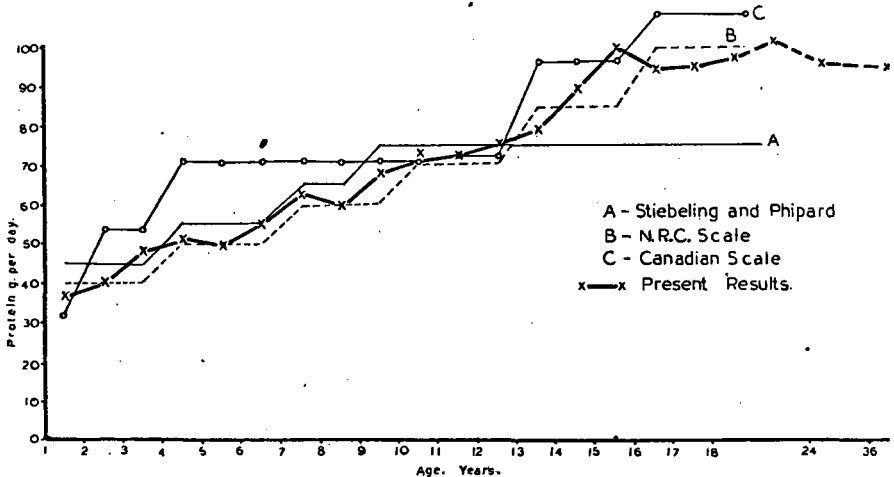


FIG. 46.—Boys' Average Protein Intakes compared with Scales of Allowances.

protein and calories need be considered (see p. 3). Hawley (1927), and Stiebeling and Ward (1933), appreciated the importance of differentiating between calorie and protein requirements on a man-value basis. Later, the Canadian Council on Nutrition (McHenry, 1941) drew up a Canadian dietary standard, and still more recently the National Research Council of the United States (1943) published their recommendations. The average protein intakes of the children taking part in the present investigation are shown graphically in Figs. 46 and 47. The Canadian and American scales of requirements and Stiebeling's scale are also shown. It will be seen that the average amounts of protein in the freely chosen diets of our boys and girls were at all ages very close to the recommended dietary allowances of the National Research Council. For boys they tended to be slightly higher and for girls slightly lower. Stiebeling's scale for boys runs parallel with the National Research Council scale, but it is 5 g. higher until the age of 13. It then remains at 75 g., whereas the National Research Council scale continues to rise, as do also our boys' protein intakes. For girls, Stiebeling's scale, the National Research Council scale, and our results for protein intakes agree very closely. The Canadian scale for boys of all ages,

and for girls of four and five years is high, and our children's intakes fall short of it. For girls above nine, however, it is close to the American scale, and our results for the older girls agree very well with it.

If Figs. 46 and 47 are compared, it will be seen that boys and girls up to the age of eight ate approximately the same amounts of protein. Above that age the boys always ate more than the girls. The intakes of both boys and girls continued to rise until the age of 15, when they attained their maximum level, and thereafter they remained approximately the same or fell slightly. At 15 years the boys were eating 100 g. a day, and the girls 78 g. It should be noted how the results for the older children fit in with the figures previously obtained for the protein intakes of men and women.

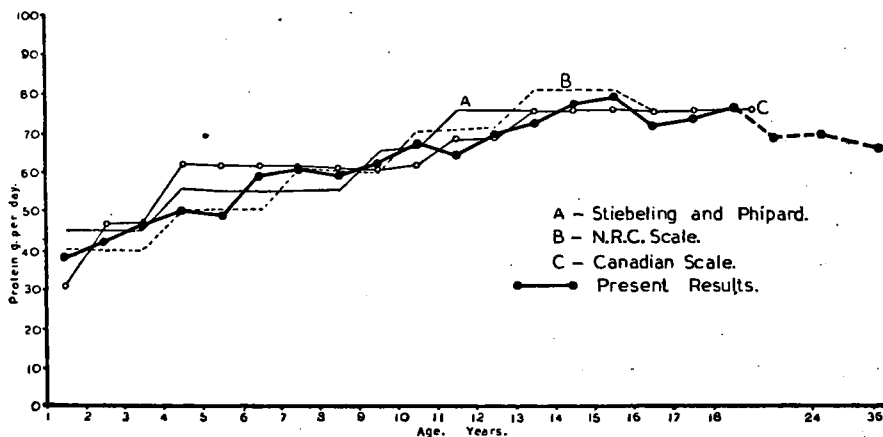


FIG. 47.—Girls' Average Protein Intakes compared with Scales of Allowances.

Discussion of protein intakes has so far been limited to average results. The next question that arises is the individual variation from one child to another. Tables LIV and LV show the average protein intakes in each age

TABLE LIV
Boys' Protein Intakes
(g. per day)

Age group	Average protein intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	37	61	28	7.7	20.8
2	41	57	29	8.2	20.0
3	49	80	29	10.9	22.2
4	52	82	34	11.5	22.1
5	50	64	36	7.4	14.7
6	55	71	26	11.0	20.0
7	63	80	46	8.3	13.2
8	60	86	39	11.4	19.0
9	68	94	53	10.3	15.1
10	73	94	47	13.3	18.2
11	72	112	43	14.6	20.2
12	76	117	57	14.5	19.0
13	79	117	53	15.7	19.8
14	89	132	56	20.5	23.0
15	100	132	78	15.5	15.5
16	94	138	72	17.1	18.2
17	95	142	71	18.4	19.3
18	97	115	67	13.3	13.7

TABLE LV
Girls' Protein Intakes
(g. per day)

Age group	Average protein intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	38	51	27	7.4	19.4
2	42	64	33	8.0	19.1
3	46	72	28	9.4	20.4
4	50	65	22	9.9	19.8
5	49	70	38	8.5	17.3
6	59	80	41	9.6	16.3
7	60	79	47	9.5	15.8
8	59	73	46	7.3	12.4
9	62	87	36	12.1	19.5
10	67	89	50	11.3	16.9
11	64	111	26	14.8	23.1
12	69	99	44	12.4	17.9
13	72	128	43	16.4	22.7
14	77	103	47	13.5	17.5
15	78	113	46	15.6	20.0
16	71	98	49	11.9	16.7
17	73	101	50	13.2	18.0
18	76	97	55	12.0	15.7

group, the highest and lowest values, the standard deviation and the coefficient of variation. It will be seen that the variation in protein intake is very similar to the variation in calorie intake (Tables XLI and XLII). In every age group, both for boys and girls, there was one child who ate about twice as much protein as another. One boy of one year actually ate more than a boy of 14; both were slightly over-weight for their age. The coefficients of variation for protein are of the same order as the corresponding figures for calories, and the 63 men and 63 women previously studied (Widdowson, 1936; Widdowson and McCance, 1936) had protein intakes with coefficients of variation of 24.5 and 18.4 respectively. In contrast to this, Boulton's (1945) study of the diets of eight individual children over four successive weeks showed that the protein intake of an individual child from week to week was remarkably constant.

Protein intakes per kilogram of body weight in relation to age

From the results of balance experiments, Leitch and Duckworth (1937) have constructed a proposed scale of protein allowances for children on the basis of body weight. This is somewhat higher than the scale proposed by the Technical Commission of the League of Nations (1936). Both scales are shown in Figs. 48 and 49, together with the average values for our children's protein intakes calculated in the same way. (Weights, naked, were used for these calculations.) At most ages our children's intakes fell short of Leitch and Duckworth's standards, but they agreed quite well with the League of Nations allowances till the children reached the age of eight. Above that age the intakes fell but not the standards, so that by 14 years the discrepancies were considerable. Both the League of Nations, and Leitch and Duckworth, recommended lower allowances for children between 14 or 15 and 17 years, so that their figures for the latter age were again approaching our experimental findings.

If the total protein allowances recommended by the National Research Council are calculated on the basis of body weight, using Woodbury's (1921) and Baldwin and Wood's (1923) height-weight-age tables, it is found, as might be expected, that the figures obtained are very close to the actual protein intakes

of our children at all ages, and are well below the scale proposed by Leitch and Duckworth. Up to eight years they are approximately the same as the League of Nations standards, but above that age they are very much less.

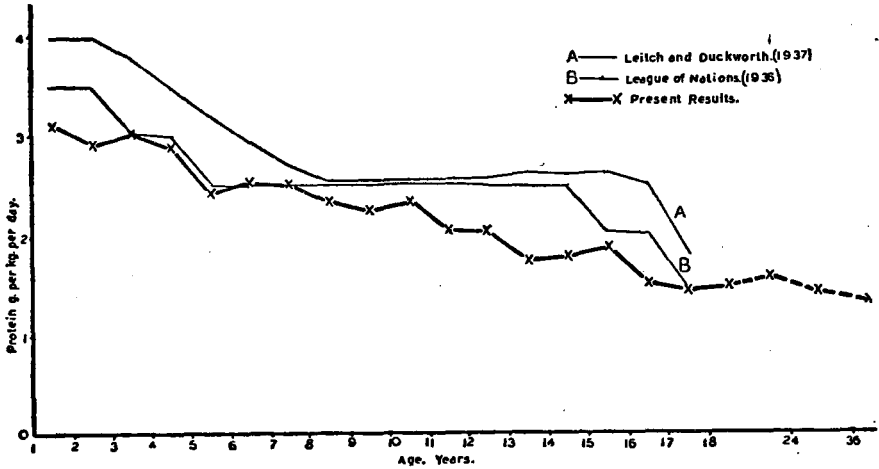


FIG. 48.—Boys' Protein Intakes per kilogram of Body Weight in relation to Age.

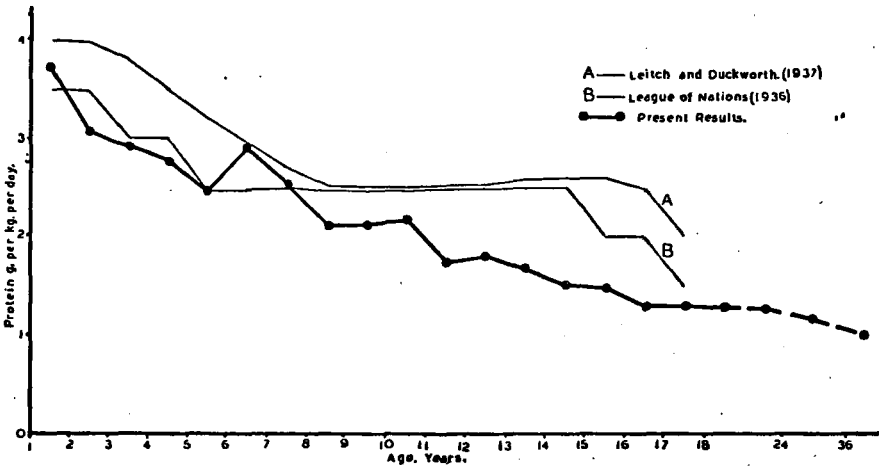


FIG. 49.—Girls' Protein Intakes per kilogram of Body Weight in relation to Age.

It must, therefore, be concluded that the protein intakes of the children taking part in this investigation may or may not have been adequate, according to the scale of protein requirements that is chosen for comparison. It is, however, interesting that they should agree so well with the most recent scale which represents the "combined judgment of more than fifty persons qualified to express an opinion on the subject" (National Research Council, 1943).

Percentage of calories derived from protein

The results of dietary studies in various parts of the world all go to show that the majority of mankind take 10–15 per cent. of their calories in the form of protein. African natives, for example, living on millet, mushrooms, pumpkins and caterpillars, get 10.5 per cent. of their calories from protein (Richards and Widdowson, 1936). Indians subsisting largely on rice derive 10–11 per cent.

of their calories from the same source (Wilson and Widdowson, 1942). This is because cereals, which are always the mainstay of such diets, themselves contain enough protein to provide at least 10 per cent. of their total calorie value.

Breast-fed infants obtain only 6-7 per cent. of their calories from protein, and this suffices them for their period of most rapid growth. The protein of human milk presumably has the highest possible biological value for them, and they are able to absorb and make use of a greater proportion of their protein intake than can older children from mixed diets. It is generally recommended that a higher percentage of protein is desirable for older children, though the optimum level is quite unknown. Sherman (1937) says that "well-planned dietaries for children usually contain between 10 and 15 per cent. of the total energy in the form of protein," but that "little can be said with confidence regarding the best amount of protein for children after the nursing period". Table LVI shows the percentage of

TABLE LVI
Percentage of Total Calories derived from Protein

<i>Age group</i>		<i>Boys</i>	<i>Girls</i>
1	.. ..	13.2	13.7
2	.. ..	12.0	12.0
3	.. ..	11.9	12.2
4	.. ..	11.8	11.9
5	.. ..	11.9	11.7
6	.. ..	11.6	12.3
7	.. ..	12.0	12.4
8	.. ..	11.2	11.7
9	.. ..	11.3	11.7
10	.. ..	12.2	11.8
11	.. ..	11.7	11.5
12	.. ..	11.9	11.8
13	.. ..	11.8	11.6
14	.. ..	11.8	11.9
15	.. ..	12.1	12.4
16	.. ..	12.5	12.3
17	.. ..	12.1	12.0
18	.. ..	11.8	12.5

the total calories derived from protein by children of various ages taking part in this investigation. This is one of the most constant features of the diets. It is evident that a great increase in the intake of protein must take place as soon as children are weaned, for boys and girls of all ages above one year took approximately 12 per cent. of their calories in the form of protein. This figure is very similar to the 12.4 per cent. found by Wait and Roberts (1933) for adolescent girls living in institutions in America, and Bedale's findings for adolescent children at an English boarding school. It is lower than the 15 per cent. found by Holt and Fales (1922c) in their study of the diets of well-to-do families in America, or than Sundström's (1908) and Tigerstedt's (1916) findings for children living in Finland. There is no evidence, however, that our children were any the worse because they did not attain these high levels.

Animal protein intakes

The Technical Commission of the League of Nations (1936) stated that "during growth, pregnancy and lactation some animal protein is essential, and in the growing period it should form a large proportion of the total protein". The Canadian Council on Nutrition (McHenry, 1941) suggested that 50 per cent. of the total protein should be animal protein, and this was the proportion previously suggested by the British Medical Association (1933). Russian work seems to indicate that for children the optimum ratio of animal to vegetable protein is 3 : 2 (Belousov and Gilman, 1934, 1936): this favoured the greatest

nitrogen retention and produced optimal growth and the best general condition. Holt and Fales (1921b), as a result of dietary surveys, considered that two-thirds of the total protein should be of animal origin.

It is generally considered by workers on nutrition that most proteins derived from animal sources are greatly superior to proteins derived from plants, and animal proteins are often referred to as "first class" proteins. This idea is based upon the fact that casein and some other animal proteins have been shown to have a higher biological value than certain plant proteins when made to serve as the sole source of nitrogen for the growing rat. It is well known that some proteins of animal origin, such as gelatin, will not support growth at all, but it should never be forgotten that human beings live on foods and not on synthetic diets, for even the most restricted of human diets contains a mixture of proteins. In India, China and Africa, for example, cereals are supplemented with green

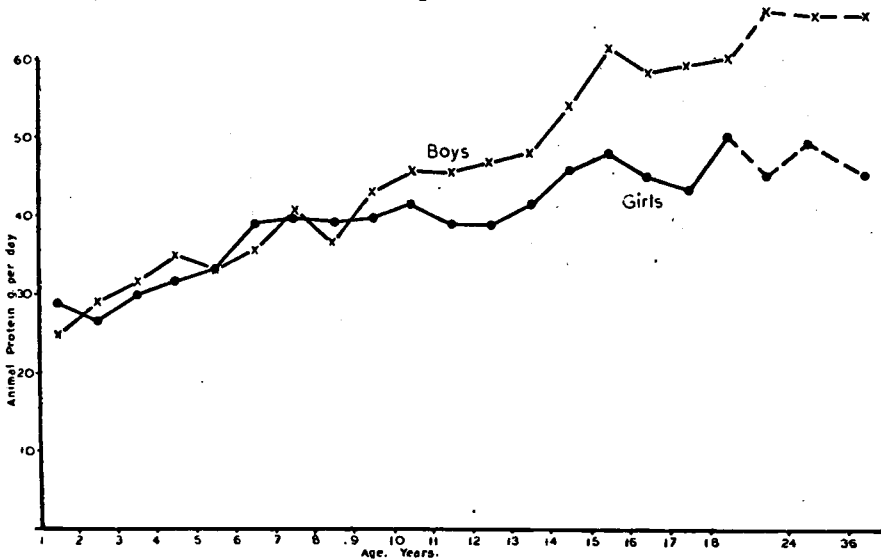


FIG. 50.—Children's Average Animal Protein Intakes.

leaves and legumes, and even the cereals themselves contain more than one protein. Native diets are undoubtedly deficient in many respects—often in calories and usually in calcium—but there is no proof that the poor growth of children living on them is due to a deficiency of animal protein *per se*. It has yet to be proved that a proper mixture of plant proteins may not be as good for maintenance and growth as proteins from animal sources. Nutrition workers of the future will no doubt give up the distinction between plant and animal proteins, and speak in terms of amino-acid requirements. We know that certain amino-acids are essential for the growth of rats consuming an otherwise adequate diet, and for spermatogenesis and the maintenance of nitrogen equilibrium in adult man. We are only just beginning to learn something about the quantitative requirements of the individual amino-acids; and this being so, the animal protein intakes of our children have been calculated, with the full realization that the conception of a higher biological value of animal as opposed to plant protein may pass away as knowledge about amino-acid requirements increases.

Fig. 50 shows our children's average intakes of animal protein, and further details of the intakes are given in Tables LVII and LVIII. Table LIX shows the percentage of total protein which the children took in this form. The curves for animal protein run parallel with those for total protein (Figs. 46 and 47). Boys

TABLE LVII
Boys' Intakes of Animal Protein
(g. per day)

Age group	Average animal protein intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	25	42	17	5.6	22.4
2	29	43	15	6.9	23.8
3	32	54	14	7.5	23.4
4	35	63	21	9.5	27.1
5	33	50	19	6.9	20.8
6	36	57	14	10.6	29.4
7	41	47	25	6.0	14.6
8	37	53	25	8.1	21.8
9	43	69	25	10.7	24.8
10	46	75	24	12.3	26.8
11	46	82	23	13.5	29.4
12	47	81	26	14.4	30.7
13	48	84	20	15.0	31.3
14	54	88	23	17.3	32.0
15	62	96	31	16.5	26.7
16	58	88	34	13.9	24.0
17	59	98	31	16.6	28.2
18	60	79	47	9.7	16.2

TABLE LVIII
Girls' Intakes of Animal Protein
(g. per day)

Age group	Average animal protein intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	29	43	19	6.3	21.7
2	27	40	20	5.7	21.1
3	30	49	16	6.5	21.6
4	32	46	12	8.8	27.5
5	33	50	20	7.6	23.1
6	39	60	27	8.1	20.8
7	40	58	22	9.4	23.5
8	39	54	29	6.7	17.2
9	40	58	18	10.3	25.7
10	42	61	24	9.8	23.2
11	39	63	16	12.3	31.5
12	39	67	24	10.2	26.2
13	42	85	21	12.4	29.5
14	46	66	30	10.2	22.2
15	48	78	19	12.2	25.4
16	45	64	28	8.7	19.3
17	43	69	19	12.6	29.2
18	50	65	30	10.8	21.7

and girls ate approximately equal amounts up to the age of nine; above this age the boys always ate more than the girls. The intakes of both animal and total protein by boys and girls continued to rise until the age of 15, and then remained approximately level or fell slightly. The younger children were deriving 65-75 per cent. of their protein from animal sources, the older children 60-65 per cent. In only three age groups, the 12, 13 and 17-year-old girls, did the figure fall below 60 per cent. It is to be noted from Tables LVII and LVIII that the

individual variation in the amount of animal protein consumed was greater at all ages than the individual variation in the intake of total protein (Tables LIV and LV) or of calories (Tables XLI and XLII), and this was particularly true of the older children. The coefficients of variation are high, and in several age groups one child ate four times as much animal protein as another.

TABLE LIX
Percentage of Total Protein derived from Animal Sources

<i>Age group</i>		<i>Boys</i>	<i>Girls</i>
1	.. ..	68	76
2	.. ..	71	64
3	.. ..	65	65
4	.. ..	67	64
5	.. ..	66	67
6	.. ..	65	66
7	.. ..	65	67
8	.. ..	62	66
9	.. ..	63	64
10	.. ..	63	63
11	.. ..	64	61
12	.. ..	62	56
13	.. ..	61	58
14	.. ..	61	60
15	.. ..	62	62
16	.. ..	62	63
17	.. ..	62	59
18	.. ..	62	66

An attempt was made to see whether the children who ate most animal protein tended to be taller and heavier than those who ate the least. The method previously used for calories (p. 70) was applied, and it was found that, while those who had most animal protein were as often short and light as they were tall and heavy, of the 36 children who ate the least (Tables LVII and LVIII), 23 were less than the average height and 25 less than the average weight. Too much emphasis must not be laid on this, however, for children who had least animal protein usually had low total protein intakes as well, and of the 36 children eating least protein, 24 were below average height and 26 below average weight. Of the 36 children with the highest total protein intakes, 23 were above average height and 26 above average weight. Furthermore, protein tended to run with calories; and children who ate least food ate least protein. There is no way of telling which, if any, of these factors was responsible for the heights and weights found.

Fat and carbohydrate intakes

Most of the dietary surveys previously made on individual children have included estimates of the children's fat and carbohydrate intakes. The results show wide variations in the relative proportions of these two substances in the diets of children living in different countries. They are a reflection of custom and habit among particular groups of people, rather than a measure of true dietary requirements. No standards have been set up for fat and carbohydrate because large variations in their relative proportions are compatible with health. Holt and Fales (1922a) found that American children under six ate over 3 g. of fat per kg. body weight per day. Children over six took about 3 g. per kg. This provided them with 34 per cent. of their total calories (Holt and Fales, 1922c). The carbohydrate intakes of the same children averaged 10 g. per kg. (Holt and Fales, 1922b), and this provided them with an average of 51 per cent. of their total calories (Holt and Fales, 1922c). Other surveys in the United States (McKay, 1926) have confirmed these figures, though Koehne and Morrell (1934), in their study of the diets of girls in hospital for gonorrhoeal vaginitis, but who were otherwise healthy, found that these children liked fat

foods, and that they obtained approximately 43 per cent. of their calories from fat and a similar amount from carbohydrate. In Finland, on the other hand, fat intakes have been found to be very low, and the carbohydrate intakes correspondingly high. Tigerstedt (1916) found that fat contributed a mere 15 per cent. to the total calories, and carbohydrate 75 per cent.

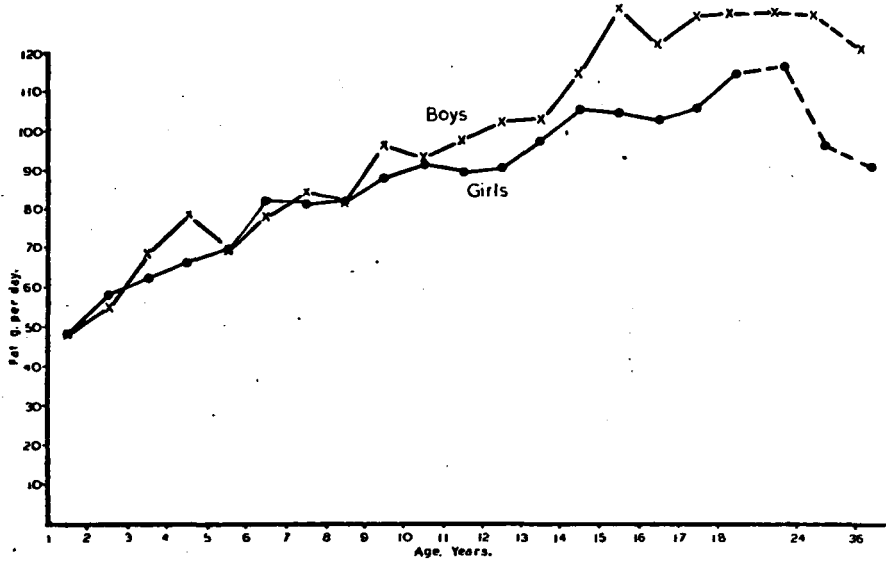


FIG. 51.—Average Fat Intakes.

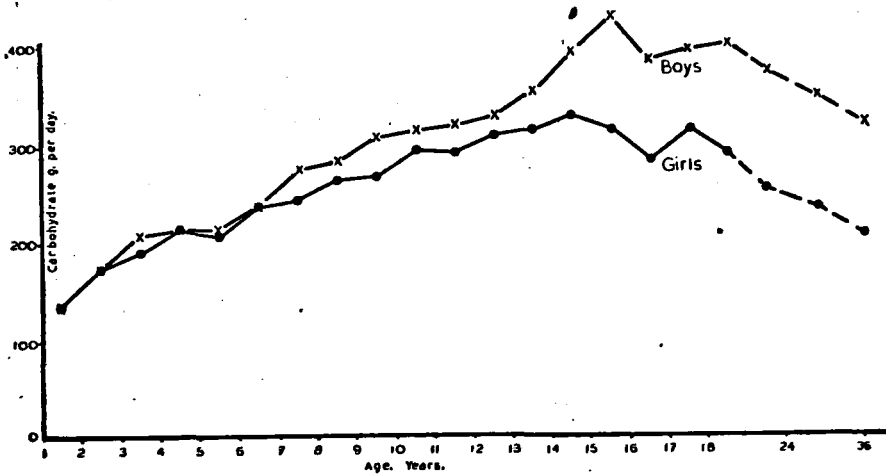


FIG. 52.—Average Carbohydrate Intakes.

So far as English children are concerned, very little information is available. Cathcart and Murray's (1930-31) data on 12 children living in Scotland showed that they were getting about 30 per cent. of their calories from fat and rather more than 50 per cent. from carbohydrate.

Figs. 51 and 52 show the average fat and carbohydrate intakes of our children. Further details about the individual variations are given in Tables LX, LXI, LXII and LXIII. Judging by the averages, boys began to eat more fat than

TABLE LX
Boys' Fat Intakes
(g. per day)

Age group	Average fat intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	49	73	34	11.2	22.9
2	55	90	37	12.8	23.3
3	69	103	44	15.0	21.7
4	79	130	41	21.0	26.6
5	70	104	46	13.7	19.6
6	79	114	50	18.1	22.9
7	85	110	60	12.8	15.1
8	82	135	47	18.8	23.0
9	97	143	58	18.9	19.5
10	94	121	64	13.6	14.5
11	98	140	67	17.4	17.8
12	103	176	68	27.4	26.7
13	104	147	81	21.4	20.6
14	116	179	61	22.6	19.5
15	137	249	84	34.1	25.0
16	123	199	54	27.8	22.7
17	131	218	81	26.8	23.7
18	137	189	98	23.9	17.5

TABLE LXI
Girls' Fat Intakes
(g. per day)

Age group	Average fat intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	48	66	27	11.1	23.2
2	58	90	42	14.9	25.7
3	62	104	44	12.9	20.9
4	67	87	40	12.5	18.7
5	70	108	49	14.8	21.2
6	82	110	59	15.0	18.3
7	82	143	53	19.4	23.7
8	82	151	50	22.7	27.7
9	89	121	50	17.2	19.4
10	92	128	54	19.1	20.8
11	90	155	54	21.6	24.1
12	91	149	62	19.7	21.7
13	99	146	61	21.2	21.5
14	106	176	66	22.6	21.4
15	105	159	57	23.5	22.4
16	99	145	71	17.7	18.0
17	101	131	74	15.8	15.7
18	110	150	75	18.8	17.1

girls before they were ten, and they were taking more carbohydrate when they were seven. Individual variation tended to be greater than for calories or protein. Two boys had more than 200 g. of fat per day. The highest intake among the girls was 176 g. One of these boys and the girl have already been referred to (p. 36) as eating more butter than any of the other children. The other boy, aged 17, the son of a wine and spirit merchant, was less than the average weight for his age, in spite of his 3,844 calories per day. When calculated on the basis of

TABLE LXII
Boys' Carbohydrate Intakes
(g. per day)

Age group	Average carbohydrate intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	135	196	73	28.1	20.8
2	176	266	115	36.4	20.7
3	208	275	150	37.3	18.0
4	218	305	164	42.2	19.4
5	213	283	140	35.4	16.7
6	239	314	137	34.2	14.4
7	275	380	188	54.5	19.9
8	283	382	202	46.8	16.6
9	308	405	251	36.2	11.8
10	315	420	190	62.8	19.9
11	320	439	217	63.6	19.9
12	331	496	258	52.5	15.9
13	357	491	227	65.4	18.3
14	396	563	221	59.8	15.1
15	429	627	282	91.5	21.4
16	384	547	129	95.0	24.8
17	395	554	164	83.3	21.2
18	402	620	198	96.9	24.1

TABLE LXIII
Girls' Carbohydrate Intakes
(g. per day)

Age group	Average carbohydrate intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	135	205	87	29.2	21.6
2	175	245	133	30.6	17.6
3	188	271	108	41.2	21.9
4	217	342	123	50.4	23.2
5	209	310	148	46.2	22.2
6	240	318	185	45.7	19.1
7	241	321	151	40.4	16.8
8	263	349	200	42.0	16.0
9	264	371	180	48.4	18.5
10	296	463	203	59.3	20.1
11	291	460	205	61.8	21.2
12	308	459	210	62.4	20.3
13	315	452	201	59.0	18.8
14	327	448	208	64.0	19.7
15	314	544	159	68.4	21.5
16	281	373	179	58.0	20.6
17	312	435	171	54.9	17.6
18	287	425	200	48.4	16.9

body weight (Fig. 53), boys' fat intakes were approximately equal to those of girls' at all ages, falling from 4.5 g. per kg. at the age of one year to 2 g. per kg. at 16; this seems to dispose of the idea that young children cannot tolerate fat. The carbohydrate intakes per kg. of body weight were also about half as great at 16 and 17 years as they were at one year, but from seven years old upwards boys always ate more carbohydrate per kg. than girls. The sex differences in the number of calories consumed per kg. of body weight, which have already been noted and discussed (Fig. 41, p. 75), were therefore due primarily to carbohydrate and not to fat.

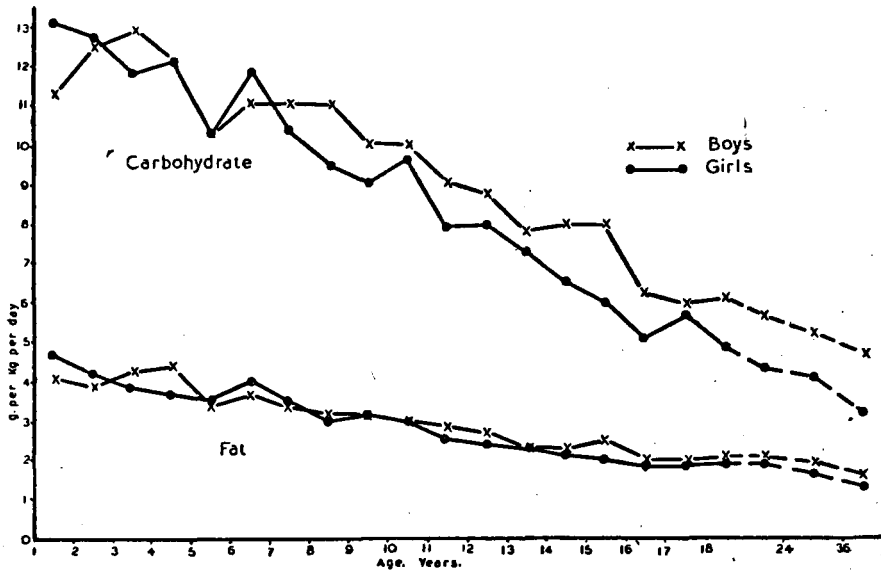


FIG. 53.—Fat and Carbohydrate Intakes per kilogram of Body Weight in relation to Age.

TABLE LXIV
Percentage of Total Calories derived from Fat and Carbohydrate

Age group	Boys		Girls	
	Per cent. calories from fat	Per cent. calories from carbohydrate	Per cent. calories from fat	Per cent. calories from carbohydrate
1	39.1	47.7	38.3	48.0
2	36.6	51.3	37.8	50.0
3	37.6	50.5	37.6	50.2
4	39.1	49.1	36.4	52.7
5	37.6	50.5	38.1	50.0
6	37.8	50.5	38.1	49.6
7	36.5	51.5	38.0	49.6
8	35.3	53.5	36.2	52.1
9	36.9	51.8	38.2	50.1
10	35.6	52.2	36.5	51.7
11	36.4	51.8	36.2	52.3
12	36.1	52.0	35.8	52.4
13	35.2	53.0	36.7	51.5
14	35.3	52.9	37.0	51.1
15	36.8	51.1	37.8	49.8
16	36.8	50.3	39.0	48.7
17	37.8	50.1	37.1	50.9
18	37.6	48.0	40.7	47.0

Table LXIV shows the distribution of calories between fat and carbohydrate, and it is worthy of note that the percentage of calories derived from these two sources was the same at 18 years as it was at one year. Age made no difference to the relative amounts of fat and carbohydrate in the diets, and indeed above the age of one year it made no difference to the percentage of calories derived from protein (Table LVI, p. 88). It may be stated that British children of the social classes studied here were obtaining, during the years 1935–1939, an average of 12 per cent. of their calories from protein, 37 per cent. from fat and 51 per cent. from carbohydrate, and this was true whatever their ages.

CHAPTER 7

CALCIUM REQUIREMENTS, CALCIUM ALLOWANCES AND CALCIUM INTAKES**Calcium requirements**

"Children require about 1 gram of calcium per day." "From 3-14 years of age the calcium requirement is 0.77-0.99 gram daily." These are common enough statements in modern text books on nutrition, and probably few who read them realize the complexity and difficulties confronting anyone who sets out to determine the amounts of calcium that children should have. The first difficulty concerns the word "requirement" itself which, as already stated on p. 1, has been used in several different senses. In the above passages the authors are referring to "optimum requirements" (see Chapter 1) or to what others have termed "allowances" (see p. 102) for they are thinking of the amounts of calcium which children's diets should contain to cover all the ordinary eventualities.

DETERMINATION BY MEANS OF SKELETAL GROWTH RATES

Leitch (1937) and Shohl (1939) have attempted to calculate the amount of calcium in the body at different ages and so to arrive at the average quantities acquired and retained by the growing child per annum. Several assumptions, however, are necessary if this method is to be used because no direct analytical data on the whole body are available. Leitch assumed that the fresh weight of the skeleton bore an approximately constant relationship to the body weight throughout growth, and that in the skeleton the amounts of calcium and water varied inversely. Unfortunately, she did not give the authority for her figures for skeletal water. Shohl's figures were based on "the variable increase in weight, increase in percent. of skeleton, and increase in percent. of calcium and the chemical maturity". There were large discrepancies between the values obtained by the two authors, Leitch's figures for adolescent boys being about double those of Shohl. The latter's results were probably much more nearly correct, for they fall reasonably into line with estimates of calcium retentions obtained from metabolism studies. Leitch's conclusions have been heavily criticized (Outhouse, Kinsman, Sheldon, Twomey, Smith and Mitchell, 1939). Even at its best, however, this method does not provide any information as to the amount of calcium that must be consumed to ensure that the calculated "annual increment" shall be added and this, after all, is the real desideratum. To obtain a figure for intake, Leitch took the estimate for calcium required for skeletal growth given in some unpublished data of Stearns, arbitrarily doubled it and added 10 mg. per kg. body weight for maintenance. Both these assumptions can be and have been criticized (Fairbanks and Mitchell, 1936; Kinsman, Sheldon, Jensen, Bernds and Outhouse, 1939; and see below.)

DETERMINATION BY MEANS OF BALANCE EXPERIMENTS

Metabolism experiments have provided a second method of estimating children's calcium needs. The calcium intakes are raised until a further increase brings about no further rise in the amount of calcium retained. The lowest intake promoting maximum storage has been taken as the requirement. The term "requirement" as thus defined is really the minimum requirement, and must not be confused with the optimum requirement or with the term "allowance". Reviews of the literature on the calcium balance of children have been made by Sherman and Hawley (1922), Czerny and Keller (1923-28), Schmidt and Greenberg (1935), Leitch (1937), Shohl (1939), Duckworth and Warnock (1942), and Holmes (1945).

Metabolism experiments are exceedingly tedious to carry out, and they are, of necessity, confined to a relatively small number of children, so that the investigator is at once confronted by the difficulty of individual variations. "Every individual has a characteristic physiological capacity to utilize and store chemical elements from ingested foodstuffs, predetermined by heredity, and difficult to evaluate, for it may be modified by life's experiences." (Macy, 1942). Even if carried out with the best possible technique, all that a metabolism experiment can show is the calcium absorption and retention of a certain child at a particular period of its life, at a given level of calcium intake and eating a particular combination of foods. Another child of the same age, height and weight, eating exactly the same diet and living under the same environmental conditions, may have quite a different level of absorption, excretion and retention of calcium. Furthermore, the same child may behave quite differently on another occasion (Porter-Levin, 1933 ; Hunscher, Hummel and Macy, 1936 ; Outhouse *et al.*, 1939).

It is generally agreed that children require more calcium per kg. body weight than do adults, to allow for bone formation during the periods of rapid growth. Age, height, weight and skeletal maturity must therefore be taken into account in determining a child's minimum calcium requirements. Further, the actual amount of calcium that must be eaten to promote maximum storage depends upon yet other factors, both physiological and chemical, and among these the previous nutritional history of the individual has been shown to be of prime importance (Wang, Kaucher and Frank, 1928 ; Daniels, Hutton, Knott, Everson and Wright, 1934 ; Daniels, Hutton, Knott, Wright and Forman, 1935 ; Macy, 1942). Experimental work on rats has confirmed this observation (Fairbanks and Mitchell, 1936 ; Rottensten, 1938).

Nicholls and Nimalasuriya (1939) have presented evidence that Sinhalese children frequently get no more than 0.2-0.4 g. of calcium a day, and yet they grow satisfactorily and look normal, and their bones resemble those of European children in structure and composition. The authors admit that the children are small of stature, but put forward the view that a process of racial adaptation has taken place, enabling tropical peoples to survive on diets which would not support an European population. If it is true that tropical peoples' requirements are lower than Europeans', then it seems reasonable to suppose that a similar process of adaptation should have lowered the requirements of poor people in any country who have for generations lived on diets which contained less than the optimal amounts of calcium. There is evidence that such persons do in fact absorb more calcium from any given diet than their well nourished counterparts, but it is suggested that this can be explained by the paucity of their stores of calcium, and that there is no need to invoke the phenomenon of adaptation. Be that as it may, it is clearly impossible, even apart from the problem of individual variations, to give figures for the minimum requirements of children which will apply to all parts of the world, and, in trying to assess children's minimum requirements by means of balance experiments, it is essential only to consider those studies which have been carried out on children with a good nutritional background.

VITAMIN D AND SEASONAL EFFECTS

It is still uncertain how much, if any, vitamin D may be required by adults (Kroetz, 1927 ; Henderson and Kelly, 1929-30a, b ; Hunscher, Donelson, Erickson and Macy, 1934 ; McCance and Widdowson, 1942a ; McKay, Patton, Pittman, Stearns and Edelblute, 1943), but there is no doubt that vitamin D has a profound influence on the calcium absorption and retention of growing animals and of children (Mellanby, 1925 ; Daniels, Stearns and Hutton, 1929 ;

Jeans and Stearns, 1938). Both food and sunlight must be taken into account in assessing the available supplies of vitamin D, and hence season, latitude, locality and taste all affect the efficiency with which a child will utilize the calcium in his food (Hess, 1925 ; Tisdall and Brown, 1929). It has recently been shown, moreover, that some adults absorb much more calcium in the late summer than they do in the early spring, and that this is unlikely to be due to variations in the supply of vitamin D (McCance and Widdowson, 1943a). It is possible that children may also be subject to this seasonal effect. Nicolaysen (1943) has postulated that there is some endogenous factor—apart from vitamin D—which promotes calcium absorption in growing rats. Other species have not so far been investigated and for the present, therefore, Nicolaysen's theory cannot very well be taken into account in assessing children's needs for calcium.

Lastly, there seems to be evidence that there is a seasonal rhythm in children's growth, and that the greatest gains in weight occur in the autumn, and in height in the spring (Nylin, 1929 ; Orr and Clark, 1930 ; McKay and Brown, 1931 ; Roberts, 1935 ; Fitt, 1941). It is not, however, clear how these rhythms would, or should, affect a child's need for calcium. Outhouse and Mendel (1933), for example, have suggested that rapid growth in height is associated with the laying down of soft rather than of skeletal tissue, and therefore with smaller rather than greater demands for calcium.

CHEMISTRY OF CALCIUM ABSORPTION

The chemical properties of calcium render it liable to precipitation in the intestine and this fact must be taken into account in any consideration of calcium requirements—whether minimal or optimal. Thus, E. Mellanby (1925) proved that oatmeal contained some substance which interfered with proper bone calcification. Harrison and E. Mellanby (1939) showed that this anti-calcifying factor was phytic acid. Calcium forms a phytate which is insoluble at the *pH* of the intestine, and hence the phytic acid in oatmeal will precipitate calcium in the intestine and prevent its absorption. The seeds of wheat also contain phytic acid, particularly in the outer covering layers, and it has been shown (McCance and Widdowson, 1942a) that the nature of the flour, *i.e.* whether it be wholemeal or white, determines to some extent the calcium requirements of adults. The first experimental work of this sort on children was that of Burton (1929-30). She set out to compare the effects of oatmeal and white wheat flour on the absorption and excretion of calcium, but unfortunately her experimental periods were very short, the diets did not contain much of the cereal, and the intakes were not closely similar in the periods to be compared. Nevertheless her results showed that oatmeal depressed the absorption and retention of calcium. During the past few years a great deal of work has been carried out in Denmark on the effect of phytic acid on calcium absorption, and this has included metabolism experiments on two children aged 10 years (Andersen and Hoff-Jørgensen, 1946). These authors found that the absorption and retention of calcium was greatly reduced, and in one case a negative calcium balance was obtained, when the diet contained 25 per cent. of its phosphorus in the form of phytic acid. Figures for calcium requirements are, therefore, meaningless unless the nature of the staple cereal and the quantity of it consumed are specified. It is an unfortunate combination of circumstances that in those countries where the supply of milk is grossly deficient the diets very often consist largely of whole cereals.

Calcium is well known to form an insoluble oxalate, and if the diet includes foods containing oxalates such as spinach or rhubarb, a chemically equivalent amount of calcium will be precipitated in the intestine, and little of it will be absorbed. This has been demonstrated to be true for children (Bonner *et al.*,

1938), and also for rats (Fincke and Sherman, 1935 ; Tisdall and Drake, 1938 ; Fairbanks and Mitchell, 1938 ; Kohman, 1939). The poor utilization of the calcium of vegetables found by Sherman and Hawley (1922) was almost certainly due to the inclusion of spinach among them. Both spinach and rhubarb also contain calcium, but oxalate is present in excess (Kohman, 1939). The calcium in these vegetables, therefore, will be incompletely absorbed, and should really be discounted in any assessment of calcium intakes. The excess oxalate, moreover, will interfere with the absorption of some of the calcium from the rest of the diet.

Phosphates also hinder calcium absorption to a certain extent (McCance and Widdowson, 1942b), but not so much as phytates or oxalates. There is no doubt that a high Ca/P ratio in the diet favours calcium absorption, but its exact significance for children has never been assessed.

Finally, calcium forms insoluble soaps with the fatty acids, and there is some evidence that an increased intake of fat leads to an increased elimination of calcium soaps in the faeces, even in normal children (Macy, 1942). The fat in Macy's experiments was derived from milk, and the calcium intake was increased as well as the fat. An increased excretion of calcium in the faeces was, therefore, to be expected. Other workers (Aub, Tibbetts and McLean, 1937) found that the excretion of calcium by normal young adults was unaffected by large amounts of fat in the diet. A considerable amount of work has been carried out on rats (Lowe and Steenbock, 1936 ; McDougall, 1938 ; Jones, 1940 ; French, 1942 ; Booth, Henry and Kon, 1942 ; French and Elliott, 1943 ; Bunkfeldt and Steenbock, 1943), but the results have been very contradictory and it is still impossible to make an unequivocal statement about rats, and much less about the applicability of such findings to man. One of the more recent observations is that fats may improve or depress the absorption of calcium according to the Ca/P ratio of the diet, and this finding may help to clarify the issue.

In contrast with phytates, phosphates, oxalates and possibly fats, which interfere with calcium absorption, other substances have been shown to facilitate it. Protein, for example, promotes the absorption of calcium (McCance, Widdowson and Lehmann, 1942) because calcium phosphate is rendered soluble by the presence of amino-acids in solution (Lehmann and Pollak, 1942). Lactose has been shown to increase calcium retention in children (Mills, Breiter, Kempster, McKey, Pickens and Outhouse, 1940), not by altering the amount absorbed, but by decreasing the amount excreted in the urine. Lactose might be expected to facilitate absorption also, since it has been shown that the pH of the intestinal contents of rats is lowered by adding lactose to the diet (Robinson and Duncan, 1931). The inclusion of citrates in the diet has also been thought to improve calcium absorption in children (Chaney and Blunt, 1925 ; Shohl and Butler, 1939), though the evidence is somewhat fragmentary.

Since the absorption and retention of calcium is influenced by so many dietary factors, it is not surprising that the calcium in some foods has been found to be more readily available than the calcium in others. Many investigations have been carried out on growing animals and on children to compare the availability of the calcium in different foods and also in different medicinal preparations. Most workers have adopted milk as their standard source of calcium. Spinach, of course, has always shown up very badly (Fincke and Sherman, 1935 ; Fairbanks and Mitchell, 1938 ; Kohman, 1939). Dicalcium phosphate (Kempster, Breiter, Mills, McKey, Bernds and Outhouse, 1940), calcium lactate and triple calcium phosphate (Stearns and Jeans, 1934 ; Aykroyd and Krishnan, 1938, 1939 ; Pierce, Dags, Meservey and Simcox, 1940), seem to be well utilized by children. Bone meal appears to be a slightly better source of calcium than bone

ash, possibly because of the protein it contains (Yeh and Adolph, 1939), but bone ash always improved the calcium retention of poor Chinese adolescent boys (Hsu and Adolph, 1940). Experiments in which different types of milk have been compared have suggested that evaporated milk is as good a source of calcium as fresh milk (Willard and Blunt, 1927; Kramer, Latzke and Shaw, 1928; Jeans and Stearns, 1933).

PRACTICAL APPLICATIONS AND OTHER CONSIDERATIONS

It will be clear from what has been said that the absorption of calcium depends upon many factors, and all of these must be taken into account in planning a metabolism experiment to find out a child's minimum calcium requirement. Firstly, the child must be in a good nutritional state before the beginning of the experiment; secondly, a plentiful supply of vitamin D must be provided, and no two children will require the same amount; thirdly, the diet should contain little or no phytic or oxalic acids, nor should there be a great excess of phosphates in the diet; furthermore, the proportions of protein, fat and carbohydrate in the diet should be clearly defined. If either of the first two conditions is unfulfilled, the figure for the requirement will be higher than the true "minimum" requirement. Metabolism experiments carried out during the past 10 years—and since these various factors have begun to be appreciated—have tended to indicate that the minimum requirements are lower than had previously been supposed. Thus, Sherman and Hawley (1922), on the basis of their experiments on children between three and 14 years of age, concluded that maximum storage was not attained until the children were receiving one gram of calcium daily and their diets included one quart of milk. In the light of more recent work (*vide infra*) this figure seems very high, and the best way of explaining it is to suppose that the children had not been in a good state of nutrition before the experiment began. The same explanation almost certainly holds for the very high calcium retentions of the 23 adolescent girls taking part in Wang, Kaucher and Wing's (1936b) study. These girls came from homes of limited means where hygienic conditions were only fair, and they were nearly all under weight (Wang, Kaucher and Wing, 1936a). No precautions were taken to remedy their state of malnutrition before the start of the metabolism study, which lasted for six days only.

Daniels *et al.* (1934), came to the conclusion that children were able to absorb and retain as much calcium from a pint as from a quart of milk daily. They carried out metabolism experiments on 10 children between 3 and 5 years. When the diet contained one pint of milk and the average calcium intake was 0.8 g. a day, the children absorbed 0.22 g. and retained 0.15 g. When the intake was increased to 1.34 g., the absorption was 0.26 g. and the retention 0.16 g. Even in this experiment, however, some of the children may have been suffering from previous calcium starvation. Outhouse *et al.* (1939) and Kinsman *et al.* (1939) overcame this difficulty by feeding their children with generous quantities of dicalcium phosphate for a long time before they began their experiment. They studied the calcium metabolism of 11 pre-school children for 28 weeks at different levels of calcium intake. They found that a daily intake of about 0.6 g. a day was sufficient to provide maximum retention, which amounted to about 0.125 g. a day. On an intake three times as high the children retained no more calcium.

By far the most comprehensive series of metabolism experiments is that of Macy and her co-workers. The results are summarized in Macy's (1942) book. The diets which were used were generous mixed diets, including about a pint of milk daily, and containing little or no phytic or oxalic acids. The supply of vitamin D was thought to be adequate, and the children were healthy and grew normally. A total of 593 five-day metabolism experiments were carried

out on 29 children between 4 and 12 years. There seem to have been no consistent differences between the average results for the various ages studied, though variations in behaviour from one child to another were well recognized. On an average daily intake of 0.92 g. of calcium, 0.64 g. was excreted in the faeces. Hence the children absorbed at least 0.28 g., which is 30 per cent. of the intake. They may have absorbed more, only to re-excrete it into the intestinal tract as an integral part of the digestive juices, but this complication need not be considered here. Of the absorbed calcium, 0.10 g. was excreted in the urine, and 0.18 g., or 20 per cent. of the intake, was retained. This retention is rather higher than that found by Outhouse *et al.* (1939) and Kinsman *et al.* (1939), and in this instance it does not seem likely that there was any previous calcium deficiency. Macy's results do not prove that her children required exactly 0.92 g. of calcium a day, but they do provide valuable confirmation of the fact that when well-nourished children are receiving about the right amount of calcium to meet their requirements they will store approximately 20 per cent. of the calcium intake, under her stated conditions. This is far removed from 50 per cent., which was the proportion used by Leitch (1937) to calculate children's calcium requirements from the weight of the skeleton at different ages (see p. 96), and yet her figures are too high—not too low. Even the calcium in milk appears to be utilized only to the extent of 20 per cent. by children on mixed diets (Kinsman *et al.*, 1939). Infants are able to retain a higher proportion of the calcium of breast-milk, but babies fed on cow's milk rarely seem to store more than 30 per cent. of their calcium intake (Leitch, 1937).

There is no clear evidence in the literature that calcium absorption and retention, whether expressed as an absolute amount or as a percentage of the intake, alter significantly between 5 and 12 years. If they do not, then the calcium requirement per unit of body weight or height must obviously fall off as age increases. For older children the information is much more meagre. No metabolic study has yet been carried out on adolescents who were known to be in a satisfactory state of nutrition before the beginning of the experiment. Duckworth and Warnock (1942) state with confidence in respect of calcium that "the percentage net absorption is lowest in young children and improves with age. The greatest efficiency is found about the time of puberty in girls, and constitutes an effective adaptation to the increased rate of growth at that time". This assertion seems to be based on metabolism studies on eight 12-year-old girls and three of 13 years. The source of their information is not given, but it seems likely to have been one of the earlier experiments, carried out before the importance of the previous nutritional history was appreciated. The results, therefore, cannot be compared with those subsequently obtained by other workers on younger children who were given a generous diet for some time before the experiment began. From a consideration of some calcium balances on six adolescent girls, three convalescing from a childhood type of tuberculosis and three with minimal adult type tuberculous lesions, Johnston (1940) concluded that sexual maturity in the girl is accompanied by a fall in the retention of calcium, and Shohl (1939) was of the same opinion, for he suggested that children of 8–12 years old might be expected to retain more than 25 per cent. of their intakes, but adolescents only 15 per cent.

It must be concluded, therefore, that we shall never be able to predict the minimum calcium requirement of any individual child. The best we can hope to do is to give some rough idea of the average requirement; for this purpose, the data so far provided by metabolism experiments cannot legitimately be used because at every age they are too scanty, and they are, therefore, unduly influenced by the individual variations of the experimental subjects. Estimates, however, have a certain value, if only as skittles for future workers to knock down, and if Shohl's figures for the average amounts of calcium in the

body are adopted,*and the average calcium retention is assumed to be 20 per cent. of the intake, the minimum calcium requirements under ideal conditions would be as follows :—

Age (years)						Minimum Calcium Requirement (g. per day)
0-4	..	..	..	..	..	0.5
5-7	..	..	..	..	..	0.7
8-12	..	..	..	..	..	0.8
13-18	..	..	..	..	..	0.95

Calcium allowances

Discussion has so far been limited mainly to the minimum calcium requirement of the perfectly nourished child living under conditions ideal for calcium absorption. This is largely a theoretical consideration, for the great majority of children are far from being perfectly nourished, and even if they were they might be eating foods which interfere with calcium absorption. They will, therefore, require more than the theoretical and minimal amounts of calcium. Furthermore, since children vary in their ability to utilize the calcium in their food, and since there is no way of telling whether a child will utilise it well or ill unless he has been subjected to a metabolism experiment, it must be assumed in making any recommendation that all are poor absorbers of the element, for as Sherman (1937) pointed out, "we should always give the child the benefit of any scientific doubt".

Hence, while figures for the minimum requirements of calcium have tended to be reduced as knowledge about calcium metabolism has increased, estimates of the amounts of calcium which children's diets should contain, *i.e.* their so-called "allowances", have remained high. The Committee of the Technical Commission of the Health Organization of the League of Nations (1936) did not state specifically what they considered the calcium allowances of children should be, but they recommended that children up to five should receive 1,000 grams of milk a day. If they had this amount, their calcium intake from milk alone would be 1.2 g. Stiebelling and Ward (1933) and Stiebelling and Phipard (1939) suggested that children of all ages up to 15 should have one gram of calcium a day. More recently the Canadian Council on Nutrition (McHenry, 1941), the National Nutrition Council, South Africa (1942) and the National Research Council of the U.S.A. (1943) have put forward their views on the matter. The American and Canadian committees have made the same allowance for all children up to 11 or 12 years—namely, one gram a day. The South African committee was rather less generous, and suggested 0.8 g. The Canadian Council recommended that the allowance be increased to 1.25 g. a day throughout adolescence. The National Research Council advocated 1.3 g. a day for girls between 13 and 15 years, and 1.4 g. a day for boys between 13 and 20. This greater allowance for boys is presumably to allow for their bigger skeletal growth. If we assume for purposes of argument that individual idiosyncracies and the effect of phytic acid and oxalates might reduce the absorption from 20 per cent. to 15 per cent. of the intakes, then the optimum calcium requirements based on Shohl's data would be as follows :—

Age (years)						Optimum Calcium Requirement (g. per day)
0-4	..	..	..	..	..	0.7
5-7	..	..	..	..	..	0.9
8-12	..	..	..	..	..	1.05
13-18	..	..	..	..	..	1.25

Calcium intakes

In any consideration of calcium intakes it must be realized that an individual's calcium intake on a freely chosen diet provides little clue to the amount of calcium he should have, and no clue at all as to the amounts which other children of the same age require or should be allowed. We have no "appetite" for calcium, and there is no reason to suppose that individual intakes and requirements run together. Nevertheless, the average intakes of children who are well up to accepted standards of height and weight do at least indicate that similar intakes would enable other children on similar diets to develop equally well on the average.

The consumption of milk, more than of any other food, determines the calcium intake, and a child who likes milk, and who drinks plenty of it, will almost certainly have a calcium intake above the average. Milk provided our children with more than 50 per cent. of the total amount of calcium in their diets at all ages, and below 11 years of age it provided more than 70 per cent. Cheese, which is of all common foodstuffs the richest in calcium, provided the children below 12 years of age with about 3 per cent. of their calcium, and those over 12 with some 6 to 10 per cent. Even the boy eating most cheese in this survey only got 3 per cent. of his total calcium from that source, for he had $1\frac{1}{2}$ pints of milk a day as well.

In calculating our children's calcium intakes, no allowance has been made for the calcium in tap-water, and the results are therefore likely to be lower than the true intakes in many cases. About half the children lived in London (see Table II, p. 7), and they were probably obtaining about 0.1 g. of additional calcium a day from their water supply (Widdowson and McCance, 1943).

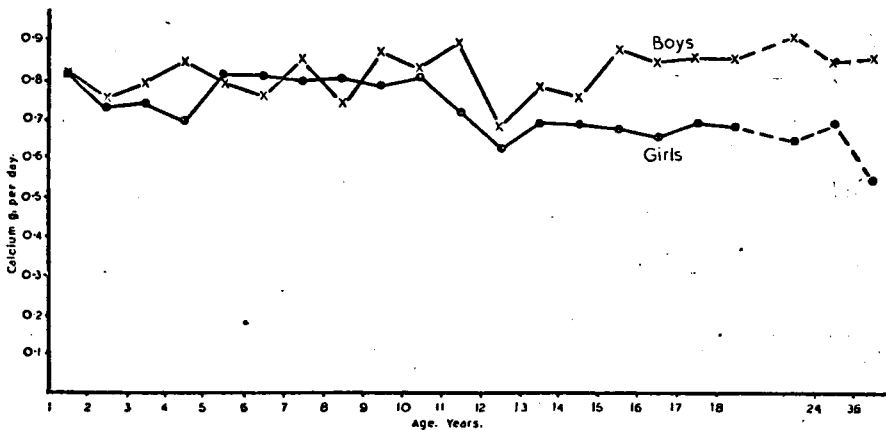


FIG. 54.—Average Calcium Intakes.

Fig. 54 shows the average results for the calcium intakes of our children, and Fig. 55 their frequency distribution. The highest calcium intake recorded was that of a 15-year-old boy who had 1.63 g. a day. Only 16 out of 232 girls of 12 years and over were receiving as much as 1 gram of calcium a day. Of these, only five had as much as 1.25 g. The boys averaged about 0.8 g. a day at all ages. Up to the age of 10 years girls also derived about 0.8 g. a day from their food, but thereafter their mean intake fell below 0.7 g., and there it

remained. Thus at all ages these children as a group were getting considerably less than the calcium allowances suggested by the various committees whose recommendations have already been discussed, and the adolescent girls were having little more than half the recommended amounts. One girl of 11, in Liverpool, was only having 0.13 g. a day. She had no cheese and only 13 oz. of milk in the week. Her sister, aged 15, evidently lived on a somewhat similar diet. In defiance of all the rules of mineral metabolism, however, this 11-year-old girl had reached a height and weight superior to the average of her age group, and she had five carious teeth, which was less than the average number. It is interesting to speculate on what she might have done on a calcium intake of 1 g. a day. Of the children getting less than 0.5 g. a day, 11 boys and 8 girls were below five years of age, and may have been receiving sufficient calcium, but 19 boys and 47 girls who were over 12 years can hardly have been getting enough (p. 102). Undoubtedly the extension of the "Milk in Schools" scheme,

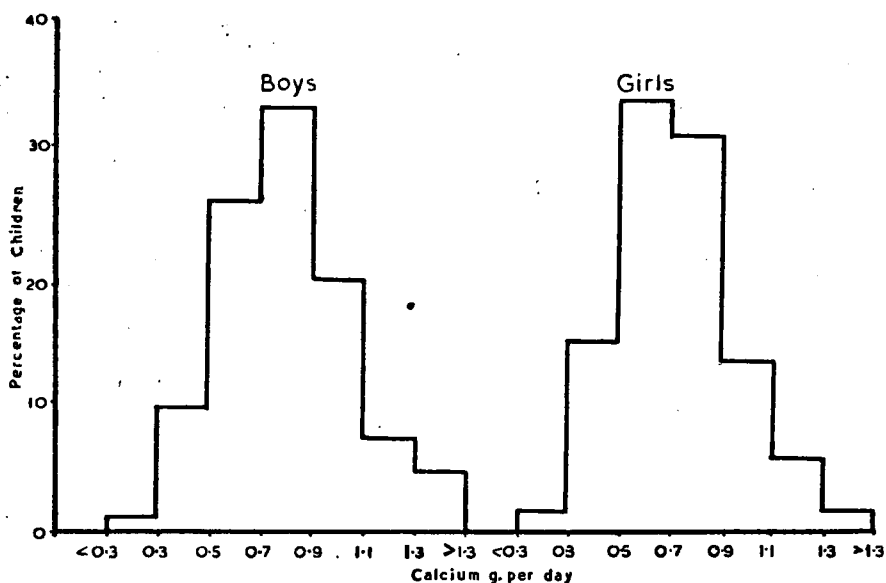


FIG. 55.—Frequency Distribution of Calcium Intakes.

which took place during the war, will help to put this right as one-third of a pint of milk provides over 200 mg. of calcium. In this connection another factor may be considered. Assuming that all their bread had been enriched with calcium at the rate of 65 mg. per 100 g. flour (or 50 mg. per 100 g. bread), which was the amount added to the National Wheatmeal Loaf in 1942, at no age would the girls' average intakes have been raised by 100 mg. a day, because at no age was the average amount of bread eaten as much as 7 oz. The boys of 14 years and upwards would have received a little over 100 mg. of additional calcium a day. Hence the fortification of flour with this amount of calcium would not, generally speaking, have made a great difference to the calcium intakes of these children at the time at which they were studied. It would have made rather more difference to a similar group of children during the war, for they would have been eating more bread at that time. When the individual children who ate most bread are considered (see p. 26), the one boy consuming more than 1 lb. of bread a day would have had his intake

of calcium raised by 230 mg., and the girl who ate 17.6 oz. bread by 250 mg., if their bread had been fortified. No other girl would have obtained as much as 170 mg., and only six other boys as much as 200 mg.

TABLE LXV
Boys' Calcium Intakes
(g. per day)

<i>Age group</i>	<i>Average calcium intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	0.82	1.73	0.46	0.29	34.7
2	0.76	1.08	0.35	0.18	24.3
3	0.79	1.49	0.32	0.24	30.2
4	0.85	1.56	0.38	0.29	33.9
5	0.80	1.26	0.34	0.25	31.0
6	0.76	1.33	0.47	0.20	25.6
7	0.86	1.24	0.53	0.18	21.3
8	0.74	1.26	0.35	0.23	31.7
9	0.88	1.29	0.35	0.21	23.9
10	0.84	1.25	0.40	0.22	26.0
11	0.89	1.60	0.38	0.31	34.6
12	0.69	1.23	0.40	0.19	27.8
13	0.79	1.28	0.33	0.25	31.8
14	0.76	1.48	0.36	0.28	36.3
15	0.87	1.63	0.41	0.28	32.2
16	0.79	1.39	0.26	0.27	34.2
17	0.85	1.48	0.28	0.29	34.0
18	0.85	1.37	0.48	0.23	26.8

TABLE LXVI
Girls' Calcium Intakes
(g. per day)

<i>Age group</i>	<i>Average calcium intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	0.81	1.55	0.30	0.25	30.0
2	0.73	1.21	0.43	0.21	28.5
3	0.75	1.10	0.44	0.17	23.2
4	0.70	1.10	0.42	0.18	25.0
5	0.82	1.24	0.36	0.24	29.7
6	0.82	1.26	0.46	0.23	27.9
7	0.80	1.26	0.50	0.18	22.7
8	0.81	1.18	0.42	0.19	23.8
9	0.79	1.36	0.26	0.28	35.2
10	0.81	1.41	0.39	0.24	29.1
11	0.72	1.22	0.13	0.27	37.2
12	0.63	1.00	0.33	0.17	26.8
13	0.70	1.32	0.27	0.26	37.2
14	0.69	1.64	0.40	0.20	29.0
15	0.67	1.35	0.24	0.25	36.4
16	0.66	1.27	0.31	0.20	31.1
17	0.69	1.39	0.41	0.23	32.9
18	0.68	1.03	0.38	0.17	25.6

Tables LXV and LXVI provide further information as to individual variations in calcium intake. There is an enormous difference between the maximum and minimum figures in each age group—one child was almost always getting four times as much as another.

Fig. 56 shows our children's average calcium intakes expressed per kilogram of body weight, and Fig. 57 shows them expressed per centimetre of height. Since the boys' total intakes remained approximately constant at all ages, their intakes per kg. and per cm. decreased in direct proportion to their

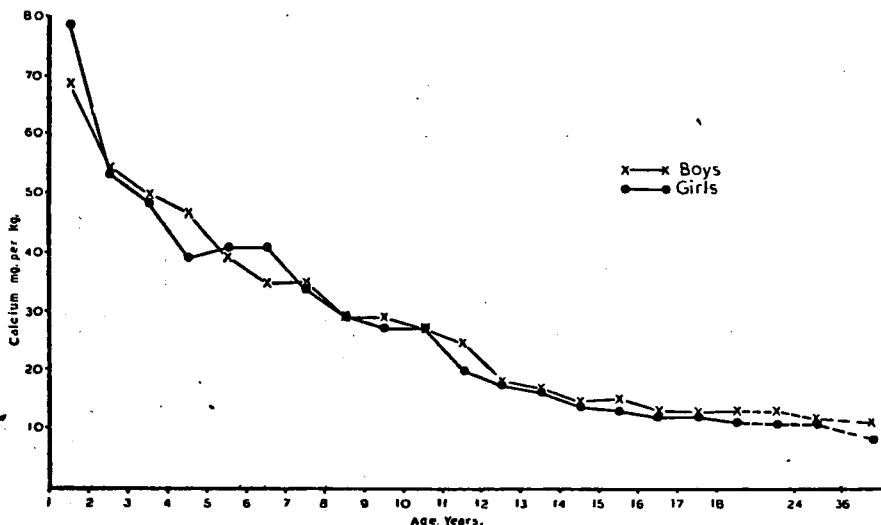


FIG. 56.—Calcium Intakes per Kilogram of Body Weight.

increases in weight and height. The adolescent girls' lower calcium intakes are almost exactly paralleled by their smaller body weights, so that boys' and girls' calcium intakes per kg. body weight are the same. On the basis of height the girls had lower calcium intakes from nine years and upwards, when their total calcium intakes fell.

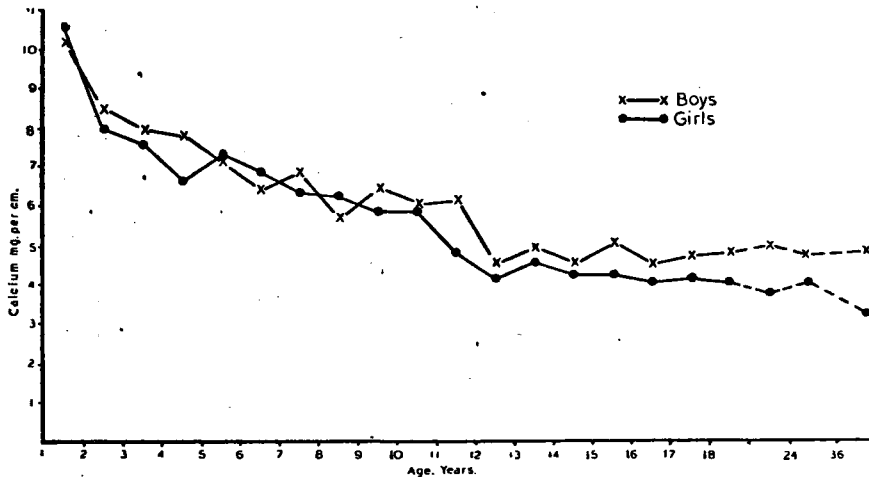


FIG. 57.—Calcium Intakes per Centimetre of Height.

It is frequently suggested that calcium retention is related to growth in stature rather than to growth in weight (Macy, 1942). McKay and Patton (1935), in the course of a dietary study on nine children carried out at intervals over a period of two years, found some indication that the children tended to grow most rapidly in height when their diets contained the most calcium.

Rapid weight increases, on the other hand, were associated with high intakes of calories, protein, phosphorus and iron. The number of children studied was, however, small, and other workers consider that growth in height is associated with the laying down of soft rather than of skeletal tissue (p. 98). Others, again, have found that the most rapid increase in height is accompanied by high retentions of both nitrogen and calcium (Daniels, Everson, Dearthoff, Wright and Scoular, 1941). Be that as it may, there does seem to be fairly clear evidence that if there is a seasonal variation in growth, the greatest increase in height occurs in the spring. Since milk is so much the most important source of calcium, and since the supply of milk tends to be seasonal, being lowest in the spring, it was thought that it might be of interest to calculate our children's calcium intakes at different seasons of the year, to see whether a seasonal variation in calcium intake could be correlated in any way with the reported seasonal variation in growth. Children of all ages have been averaged together, and the results are set out in Table LXVII. It is quite clear that they

TABLE LXVII
Seasonal Variation in Calcium Intake

	Boys average (g. per day)	Girls average (g. per day)
January	0·81	0·65
February	0·72	0·72
March	0·79	0·75
April	0·71	0·74
May	0·89	0·82
June	0·84	0·70
July	0·76	0·69
August	—	—
September	0·80	0·77
October	0·88	0·76
November	0·84	0·70
December	0·77	0·63

were not getting more calcium in the early spring months, and, in fact, the figures show no definite seasonal trends at all. This being so, it is difficult to see why they should have been laying down more calcium in the spring than in the autumn, for the efficiency with which they utilized the supplies in their food would have tended to be lowest in the spring (p. 98). It seems reasonable to suppose that if the intake is constant all the year round, least will be stored in the spring and most in the autumn. Hence, if the most rapid growth in height occurs in the spring, it is unlikely that this is associated with the rapid laying down of skeletal tissue.

Another factor that should perhaps be borne in mind in considering seasonal variations in calcium intakes is the availability of the calcium in the food at different seasons of the year. For example, 274 boys and 310 girls ate brown bread, but the amount eaten was small, and consumption was not limited to any one particular season. This was not true of rhubarb, however; 63 boys and 88 girls ate rhubarb, in fact almost every child did so who weighed his food during the time when rhubarb was in season, and this, be it noted, is when calcium absorption tends to be low. The average amount of stewed rhubarb eaten by these children during the week was about 5 oz. This would have contained about 500 mg. of oxalic acid, which is sufficient to immobilize 220 mg. of calcium, or just over 30 mg. of calcium a day. It must be concluded that the rhubarb cannot have interfered seriously with these children's calcium absorptions. Again, 36 boys and 42 girls ate spinach, and the amount they ate would have contained sufficient oxalic acid to precipitate about 100 mg. of

calcium a day. This would certainly have made a difference to the calcium absorptions of these 78 children, but, as they formed a very small proportion of the total number, it may be concluded that spinach does not constitute a serious menace to English children as a whole.

Calcium intakes and the incidence of dental caries

While it is fully realized that the amount of calcium in the diet today cannot be directly related to the structure of the teeth that were formed many years ago, yet families tend to be conservative about their feeding habits, and it is highly probable that the diet which the older children were eating in 1935-39 was similar to that which they themselves had eaten in their early childhood, and to that which their mothers had eaten before they were born. Furthermore, there is evidence that nutritional factors are of importance in determining dental health, even after calcification is complete (M. Mellanby, 1934; M. Mellanby and Coumoulos, 1944). It is of some interest, therefore, to compare the diets of the children, still in their teens and with only a very few healthy teeth left in their mouths, with those of the children of similar ages who had no caries at all.

The calcium intakes of the three boys over 13 who had no carious teeth were 0.45, 1.22 and 0.89 g. a day, while those of the two boys with more than 20 carious teeth were 1.23 and 0.76 g. a day. No girls of this age had caries-free mouths, but two had only one bad tooth, and their diets provided them with 0.72 and 0.41 g. of calcium a day. The four girls with 20 or more carious teeth had 0.91, 0.25, 0.62 and 0.55 g. a day. It has, of course, been recognized for a long time that a high calcium diet will not of itself produce a perfect set of teeth. A most interesting example of this is seen in the case of twin brothers, aged seven, who took part in this investigation. Their calcium intakes (0.87 g. a day) were almost identical at the time of the survey, and had probably been so all their lives. One had 12 carious teeth, the other had none.

CHAPTER 8

PHOSPHORUS

The physiology of phosphorus is, in some respects, linked with that of calcium as both are essential for bone formation. The calcium/phosphorus ratio in bone is approximately 2:1, so that twice as much calcium as phosphorus is required for this tissue, especially during periods of active growth. Whereas, however, about 98 per cent. of the calcium retained by growing children is deposited in the bones, less of the phosphorus can be accounted for in this way. Some of the phosphorus is utilized for the development of the soft tissues and red blood cells. The optimum amount of phosphorus in the diet depends partly upon the amount of calcium. For bone calcification, one of these minerals is of no use without the other, but an excess of either in the diet tends to depress the absorption of the other (Bowditch and Bosworth, 1917). The mixture of foods which together constitute human diets contains much more phosphorus than calcium, and inorganic phosphorus, unlike calcium, is readily absorbed. Consequently, man always absorbs more phosphorus than calcium, and, since he requires rather less for the purposes of growth, he invariably excretes more in the urine. It must be very rare for a human diet to contain too little phosphorus. Although there is no clear evidence as to the optimum Ca/P ratio in children's diets, some estimates have been made of the ratio of these elements that should be retained. Stearns (1931), on the basis of

metabolism experiments published up to that time, and the chemical composition and rate of growth of bone and soft tissues, considered that the Ca/P retention ratio should be greater than 1 : 1 throughout the growth period. A ratio of less than 1 indicates a rapid formation of soft tissues, while a ratio of 1.3 : 1 shows that bone and soft tissue are being laid down at a relatively equal rate.

Macy and her co-workers (Macy, 1942) carried out phosphorus as well as calcium balances on the 29 children already discussed, while on diets which were considered to be adequate but not excessive as regards both these minerals. It will be recalled that from an average daily calcium intake of 0.92 g. the children absorbed 30 per cent. Of this, 20 per cent. was retained and 10 per cent. excreted in the urine. At the same time the mean phosphorus intake was 1.25 g., of which 69 per cent. was absorbed. Only 14 per cent. was retained, however, and the remaining 55 per cent. was excreted in the urine. When these results are considered in terms of Ca/P ratios, the average ratio in the food was 0.74, that excreted in the urine 0.14, in the faeces 1.64, while the ratio of the absorbed elements was 0.30, and of the retained elements 1.05. Similar calculations can be made from the data of Daniels *et al.* (1934) on 10 pre-school children. When the average calcium intake was 0.8 g. a day and the phosphorus intake 1.01 g., the Ca/P ratio in the food was 0.79. This resulted in a urinary ratio of 0.13 and a faecal ratio of 1.61. The ratio of the amounts absorbed was 0.32 and of the amounts retained 1.02. These entirely independent investigations, therefore, afford good confirmation of each other. Both teams of workers, however, obtained wide variations in the Ca/P retention ratios of individual children. Macy considers that these variations demonstrate changing demands for minerals for the hard skeletal structures and for the soft muscular, glandular and nervous tissues.

Vitamin D appears to influence the amount of phosphorus absorbed by growing children, just as it does the amount of calcium (Daniels, Stearns and Hutton, 1929). It is possible that it also affects the level of inorganic phosphate in the blood of infants. At all events, Hess and Lundagen (1922) showed that there is a seasonal "tide" of phosphate in the blood, the values being highest in the summer and autumn, and lowest in the early spring.

Other chemical factors influence phosphorus absorption to a certain extent, but they are not as important as they are for calcium, since phosphorus is usually present in the diet in excess. The phosphorus in phytic acid has already been discussed (p. 98), but in mixed diets such as our children were eating only about 3 per cent. of the total phosphorus was present in that form. In those regions of the world where whole cereals form a large part of the diet, phytic acid accounts for most of the phosphorus intake, but these diets usually contain very little milk and, consequently, very little calcium, and the less calcium they contain, the more the phytic acid molecule tends to break down in the intestine, liberating inorganic phosphorus for absorption (Cruickshank, Duckworth, Kosterlitz and Warnock, 1943). In such diets, therefore, in spite of the phytic acid they contain, calcium and not phosphorus is generally the limiting element.

Chaney and Blunt (1925) found that the addition of orange juice to children's diets increased their phosphorus retentions by about three times, but why this should have occurred has not been explained.

The general conclusion to be drawn from the work which has been carried out on calcium and phosphorus is that, while there may be a fear of a deficiency of calcium, the danger with regard to phosphorus is rather of excess.

Phosphorus intakes

Fig. 58 shows the average amounts of phosphorus in the freely chosen diets of the children taking part in the present investigation. In contrast to calcium, the phosphorus intakes increased as the children got older, for foods rich in

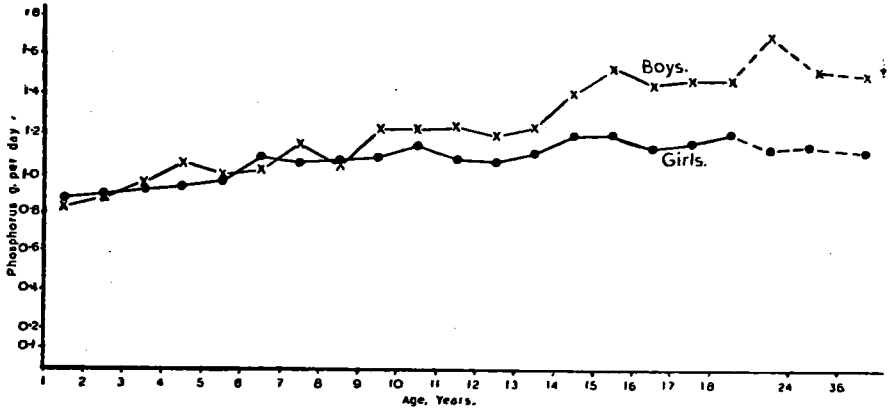


FIG. 58.—Average Phosphorus Intakes.

phosphorus, but poor in calcium, played an increasing part in their diets. Milk contributed a smaller proportion of the total phosphorus than of the total calcium at all ages. Below 10 years of age the children were getting 40–50 per cent. of their phosphorus from milk, but over 12 years only some 30 per cent. or less of their phosphorus in this form. Meat, not milk, accounted for the difference between the older boys' and girls' phosphorus intakes. This gradual increase in the intake of phosphorus as the children grew older, and the constancy of the decrease in calcium consumption, led to a fall in the Ca/P ratio in the food. This is shown graphically in Fig. 59. At the age of one year the food con-

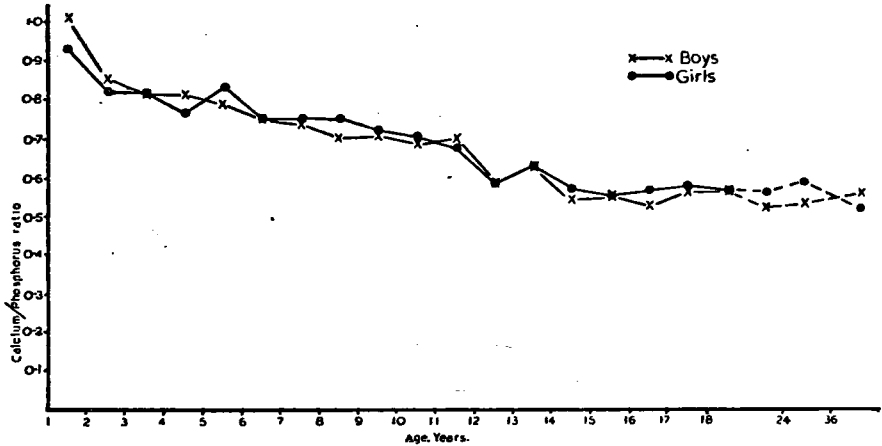


FIG. 59.—Calcium/Phosphorus Ratio in the Diets.

tained approximately equal amounts of calcium and phosphorus. The ratio for both boys and girls gradually fell until the age of 12, when it had reached a value of 0.58. Thereafter it remained approximately level. It will be recalled that the results of metabolism experiments on younger children have shown that when the Ca/P ratio in the food is about 0.75, the ratio retained is slightly over 1.0. From Macy's results, however, it is clear that individual variations again come in, and no hard and fast rules can be drawn. Four of her children

were eating a diet in which the average Ca/P ratio was 0.63, and this led to a retention ratio of 1.5. As a whole our children's diets were certainly not deficient in phosphorus, and this is probably true also of all the individual diets. Some of the individual children would certainly have fared better with more calcium.

Tables LXVIII and LXIX give details about the individual variations in phosphorus consumption. It will be noted that these were much smaller than the variations in the calcium intakes, because they were not so much

TABLE LXVIII
Boys' Phosphorus Intakes
(g. per day)

<i>Age group</i>	<i>Average phosphorus intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	0.81	1.43	0.60	0.18	21.7
2	0.88	1.17	0.62	0.16	19.5
3	0.96	1.66	0.51	0.21	21.4
4	1.04	1.72	0.54	0.27	25.5
5	1.01	1.38	0.69	0.18	18.3
6	1.02	1.42	0.57	0.19	18.6
7	1.16	1.37	0.82	0.14	11.9
8	1.06	1.79	0.66	0.24	23.1
9	1.24	1.78	0.76	0.22	17.7
10	1.22	1.57	0.80	0.22	17.7
11	1.26	1.85	0.78	0.28	22.6
12	1.20	1.92	0.80	0.25	21.0
13	1.25	1.87	0.75	0.30	24.2
14	1.41	2.26	0.75	0.36	25.7
15	1.56	2.57	1.07	0.35	22.3
16	1.48	2.59	1.00	0.37	24.9
17	1.50	2.15	0.96	0.30	20.2
18	1.50	2.41	1.01	0.30	19.7

TABLE LXIX
Girls' Phosphorus Intakes
(g. per day)

<i>Age group</i>	<i>Average phosphorus intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	0.87	1.55	0.50	0.20	23.4
2	0.89	1.29	0.67	0.18	20.2
3	0.91	1.27	0.55	0.17	18.7
4	0.92	1.37	0.56	0.19	20.5
5	0.98	1.31	0.61	0.19	19.8
6	1.10	1.48	0.76	0.21	19.5
7	1.06	1.41	0.77	0.17	15.5
8	1.08	1.38	0.87	0.18	16.3
9	1.10	1.51	0.54	0.23	20.8
10	1.15	1.80	0.74	0.25	21.6
11	1.08	1.71	0.65	0.25	22.9
12	1.08	1.52	0.67	0.22	21.0
13	1.11	1.98	0.65	0.28	25.4
14	1.21	1.79	0.84	0.21	17.6
15	1.21	1.89	0.58	0.28	22.9
16	1.15	1.58	0.73	0.22	18.8
17	1.19	1.84	0.84	0.25	21.3
18	1.21	1.55	0.88	0.20	16.5

dependent on one particular food. The maximum was usually about twice, not four times, the minimum, and the coefficients of variation were considerably smaller. Boulton (1945), in her study of the diets of eight children over four successive weeks, found that the phosphorus intake varied less from week to week than the intake of any other dietary constituent.

IRON

Iron requirements

Owing to the way in which the amount of iron in the body is regulated, special problems confront those who set out to determine the requirements for this element. Unlike calcium and magnesium, which are readily excreted by the kidney (McCance and Widdowson, 1939, 1942c), or zinc and manganese, which are excreted into the gut (Kent and McCance, 1941; McCance and Widdowson, 1942d), iron is not excreted in significant amounts, even if it is present in large excess (McCance and Widdowson, 1937a, b, 1938, 1943b; Widdowson and McCance, 1937). The physiological needs of the body are probably met by variations in the amounts absorbed, but it is easy to force up the amount of iron in the body to very high levels by blood transfusions or by very large intakes by mouth. Even from normal intakes children short of iron are likely to absorb and retain more than children in a really good nutritional state.

Iron is stored chiefly in the liver, but the spleen and the bone marrow also participate, and these three depots appear to be able to accommodate as much iron as the whole of the rest of the body put together (Hutchinson, 1937; McCance and Widdowson, 1937b; 1943b; Widdowson and McCance, 1937). The immense storage capacity of the body must be borne in mind in any discussion of iron requirements, for it complicates their determination, whether from the composition of the body at different ages or by means of balance experiments. The amount of iron in the body will depend, not so much upon the physical well-being of the individual at the time of death, as upon his previous medical history. If he has taken an iron preparation at any period of his life, most of the iron which has been absorbed from it will still be in his body, unless he has suffered from haemorrhage. One individual may well contain twice as much iron as another, and who is to say which is the normal? As a matter of fact, this has been, up to the present, a purely theoretical difficulty, for there were no data for the amount of iron in the whole body of a normal child or adult. Magnus Levy (1910) estimated the concentration of iron in some of the organs and tissues of a 37-year-old man who had committed suicide, but there is no way of finding out from his figures the total iron in the man, for he does not give the weight of the organs, nor did he analyse the blood. We have recently determined the amounts of iron in the bodies of three adults and a child of six years, and have found them to vary from 3.1 to 7.5 mg. per 100 g. body weight.

Some analyses of iron in foetuses and newborn infants were made in France and Germany at the end of the last century (Brubacher, 1890; Hugounenq, 1899, 1900; Camerer, 1900a, b, 1902; Söldner, 1903). It is interesting to remember that this Camerer was one of the five children whose metabolism had been studied by their father (p. 65). The values obtained by Camerer and Söldner for six new-born infants were all between 342 and 392 mg. with an average of 375 mg. This is in close agreement with recent unpublished findings of our own. Hugounenq's figures were somewhat lower. Adult organs and tissues have been analysed separately for iron by various investigators, but the results are very variable, as might be expected in the light of what has been said. However, the Committee on Growth and Development of the White House Conference (1932) made an attempt to calculate the iron content of the whole body from these figures. When this was done the iron in the body at maturity came to about 4.5 g., of which 2.9 g. were in the blood. This would require an average daily storage of approximately

0.5 mg. iron throughout the growth period. The Committee, who assumed a storage of 4 g. in 20 years, obtained a figure of 1.8 mg. per day, but this is obviously incorrect. A storage rate of 0.5 mg. per day is of the same order as the amount required by women to make good their menstrual iron losses (Barer and Fowler, 1936; Widdowson and McCance, 1942b). It should be pointed out, however, that if the amount of iron in the body of a new-born infant is computed from the sum of the amounts which have been reported in the blood and organs (White House Conference, 1932) the figures arrived at are only about half those found by the direct analysis of the whole body.

Heath and Patek (1937) have made some speculative calculations of the annual iron increments. They estimated the blood volume at different ages from the mean surface area, using the data of Darrow, Soule and Buckman (1928) and of Brown and Roth (1925) for this purpose. Then, from the average concentration of haemoglobin in the blood at various ages, they calculated the total amount of iron in these bloods. They then proceeded to add an arbitrary figure—5 mg. per kg. body weight—for the annual increment of extra-circulatory iron, and by so doing they arrived at a value for the increment of iron which they considered proper to each year of growth. In the case of girls a rather generous allowance was made for menstrual losses. Approximate though these figures must be, they emphasize an obvious fact that, while in infancy and early childhood the annual increments are the same in both sexes; girls who are both growing and menstruating need to absorb more iron than boys, and perhaps even more than pregnant women.

Balance experiments constitute the second method of determining mineral requirements. Johnston and Roberts (1942) pointed out that this method rests upon the assumption that all the element in the body not required for growth and reasonable storage is excreted. In other words, a child would not retain more than is required for his immediate needs. In the case of iron this assumption is unjustifiable on the evidence at present available, for the excess would not be excreted. Hence, retentions could be much greater than requirements if the intake were sufficiently high. Indeed, since the maximum storage capacity of the body has never so far been exceeded, and since any excess of iron reaching the circulation is retained, the minimum iron requirement cannot be defined as the smallest intake which will promote maximum retention. It is, in fact, difficult to see how balance experiments can ever provide the clue to children's iron requirements. Nevertheless, if done with the requisite care, they do serve to show how much of the iron in a diet may be expected to be absorbed and retained. Iron metabolism experiments are notoriously difficult to carry out, and unless they are made with great care, over long periods of time, the results are apt to be very misleading, because figures for retentions are inevitably small differences between two large numbers and are, therefore, very liable to error. Any mistake in the marking of the faeces, or an inadequate preliminary period when changing from one level of intake to another, can give results which are utterly ridiculous.

Most of such studies have been made on children below eight years of age. The most comprehensive series of experiments is again that of Macy and her co-workers (Macy, 1942). They carried out iron balance experiments on eight children, aged 4–6 years, over a total of 336 five-day periods, and their results give a good general idea of the way in which a well-nourished child of this age treats the iron in its food. The mean daily iron intake of these eight children was 8 mg. The amount absorbed varied very much from one child to another, but the average was 0.6 mg. per day, and 7.4 mg. were passed out in the faeces. 0.16 mg. of the absorbed iron was excreted in the urine and 0.44 mg. retained. Thus the retention amounted to little more than 5 per cent. of the intake. Heath and Patek's (1937) calculations suggest that children of 4 to 6 years

should be retaining between 0.2 and 0.3 mg. a day, which is appreciably less than Macy's experimental findings. Macy's seven older children, 8 to 12 years of age, on iron intakes varying from 8.5 to 12.3 mg. daily, retained 1.49 to 2.99 mg. a day. This is again very much more than Heath and Patek calculated to be necessary.

The mere fact of attaining a positive balance in a child is no proof that the full requirements of the body are being met, because the balances should always be positive during growth and are most unlikely ever to be negative, however low the intake (McCance and Widdowson, 1937a). This point was not realized by the earlier workers (Leichsenring and Flor, 1932; Daniels and Wright, 1934; Ascham, 1935; Rose, Vahlteich, Robb and Bloomfield, 1930). Experiments on children in which negative balances have been obtained have been of very short duration (Rose *et al.*, 1930). If large negative iron balances are found in children or adults, faults in technique should always be suspected.

Some workers have investigated the iron balances at two different levels of intake, but unfortunately the experimental periods have usually been very short, and, furthermore, the importance of ensuring that the subjects are in a good nutritional state before the beginning of the experiment has not always been appreciated. Leichsenring and Flor (1932), for example, studied four pre-school children at two levels of iron intake, but each experiment lasted only for five days. Their findings are very different from those of Macy and should perhaps be regarded with suspicion. They found considerably higher retentions on an intake of 6.5 mg. a day than on an intake half as great, but at both levels of intake one-third to one-half of the iron in the food was retained. One child retained more than twice as much iron as he passed out in his faeces. No individual variation in iron metabolism could possibly account for this divergence from Macy's findings unless the child was really short of iron and, therefore, absorbed unusually large amounts. Daniels and Wright (1934) also investigated the iron metabolism of eight children between 4 and 6 years of age at different levels of iron intake, but here again there was only one experimental period, five days in length, on each type of diet, with a three-day interval between. The results, therefore, probably mean very little, and it may be misleading to consider them as giving information as to healthy children's iron retentions. On an intake of 8-10 mg. a day these children apparently absorbed and retained over 3 mg. daily, a very different amount from the 0.44 mg. retained by Macy's (1942) children of the same age at a similar level of intake.

Porter (1941) studied the iron metabolism of three boys and one girl, aged 3-5 years, over nine 7-day periods. The enormous variations she obtained in the iron retentions of these children from one period to another serve to emphasize the danger of putting any faith in the results of an iron metabolism experiment carried out for one week or less. The iron intakes of the children were 5-6 mg. a day, with an average of 5.64 mg. The average retentions were 1.18, 1.14, 1.28 and 1.39 mg. a day for the four children respectively, and these represent about 21 per cent. of the intake.

Johnston and Roberts (1942) argued that, since a large part of the iron in the body was found in the haemoglobin, and since this was probably one of the first iron-containing tissues to be depleted when there was a deficiency, a good level of haemoglobin could be taken as an indication of an adequate iron supply. They accordingly followed the haemoglobin levels of 12 boys and 9 girls, 8-11 years of age, over a period of 7 months. These children were divided into three groups, and each group had a different iron intake, but all the intakes were within ordinary limits. The lowest intake (11.4 mg. a day, or 0.35 mg. per kg.) was sufficient to maintain a good haemoglobin level, and the authors consider that it was in all probability larger than necessary. They quote the

work of Davidson, Fullerton, Howie, Croll, Orr and Godden (1933) and of Davidson and Fullerton (1938), showing that there is very little anaemia among poor Scottish children of early school age in spite of a very low iron intake, and argue from this that such children must need less iron than is generally supposed. All things considered, it must be concluded that it is very difficult to give any accurate figure for the iron requirement, but, even if the amount of iron absorbed varies with the needs of the body, there must surely be a lower limit below which intakes should not be allowed to fall.

Iron allowances and iron intakes

At the time when this survey was started it seemed to have been proved by the work of Elvehjem, Hart and Sherman (1933) that only inorganic iron could be considered as available for haemoglobin formation in rats; haemoglobin and haematin iron could not be absorbed and utilized. Very little experimental work had been done with human beings along those lines, but it was generally assumed that the same would be true for them, and that, therefore, the total iron in a diet was not nearly so important as the amount of inorganic,

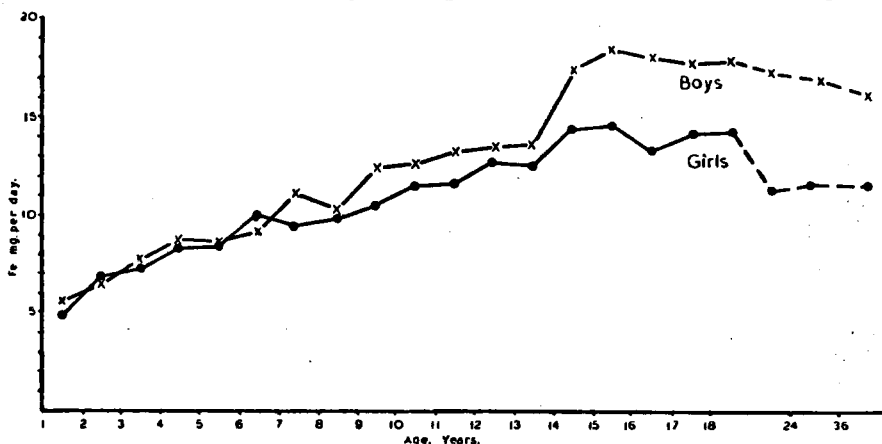


FIG. 60.—Average Iron Intakes.

ionisable iron which the diet contained. Methods were devised for the estimation of inorganic iron in biological material, and that of Hill (1930) was applied to a number of English foodstuffs (Shackleton and McCance, 1936). Calculations, based on these figures, were accordingly made of the inorganic as well as the total iron intakes of our children. Since that time, however, the whole subject has been thrown into confusion again. In 1937, Oldham, Schlutz and Morse showed that a normal infant was able to absorb just as much iron from cooked beef as from an iron salt, and in 1941 Oldham showed that, while the iron of raw meat was unavailable to anaemic rats for haemoglobin formation, the iron in oven-dried meat was utilized equally as well as inorganic iron. Bing, Benes and Remp (1936) had already come to the conclusion that some people could utilize haematin iron while others could not. Black and Powell (1942) gave 950 c.c. of blood containing 313 mg. iron to one normal person by stomach tube, and 25 per cent. of this iron was apparently absorbed. Both these last groups of workers considered that the iron is most probably set free from the haematin molecule by the action of bacteria in the intestine. Furthermore, it has recently been shown (Widdowson and McCance, 1942b; McCance, Edgcombe and Widdowson, 1943) that the iron of brown flour, and presumably of other whole cereals, must be considered to be unavailable because it is present as insoluble ferric phytate, and, in addition, the consumption of large

quantities of brown bread, rich in phytic acid, may well prevent the absorption of iron from the rest of the diet. Hence, some of the iron that was once thought to be unavailable has been shown to be available, and another portion, which was formerly reckoned as available iron, now appears to be unavailable. Only figures for total iron, therefore, have been considered. Fig. 60 shows how the

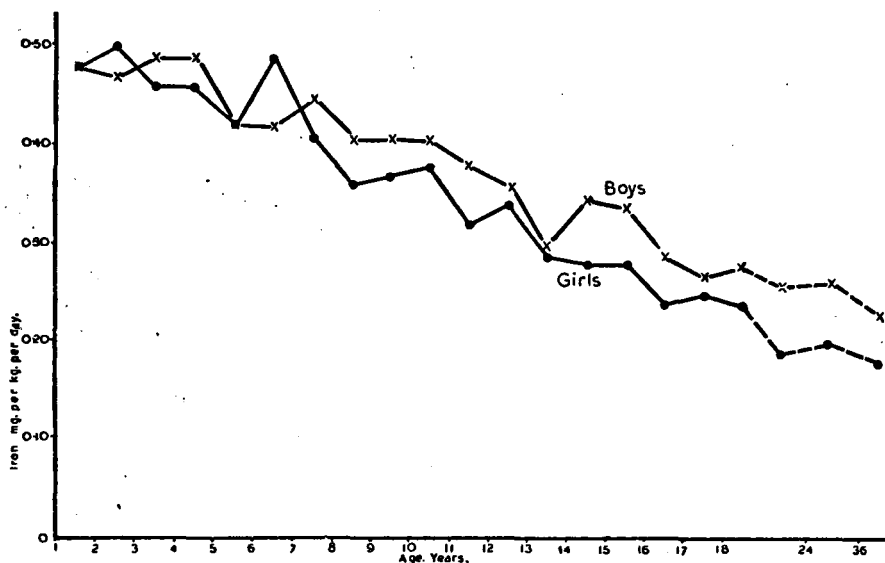


FIG. 61.—Iron Intakes per Kilogram of Body Weight in relation to Age.

iron intakes of our children varied with age, and Fig. 61 how they were also related to body weight. It must be pointed out that these iron intakes were calculated from food tables, and the foods which were analysed in the preparation of these tables were protected very carefully from iron contamination. In real life no such precautions are taken, and it is quite likely that some of the children's iron intakes were higher than the calculated values because of the contamination of their food with iron from cooking utensils (Widdowson and McCance, 1943).

If Fig. 60 is compared with Fig. 19 (p. 39), it will be seen at once that the graphs are similar. This is partly a matter of chance, but it is true enough to say that, just as milk is the chief source of calcium in the diet (p. 103), meat is, generally speaking, the principal source of iron. At the same time, meat was not an important source of iron for children under five, and, while it provided older children with more iron than any other kind of food, it was never such an outstanding source of iron as milk was of calcium. Fig. 62 shows the average percentage of the total iron in the diet derived from meat at different ages. The figure rose to about 30 per cent. in the oldest age groups and the curves for boys and girls were almost identical.

Figs. 15 (p. 32) and 54 (p. 103) show that the average intake of calcium was the same at all ages because the greater consumption of total food by the older children was counterbalanced by a slight fall in their consumption of milk. The intake of calcium per kg. of body weight (Fig 56, p. 106), therefore, showed a rapid decline as the weight increased, so that at 18 years the amount was only one-fifth of its value at one year. In the case of iron the picture is rather different. As the children grew older they ate more and more meat, and they also ate more and more food, so that their iron intakes rose quite

rapidly (Fig. 60). When expressed per kg. of body weight (Fig. 61) the iron intakes did not fall much, and the 18-year-old children were getting about half as much iron per kg. body weight as the one-year-olds. It is interesting to speculate as to whether this has any physiological basis. Whether children of one year need as much calcium as boys and girls of 18 has already been discussed (p. 102). Do boys of 18 need more than three times as much iron as children of one year? Adolescent girls certainly require to absorb considerably more iron than boys of the same age, for not only are they growing, but they also have to make good their menstrual losses. It seems illogical, therefore, that boys should take more iron than girls, although they undoubtedly do; and one would like

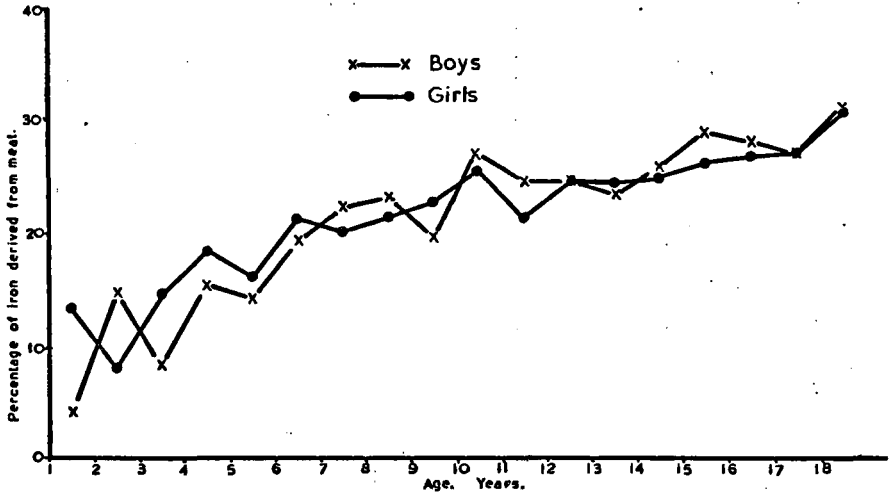


FIG. 62.—Percentage of the Total Iron in the Diet derived from Meat.

to know whether the boys have more than they require, or the girls less. It is possible that girls may be able to utilize the iron in their diets more efficiently. One would expect them to do so if the amount absorbed is regulated by the needs of the body (McCance and Widdowson, 1937 a; Hahn, Bale, Ross, Balfour and Whipple, 1943). Unfortunately, experimental evidence on this last point is very meagre, for no parallel metabolism studies on older boys and girls have been carried out. Widdowson and McCance's (1942 b) results on four men and four women living on diets containing a great deal of bread did not show any striking difference between the two sexes. On the other hand, Leverton's (1941) young women, aged 21-28 years, appeared to be able to store an average of 2.14 mg. of iron on a daily intake of only 6.55 mg. It is possible that this high retention was the result of a previous experimental period on a diet containing only about 3.5 mg. of iron a day when, on Leverton's own showing, they must have been drawing upon their iron stores.

Recommendations by Canadian and American authorities as to iron allowances (McHenry, 1941; National Research Council, U.S.A., 1943) do not differentiate between the two sexes. Both have suggested that boys and girls over 12 years should have 15 mg. a day. The Canadian Committee recommended 15 mg. from the age of six upwards, which seems very generous, and must be difficult to attain on an ordinary diet. The Americans were content with a lower level and suggested that children of 1-3 years should have 7 mg., those of 4-6 years 8 mg., those of 7-9 years 10 mg., and those of 10-12 years 12 mg. Our children's iron intakes were very close to these figures.

Iron intakes and haemoglobin levels

While it is satisfactory to have found that the average intakes of our children agreed so well with the National Research Council's allowances, the amounts of iron in the diets of individual children varied as much as the amounts of most of the other dietary constituents (Tables LXX and LXXI). In each age

TABLE LXX
Boys' Iron Intakes
(mg. per day)

<i>Age group</i>	<i>Average iron intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	5.7	11.5	3.1	2.0	35.2
2	6.6	12.1	1.9	2.1	31.8
3	7.8	10.5	5.1	1.4	17.9
4	8.8	12.8	5.3	2.1	23.8
5	8.6	10.8	6.9	1.0	11.6
6	9.1	12.9	4.7	1.7	18.7
7	11.2	15.0	8.0	2.0	17.9
8	10.4	17.3	6.8	2.2	17.6
9	12.5	16.3	8.1	2.0	16.0
10	12.7	16.5	7.6	2.4	18.9
11	13.3	18.2	9.2	2.3	17.3
12	13.6	21.6	8.4	3.2	23.6
13	13.6	19.8	8.5	3.2	23.6
14	17.5	26.7	8.6	4.8	27.4
15	18.5	25.6	12.9	3.2	17.3
16	18.0	29.4	11.8	4.2	23.3
17	17.9	25.4	10.7	3.5	19.5
18	18.0	22.6	12.2	2.9	16.1

TABLE LXXI
Girls' Iron Intakes
(mg. per day)

<i>Age group</i>	<i>Average iron intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	4.9	8.3	2.1	1.6	32.7
2	6.9	10.3	4.7	1.3	18.9
3	7.2	12.2	4.6	1.8	25.0
4	8.2	10.6	5.1	1.6	19.5
5	8.4	11.7	6.2	1.4	16.7
6	10.0	14.3	7.2	1.8	18.0
7	9.5	12.2	7.0	1.5	15.8
8	9.9	14.4	7.7	1.9	19.2
9	10.6	14.1	7.1	1.7	16.1
10	11.6	19.4	8.2	2.3	19.8
11	11.6	18.8	7.2	2.6	22.4
12	12.8	17.7	8.7	2.5	19.5
13	12.5	17.9	7.6	2.6	20.8
14	14.3	19.6	6.5	2.6	18.1
15	14.5	19.8	8.6	2.6	17.9
16	13.3	18.3	9.2	2.4	18.0
17	14.1	20.4	8.9	2.6	18.5
18	14.2	18.3	10.8	2.8	19.7

group there was usually one child who was consuming twice as much iron as another. It will be recalled that 77 per cent. of the children examined had haemoglobin levels above 90 per cent. on the Haldane scale (12.4 g. per 100 c.c.), and they must be considered to have been getting sufficient iron for their requirements. Of the two children who had haemoglobin levels below 70 per cent., one,

a boy of two with a haemoglobin of 66 per cent., had a very low iron intake (1.9 mg. a day). It might be mentioned in passing that his father was a pathologist! The other, a girl of 15, with a haemoglobin level of 68 per cent., had an iron intake of 16.9 mg. a day, which is above the average level for her age group. Similarly, of the six children with haemoglobin levels between 70 and 80 per cent., three were eating less and three more iron than the average amounts for their age and sex. Of course, it is possible to argue that these weeks may not have been representative of the children's accustomed diets, and that normally they had very much less iron, but the iron intakes, taken at their face value, will not explain all the low haemoglobin levels. They must have been due to metabolic or physiological differences between the children themselves.

CHAPTER 10

VITAMINS

Vitamin requirements

There is a wider divergence of opinion about vitamin requirements than about any of the other dietary needs. There are a number of reasons for this, but the primary one is that vitamins are subject not only to absorption, excretion and storage, but also to destruction and synthesis within the body. Hence, they cannot be followed by balance experiments in quite the same way as can calcium, phosphorus and iron, though attempts have been made to study the requirements of aneurin and ascorbic acid in this way (Knott, 1936, 1940; Everson and Daniels, 1936; Hathaway and Meyer, 1941; Meyer and Hathaway, 1944). Bessey and White (1942), Prunty and Vass (1943), and Dodds and MacLeod (1944) consider that the level of ascorbic acid in the plasma is a reliable index of nutrition as regards this vitamin, and consequently the intake which will maintain a satisfactory plasma level has been spoken of as the optimal requirement. Other workers consider that the range of plasma values among both normal and abnormal persons is so wide that no conclusions can be drawn from the results of the determinations (see Bicknell and Prescott, 1946). The daily excretion of aneurin (Harris and Leong, 1936; Wright and Baker, 1939; Wang and Yudkin, 1940; Benson, Witzberger and Slobody, 1941; Benson, Slobody, Witzberger and Lewis, 1942) and of ascorbic acid (Abbasy, Harris, Ray and Marrack, 1935; Messerli, 1943) has been used as a guide to the adequacy or otherwise of the previous intakes, but for both vitamins this method has largely been superseded by the saturation test. Harris and Leong (1936), Harris, Leong and Ungley (1938), Wang and Harris (1939), Hills (1939) and Melnick, Field and Robinson (1939) have estimated the urinary excretion of aneurin after test doses of the vitamin, and Harris and Abbasy (1937), Beck and Schorlemmer (1938), Goldsmith and Ellinger (1939), Spellberg and Keeton (1939), Pemberton (1940), Richardson and Mayfield (1940), Harris (1940, 1942, 1943), Roberts and Roberts (1942), Payne (1943) and many others have used various modifications of the ascorbic acid saturation test for the assessment of the level of vitamin C nutrition of their subjects. The urinary excretion of these vitamins has sometimes been studied in conjunction with the blood plasma level (Murphy, 1941; Roberts and Roberts, 1942; Benson, Witzberger, Slobody and Lewis, 1942; Roberts, Brookes,

Roberts, Koch and Shelby, 1943). Whether or not it is highly desirable to live in a perpetual state of vitamin saturation has never been determined. American experts appear to think that it is, and the daily intake of ascorbic acid advocated by the National Research Council is two or three times as high as the amount generally considered adequate in Great Britain. It must always be remembered that there is often no clinical evidence of scurvy to be found in persons in whom saturation tests and plasma determinations have shown the plane of vitamin C nutrition to be very low (Rietschel and Mensching, 1939; Fox and Dangerfield, 1940; Butler and Cushman, 1940; Milam and Wilkins, 1941; Fox, 1943). Further, there were no outbreaks of scurvy in Britain during the second World War, in spite of the fact that the ascorbic acid intakes of the population as a whole, and of those living in institutions in particular, were for a large part of each year only a fraction of the National Research Council standard. They were, indeed, very much less than 30 mg. a day, which was the figure recommended by the League of Nations Health Organization and subsequently adopted as the correct allowance in this country (Widdowson and Alington, 1941; Widdowson and McCance, 1942 a; Harris and Olliver, 1943 a; Macdonald, 1943; Prunty and Vass, 1944). Nevertheless, since there is absolutely no fear of an overdose of the water-soluble vitamins from natural sources, it is clearly desirable to err on the safe side and to provide a high intake if it can be achieved without undue difficulty.

The requirements of the fat-soluble vitamins A and D cannot be assessed by estimation of urinary excretion or by saturation tests, for healthy humans do not excrete either A or D in their urine, even when they have taken large doses by mouth (Lawrie, Moore and Rajagopal, 1941). Dogs and human beings appear to be able to absorb these vitamins with moderate ease (Heymann, 1937-1938 a; Wald, Carroll and Sciarra, 1941), provided no liquid paraffin or other mineral oil has been taken, and it is well known that the body has a large storage capacity for them. It is thought that vitamin A is not excreted into the intestine, and that the small amounts found in the faeces are due to incomplete intestinal absorption (Wald *et al.*, 1941; Lease, Lease, Steenbock and Baumann, 1941). The depletion of the stores of vitamin D is said to be caused by use, by excretion into the gut and by destruction within the body (Bicknell and Prescott, 1946). Heymann (1937-1938 b) considered that in dogs the excretion took place into the upper third of the small intestine.

The concentration of vitamin A in the serum appears to depend to some extent upon the vitamin A intake, and its determination has sometimes been used to detect a deficiency. Yudkin (1941), however, considers blood estimations useless for disclosing mild deficiencies because of the wide variations among normal people. The estimation of the vitamin D in the serum is so laborious, and such large quantities of serum are required, that it is not a practical proposition. The first sign of vitamin A deficiency may be a slight delay in the dark-adaptation of the eye, and this test has been extensively used for unmasking mild deficiencies of the vitamin. There is a considerable literature on the subject, and Harris and Abbasy (1939) have summarized the evidence for and against the correlation of poor dark-adaptation with a deficiency of vitamin A. They have concluded that by using a Birch-Hirschfeld photometer, and not a biophotometer, reliable results can be obtained. It is difficult to see how this method can give any clue to the vitamin A requirement, and in fact there is little or no experimental evidence to warrant any categorical statements on requirements of vitamin A or D being made (see Sheldon, Harris, Morris and Mackay, 1943). Nevertheless such statements are sometimes made (Guilbert, Howell and Hart, 1940; Lewis and Haig, 1940; National Research Council, 1943). Experiments that have recently been carried out in America (Brenner and Roberts, 1943) and England (Vitamin A

Sub-Committee, 1945), in which healthy adults have deliberately lived for a long time on diets containing very small amounts of vitamin A, have shown that it is extremely difficult to produce the generally accepted signs of vitamin A deficiency. Similar experiments on diets deficient in ascorbic acid have led to the same conclusion for this vitamin (Rietschel and Mensching, 1939; Crandon, Lund and Dill, 1940; Fox and Dangerfield, 1940). The results of experiments on diets deficient in aneurin appear to be somewhat more conflicting. Elsom, Reinhold, Nicholson and Chornock (1942) obtained signs of aneurin deficiency in three healthy women who had consumed a diet containing half the usually accepted normal requirement for 3-6 weeks, and Williams, Mason, Smith and Wilder (1942) also observed signs of deficiency on an intake of 0.22 mg. per 1,000 calories, but after a much longer time. The aneurin requirement of rats seems to depend to some extent upon the amount of fat in the diet (Williams and Spies, 1938), and the same may well be true for human beings. It has been suggested (Ferguson, Leeson and McHenry, 1944) that the great discrepancy between the values given by Williams, Mason and Wilder (1943) and Keys, Henschel, Mickelsen and Brozek (1943) for the aneurin requirement is due to the fact that the subjects in the former experiment ate a diet in which fat provided 26 per cent. of the total calories, while those in the latter obtained 36 per cent. of their calories from fat. These last workers have concluded, as a result of a later experiment (Keys, Henschel, Taylor, Mickelsen and Brozek, 1945), that an intake of 0.185 mg. per 1,000 calories is just on the borderline of safety. It is well to remember, however, that all these conclusions will have to be reconsidered in the light of the function which the intestinal bacteria have recently been shown to perform in synthesising vitamins of the B complex for the benefit of their hosts (*Lancet*, 1944).

Vitamin intakes

If the assessment of vitamin requirements is a very difficult matter, the assessment of vitamin intakes is hardly less so, and the chief reason for this is that there are so few reliable data on the quantities of vitamins in common foods. Even when there are figures, the values obtained by different workers are often so widely divergent that it is extremely puzzling to decide which to take. Furthermore, losses of aneurin and ascorbic acid are unavoidable in cooking, and may be very high if a destructive method has been employed. Since the exact kitchen procedure is not always known to the person making the dietary survey, the vitamin intakes of the subjects are partly a matter of conjecture. It was felt, however, that this survey would not be complete without some attempt being made to assess the amounts of vitamins provided by the children's diets. After consultation with various experts on the subject of vitamins in foods, tables were drawn up, which covered all the foods that were eaten. The amounts of the vitamins in made dishes were arrived at by calculation (p. 22), due allowance being made for destruction during cooking. When no figure for a foodstuff was available, as was often the case, the value for the one most likely to be similar to it was taken, and every endeavour was made to select the best possible figures. On account of the uncertainty about requirements, and the inaccuracy about intakes, no attempt will be made to compare the vitamin intakes of these children with scales of requirements, or to express an opinion as to whether they were likely to have been adequate or not. The chief interest of the results lies, not in their absolute but in their comparative values, for the same figures were used for all the calculations. While future analyses may show that the absolute figures for the intakes are likely to have been too high or too low, any comparison of one individual with another, of one age group with another, or of boys with girls will still remain valid; and the same foods, moreover, will still be the chief sources of the vitamins in the diets.

ANEURIN

The average aneurin intakes of our children are shown in Fig. 63, and some information as to individual variation is given in Tables LXXII and LXXIII. The mean intakes rose from nearly 200 I.U. (0.6 mg.) a day, at the age of one year, to 380 I.U. (1.1 mg.) for boys and 300 I.U. (0.9 mg.) for girls, at the age of 14 or 15. They then remained steady or fell a little. There were wide individual variations, which were of the same order in all the age groups, and these variations were approximately the same for boys as for girls.

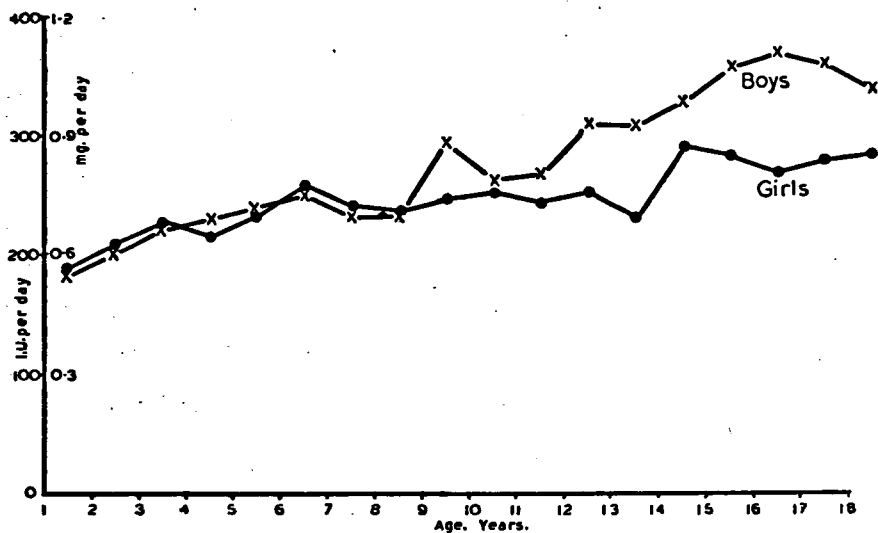


FIG. 63.—Children's Average Aneurin Intakes.

TABLE LXXII
Boys' Aneurin Intakes
(mg. per day)

Age group	Average aneurin intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	0.55	1.01	0.35	0.16	29.4
2	0.61	0.85	0.40	0.13	20.8
3	0.67	0.89	0.41	0.11	16.9
4	0.70	0.91	0.40	0.16	23.5
5	0.72	1.13	0.46	0.17	22.3
6	0.76	1.53	0.45	0.23	29.7
7	0.71	0.92	0.40	0.13	18.9
8	0.71	1.16	0.38	0.17	24.0
9	0.90	1.30	0.57	0.17	19.0
10	0.80	1.12	0.54	0.15	18.9
11	0.82	1.19	0.47	0.18	22.5
12	0.95	1.59	0.59	0.23	23.5
13	0.94	1.66	0.61	0.28	29.7
14	1.01	1.70	0.53	0.28	27.5
15	1.09	1.64	0.76	0.27	24.2
16	1.13	2.01	0.81	0.29	25.7
17	1.09	1.67	0.47	0.25	22.7
18	1.03	1.35	0.51	0.24	23.8

TABLE LXXIII.
Girls' Aneurin Intakes
(mg. per day)

Age group	Average aneurin intake	Maximum	Minimum	Standard deviation	Coefficient of variation
1	0.56	0.77	0.30	0.12	20.8
2	0.63	0.91	0.41	0.12	19.4
3	0.68	1.01	0.44	0.15	22.6
4	0.66	1.08	0.45	0.15	23.4
5	0.70	0.98	0.51	0.15	21.5
6	0.78	1.29	0.47	0.21	30.7
7	0.72	1.00	0.55	0.12	16.5
8	0.72	0.98	0.47	0.14	18.9
9	0.75	1.18	0.33	0.19	24.9
10	0.77	1.24	0.51	0.19	24.6
11	0.73	1.16	0.41	0.16	21.5
12	0.77	1.42	0.42	0.22	28.4
13	0.70	1.27	0.39	0.19	26.6
14	0.89	1.28	0.55	0.20	22.8
15	0.85	1.39	0.34	0.21	24.3
16	0.82	1.13	0.38	0.17	20.6
17	0.84	1.41	0.57	0.20	23.8
18	0.86	1.10	0.57	0.14	16.8

The aneurin requirement is known to run with calorie intake, and figures for requirements and intakes of this vitamin are sometimes expressed on a calorie basis. The present results have accordingly been calculated in this way, and Fig. 64 shows the average aneurin intakes per 1,000 calories in the diet. The

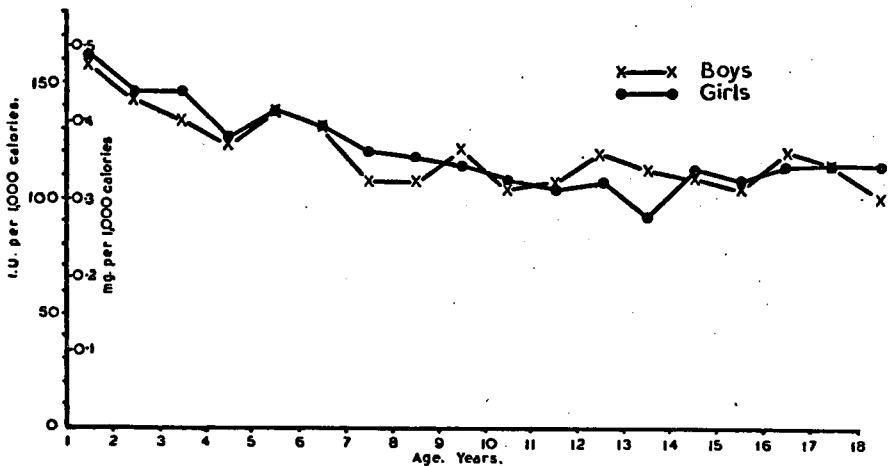


FIG. 64.—Average Aneurin Intakes per 1,000 Calories.

curves for boys and girls are almost identical. The higher total intakes of the vitamin by the older boys were exactly in tune with their higher intakes of calories, and their bigger aneurin intakes, therefore, were due solely to their bigger appetites and not to the consumption of any foods particularly rich in the vitamin. The aneurin intakes per 1,000 calories were not the same at all ages, but fell from 0.5 mg. per 1,000 calories at one year to 0.35 mg. at ten. From that age onwards they did not vary significantly.

In all age groups milk provided more aneurin than any other single food. This is interesting, because it is commonly believed that "the cereals rank first as the most important source of vitamin B₁ in human diets" and that "milk is a poor source of vitamin B₁" (Bicknell and Prescott, 1946). The figure that has been taken for the aneurin in milk, 45 µg. per 100 g. (Medical Research Council, 1945) is about the same as that given by Bicknell and Prescott themselves, so the large proportion of the aneurin intakes attributed to milk is not due to the value used for this food. It is due to the fact, so often forgotten, that the actual amount of milk consumed, particularly by young children, is greater than the amount of any other food. The only common foods that contain a very much higher concentration of aneurin are brown bread, oats and other whole cereals, eggs, legumes, pork and bacon. A perusal of Chapter 3 (pp. 22-59) will show why these are not the main sources of aneurin in the diet. A calculation has been made of what the total aneurin intakes would have been if the children had eaten bread made from National Wheatmeal (85 per cent.) flour instead of white bread. Boys of 13 to 18 would have had 0.21-0.27 mg. a day extra and girls of corresponding age 0.15-0.21 mg. The younger children ate less bread, and hence their aneurin intakes would have been correspondingly less raised.

Milk provided the children below 10 with 33 per cent. of their aneurin, and brown bread, potatoes and fruit were, next to milk, the chief sources of supply. Milk supplied about 16 per cent. of the older children's aneurin, and white bread, meat and potatoes each contributed approximately 10 per cent. The children ate so little brown bread that it only accounted for some 6 per cent. of their total aneurin. The girls obtained 10 per cent. of their aneurin from fruit, the boys a smaller proportion. The amounts of yeast extracts eaten were, as a rule, so small that they made no significant difference to the average total aneurin intakes.

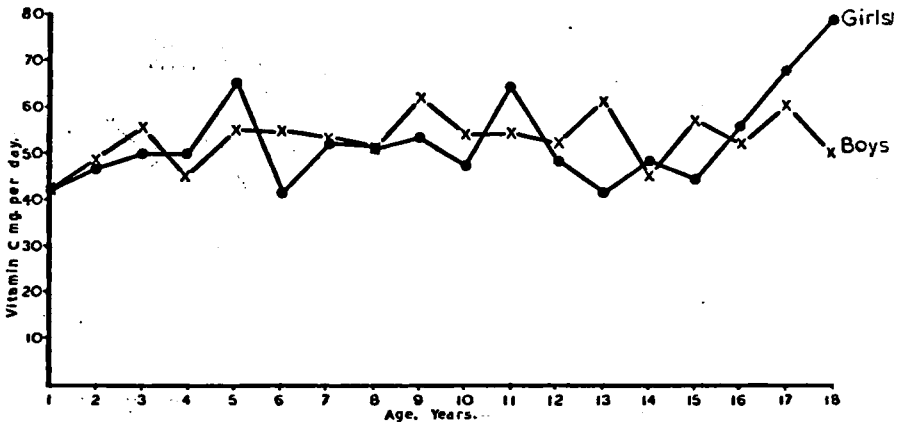


FIG. 65.—Children's Average Ascorbic Acid Intakes.

ASCORBIC ACID

Fig. 65 shows the average intakes of ascorbic acid, and it will be seen that they differ from those of aneurin in remaining approximately the same at all ages, and for both sexes. The ascorbic acid in the diet is derived chiefly from fruit and vegetables, and if Figs. 65 and 22 (p. 45) are compared, certain relationships will be seen. The high ascorbic acid intakes of the 17- and 18-year-old girls, for example, were clearly due to a large consumption of raw fruit. Fruit provided the younger children with two-thirds of their ascorbic acid, and the

older ones with approximately half. Tables LXXIV and LXXV show the average amounts of ascorbic acid which were derived from various foodstuffs, and it will be seen that citrus fruits (particularly oranges) were the small children's

TABLE LXXIV
Distribution of Ascorbic Acid in Boys' Diets
(mg. per day)

Age group	Citrus fruit	Other fruit (including tomato)	Vegetables	Jam	Milk	Total
1	24.9	3.8	9.0	0.1	4.2	42.0
2	27.3	7.9	8.9	0.5	4.8	49.4
3	34.3	6.1	10.0	0.6	4.7	55.8
4	18.8	9.7	11.6	0.7	5.4	46.2
5	28.2	9.0	13.0	0.9	4.6	55.7
6	30.8	8.7	10.8	1.1	4.4	55.8
7	18.3	12.4	16.9	1.8	4.4	53.8
8	17.8	10.4	18.6	1.5	4.1	52.4
9	25.5	11.6	19.0	2.6	4.7	63.4
10	19.7	10.8	18.4	2.2	4.3	55.4
11	15.3	11.7	21.3	2.2	4.6	55.1
12	15.7	9.6	22.1	2.6	3.4	53.4
13	17.9	12.6	25.0	2.6	3.4	61.5
14	14.7	9.6	15.4	3.4	2.9	46.0
15	24.1	11.7	16.3	2.7	3.6	58.4
16	11.8	8.6	28.4	1.5	3.2	53.5
17	16.4	12.1	28.0	2.7	3.2	62.4
18	10.6	7.5	26.3	2.7	3.5	50.6

TABLE LXXV
Distribution of Ascorbic Acid in Girls' Diets
(mg. per day)

Age group	Citrus fruit	Other fruit (including tomato)	Vegetables	Jam	Milk	Total
1	23.7	4.9	7.9	0.2	4.8	41.5
2	27.0	7.4	7.9	0.6	4.2	47.1
3	29.8	7.1	7.6	0.6	4.5	49.6
4	27.4	6.6	11.4	0.8	3.6	49.8
5	33.4	11.9	14.1	0.8	4.8	65.0
6	14.6	7.4	13.9	1.1	4.9	41.9
7	20.3	15.8	11.4	1.4	4.4	53.3
8	23.6	6.5	15.6	1.8	4.6	52.1
9	19.0	12.3	17.6	1.0	4.5	54.4
10	18.1	9.7	14.1	2.0	4.5	48.4
11	23.4	16.5	19.5	2.2	3.6	65.2
12	20.6	9.8	15.1	1.2	2.7	49.4
13	16.7	8.1	12.5	0.8	3.4	41.5
14	21.1	8.6	15.3	1.9	2.3	49.2
15	19.1	5.4	16.1	1.7	2.6	44.9
16	23.7	9.4	19.9	1.4	2.6	57.0
17	34.9	8.6	21.0	1.7	2.9	69.1
18	37.3	11.7	26.0	2.3	2.5	79.8

chief source of this vitamin. Fewer oranges were eaten as the children grew older (see p. 44), but the consumption of vegetables increased, so that the total intake of ascorbic acid remained almost constant. Small amounts of ascorbic acid were obtained from jam and from milk, but these would only have been significant had no fruit been available.

Tables LXXVI and LXXVII show the maximum and minimum intakes of ascorbic acid in each of the age groups as well as the average, and also the standard deviation and coefficient of variation. There was a wider individual

TABLE LXXVI
Boys' Ascorbic Acid Intakes
(mg. per day)

<i>Age group</i>	<i>Average ascorbic acid intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	42	80	10	19.3	46.2
2	49	154	10	21.2	43.2
3	56	150	13	31.2	55.6
4	46	87	18	19.2	41.8
5	56	99	20	20.7	37.0
6	56	151	16	30.1	53.7
7	54	129	9	25.1	46.5
8	52	82	13	19.0	36.5
9	63	141	20	33.0	52.3
10	55	139	18	27.7	50.3
11	55	106	28	17.2	31.2
12	53	141	25	27.4	51.6
13	62	178	15	34.9	56.2
14	46	150	5	29.9	65.0
15	58	169	15	37.3	64.2
16	54	88	19	19.7	36.5
17	62	134	20	27.4	44.2
18	51	94	17	20.5	40.1

TABLE LXXVII
Girls' Ascorbic Acid Intakes
(mg. per day)

<i>Age group</i>	<i>Average ascorbic acid intake</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Standard deviation</i>	<i>Coefficient of variation</i>
1	42	79	11	19.9	47.3
2	47	104	14	22.9	48.7
3	50	106	16	25.9	52.0
4	50	85	10	21.8	43.7
5	65	117	26	28.6	44.0
6	42	129	10	26.6	63.3
7	53	123	22	26.6	50.1
8	52	112	19	20.9	40.2
9	54	105	20	23.6	43.8
10	48	128	11	27.6	57.5
11	65	188	23	24.0	36.9
12	49	160	21	28.5	58.0
13	42	115	16	20.3	48.4
14	49	196	18	27.1	55.2
15	45	119	17	22.8	50.8
16	57	110	15	23.6	41.5
17	69	219	29	39.5	57.2
18	80	213	36	27.8	34.8

variation in the intake of ascorbic acid than of any other dietary constituent so far considered. One boy of 14 had 5 mg. a day and another 150 mg. The maximum was in a number of instances 10 times the minimum. A very high intake was almost always due to a great many oranges being eaten. Occasionally grapefruit provided a child with a large amount of the vitamin—one 17-year-old girl

derived 142 mg. a day from this source, but no other child approached this figure. Ten children, who weighed their food during June and July, ate sufficient strawberries to give them 30 mg. or more a day, and the maximum amount obtained from this fruit was 272 mg. during the week. Only 22 of the 916 children had any black currants (Table XXVI, p. 46), and the amounts of this fruit were too small to raise the ascorbic acid intakes to very high levels, and they made no significant difference to the group averages.

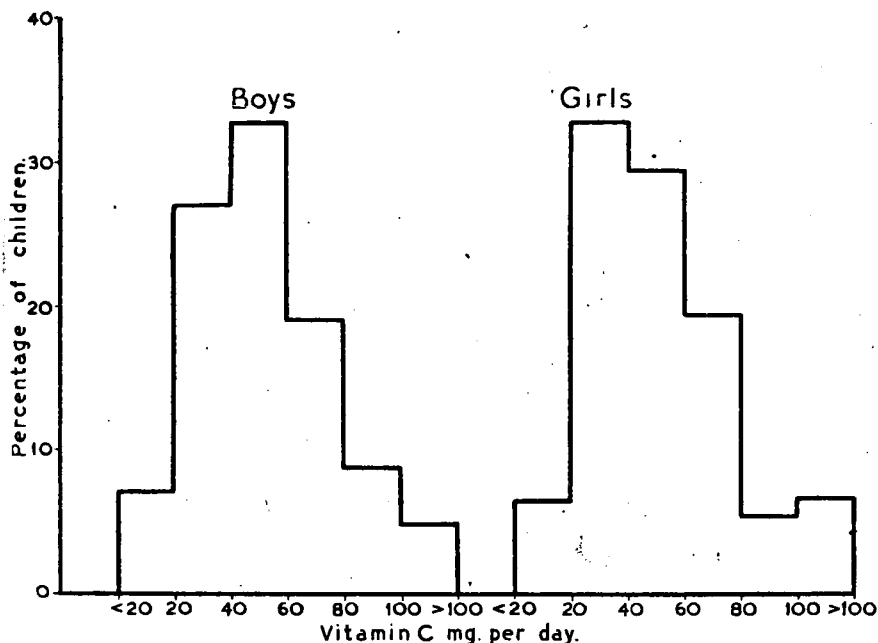


FIG. 66.—Frequency Distribution of Ascorbic Acid Intakes.

Fig. 66 shows the frequency distribution of ascorbic acid intakes, taking boys and girls of all ages together. Thirty-one boys and 30 girls had less than 20 mg. ascorbic acid a day. The majority had between 20 and 60 mg., and 22 boys and 32 girls had more than 100 mg.

VITAMIN A

The assessment of vitamin A intakes is somewhat more complicated than that of aneurin and ascorbic acid because vitamin A is present in food in two distinct forms which have different potencies. It exists as preformed vitamin A in animal fats and as carotenoids in plant tissues, and it is generally agreed that carotenoids are not wholly converted to vitamin A in the human body nor do they appear to be absorbed as completely as preformed vitamin A. In view of this difficulty the amount of carotene in the children's diets has been calculated separately from the amount of vitamin A, and the intakes of the two substances are shown independently. The total vitamin A potency of the diets has also been calculated, and for this purpose 1.8 $\mu\text{g.}$ (or 3 I.U.) of carotene have been taken as having the same potency as one I.U. of vitamin A (Medical Research Council, 1945).

Carotene Intakes

The average carotene intakes of the various age groups are set out in Fig. 67. The intakes of the two sexes seem to run together, but the girls' intakes fluctuated more widely than the boys'. The intakes tended to rise until the children were five years old, and then to remain approximately steady. The girls' curve shows a steep rise between 15 and 18 years, and the highest point in the boys' curve is at 17 years. There were such wide individual variations, however, that the fluctuations are probably due to chance. Two children, a one-year-old boy who ate a considerable amount of spinach, and a girl of nine who was a vegetarian,

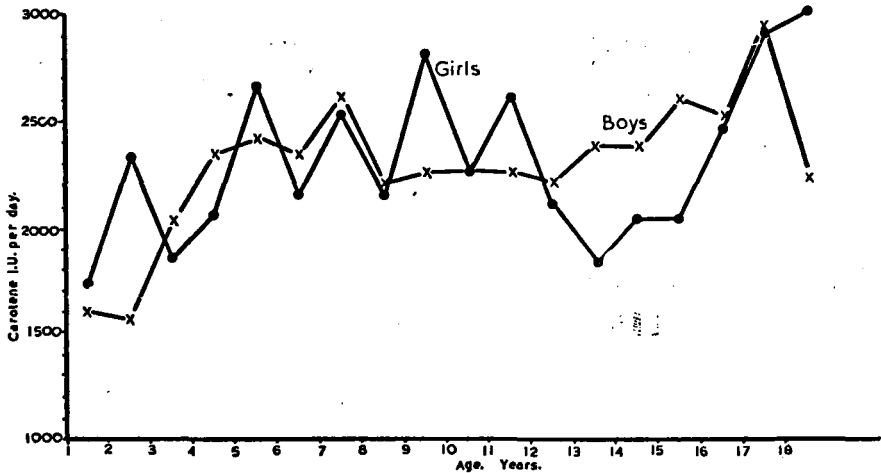


FIG. 67.—Children's Average Carotene Intakes.

had over 8,000 I.U. of carotene a day and they have been omitted in calculating the averages. Twelve boys and 11 girls had over 5,000 I.U. a day, and 19 boys and 16 girls less than 1,000. This is shown in Fig. 68, which gives the frequency distribution of the carotene intakes. Most children had 1,000–3,000 I.U. a day. The older children got most of their carotene from green vegetables, carrots, tomatoes, butter and milk. For the younger ones milk and oranges were the chief sources.

Intakes of Preformed Vitamin A

As soon as the vitamin A data had been assembled it became apparent that the children who had had liver during the week of investigation had very much higher intakes than those who had not. It was accordingly decided that it would be more useful to prepare separate averages for those who ate liver and for those who did not, and the results are set out in Fig. 69. Two hundred and thirty-six of the children had liver during their experimental week, and many more would no doubt have recorded eating liver had the period of observation been longer. Many of those who ate liver during their week of weighing would probably not have eaten it during the following week or weeks, so all the average figures must be thought of with these reservations in mind. The small numbers on which the averages for "liver-eaters" are based provide one reason for the irregularity of the charts. Another is that the amount of liver

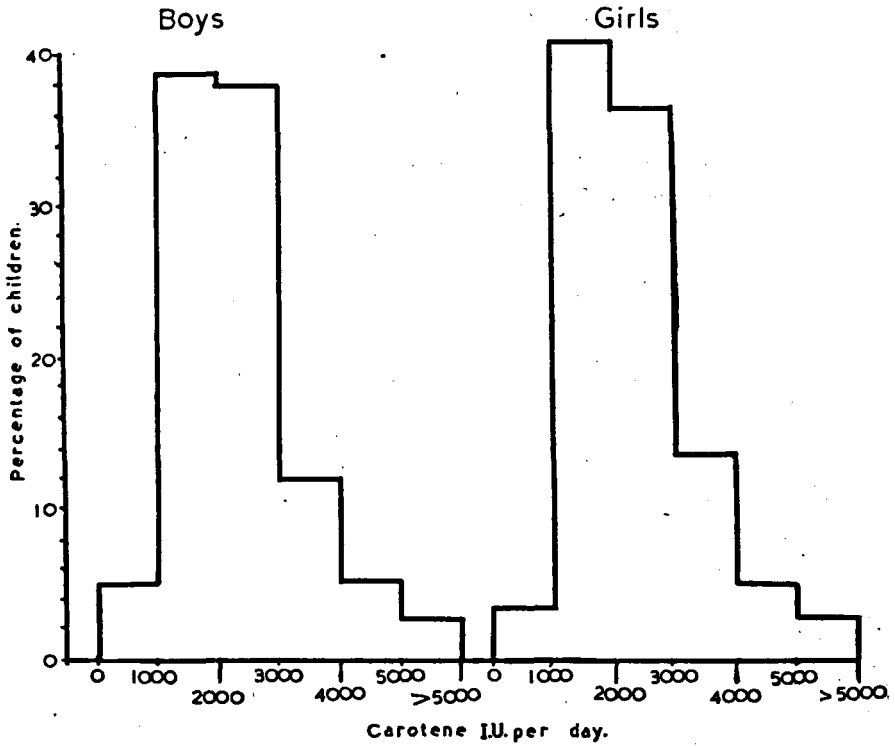


FIG. 68.—Frequency Distribution of Carotene Intakes.

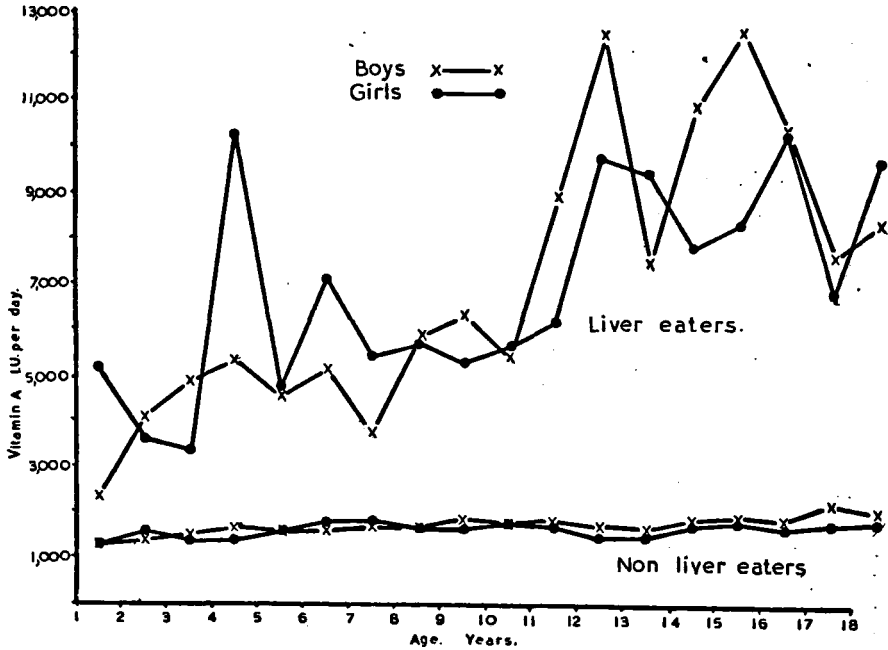


FIG. 69.—Children's Average Intakes of Preformed Vitamin A.

these children ate varied very considerably, so the averages depend to a large extent upon whether they included children who had eaten particularly large amounts. The high average for the four-year-old girls for example is caused by one of the four children in that group eating 8 oz. of cooked liver during the week, and her vitamin A intake came to over 20,000 I.U. a day. Similarly, the tendency for the curve to rise as the children grew older is due to the fact that their appetites increased, so that if they did eat liver they tended to eat more than the younger children.

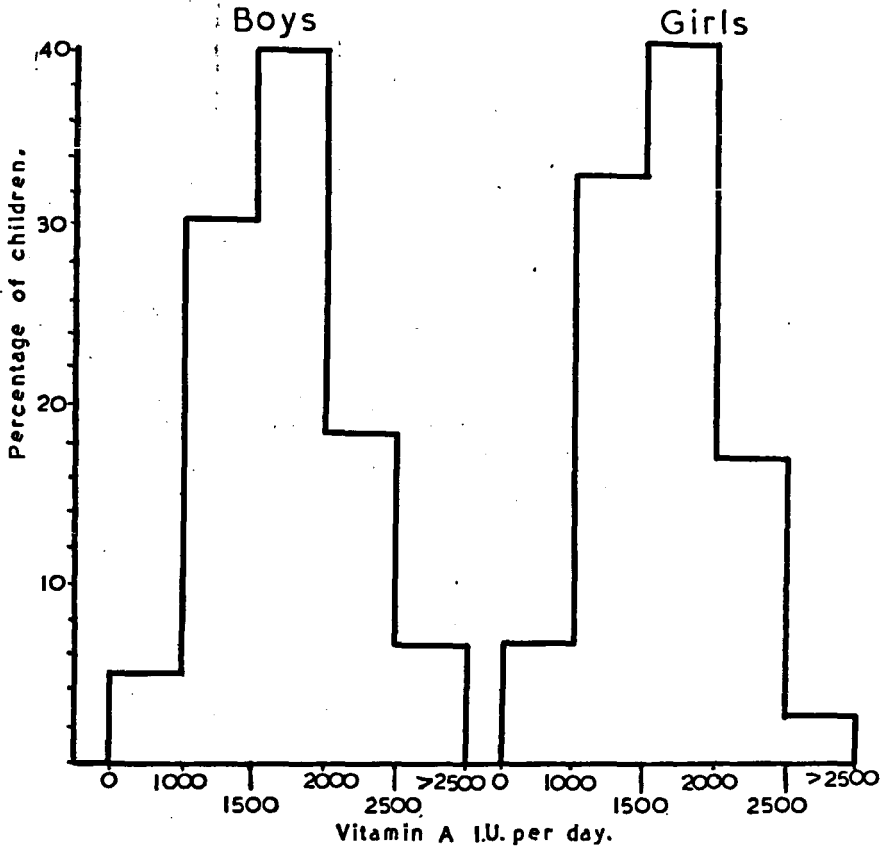


FIG. 70.—Frequency Distribution of Vitamin A Intakes of Children who did not eat Liver.

The amount of vitamin A in the diets of those children who did not eat liver during the test week was remarkably steady, and this chart probably gives a very fair picture of the vitamin A intakes of children who *never* eat liver. Older boys tended perhaps to eat a little more than the corresponding girls, and there was a slight increase in the intake with age. Some information about individual variations may be obtained from the frequency distribution diagrams shown in Fig. 70. The majority of the children had 1,000–2,000 I.U. a day.

Total Vitamin A Intakes

Tables LXXVIII and LXXIX show the average total vitamin A intakes of children of various ages, and the distribution between carotene (expressed in terms of vitamin A potency) and preformed vitamin A. The vitamin A,

TABLE LXXVIII
Distribution of Vitamin A in Boys' Diets
(I.U. per day)

<i>Age group</i>	<i>Vitamin A from carotene</i> ($\frac{1}{3}$ carotene value)	<i>Vitamin A from all foods except liver</i>	<i>Vitamin A from liver (averaged over whole group)</i>	<i>Average total intake</i>
1	540	1240	50	1830
2	530	1390	380	2300
3	690	1450	1580	3720
4	790	1610	1170	3570
5	810	1550	560	2920
6	780	1450	910	3140
7	880	1680	200	2760
8	740	1580	2280	4600
9	760	1760	1500	4020
10	770	1640	1580	3990
11	760	1720	1330	3810
12	740	1680	1880	4300
13	800	1820	1860	4480
14	800	1870	3480	6150
15*	870	2110	3480	6460
16	850	2050	2980	5880
17	990	2210	850	4050
18	750	2100	1780	4630

TABLE LXXIX
Distribution of Vitamin A in Girls' Diets
(I.U. per day)

<i>Age group</i>	<i>Vitamin A from carotene</i> ($\frac{1}{3}$ carotene value)	<i>Vitamin A from all foods except liver</i>	<i>Vitamin A from liver (averaged over whole group)</i>	<i>Average total intake</i>
1	580	1300	1080	2960
2	780	1450	790	3020
3	620	1430	570	2620
4	690	1400	1790	3880
5	890	1530	1190	3610
6	720	1740	1740	4200
7	850	1770	720	3340
8	730	1710	1560	4000
9	940	1830	760	3530
10	770	1700	950	3420
11	870	1640	890	3400
12	700	1420	550	2670
13	610	1580	1090	3280
14	680	1670	1800	3150
15	690	1660	2330	4680
16	830	1650	1410	3890
17	980	1750	1150	3880
18	1010	1880	2500	5390

moreover, has been subdivided into vitamin A from liver and from other foods. For this purpose the amount derived from liver by the few children of each age who ate it was assumed to have been divided equally among all the children in the group. Liver contains so much vitamin A, however, that it sometimes

appeared to constitute the chief source of the vitamin for the whole group. So far as foods other than liver are concerned the chief sources of vitamin A were milk and butter.

VITAMIN D

At the time this investigation was made the chief sources of vitamin D in diets in this country were dairy products and fat fish. Fat fish have by far the greatest concentration, but they are not eaten by everybody. The total amount of vitamin D in a diet depends first and foremost upon whether it has included fat fish or not. It also depends upon the season, for the amount of the

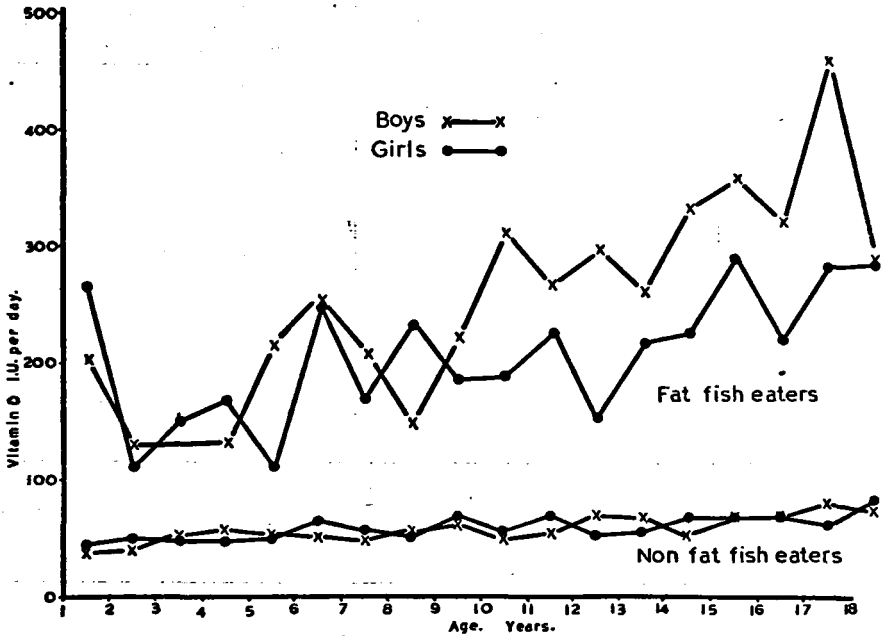


FIG. 71.—Children's Average Vitamin D Intakes.

vitamin present in milk, butter and eggs is influenced by the diet of the cows and hens, and by the amount of sunlight to which they have been exposed, so that these foods contain much more vitamin D in the summer than in the winter. In assessing the amount of vitamin D in the children's diets, the mean of the summer and winter values for dairy products was applied to all diets, irrespective of the time of year at which the investigation was made. The children who weighed their food in the summer would probably have had more, and those who weighed their food in the winter less, than the calculated figure. Children who ate fat fish were averaged separately from those who did not, and the results are set out in Fig. 71. One hundred and fifty-one boys and 148 girls ate fat fish as against 284 boys and 333 girls who did not, and the importance of herrings, kippers, bloaters and sardines in the diets of these children is clearly seen. Their vitamin D intakes were four times as high as those of the others, and intake tended to increase as the children grew older because, like the children who took liver, they had larger helpings of fat fish as their appetites increased. A partiality of the boys for herrings also explains the sex difference in the vitamin D intakes of the older children. There appeared to be no significant sex difference in the amount of vitamin D in the diets of the children who did not eat fat fish. This may seem a little surprising in view of the

fact that the older boys tended to have more milk and butter than the girls (pp. 32 and 36). The children derived twice as much vitamin D from eggs as they did from milk, and boys and girls ate approximately the same number of

TABLE LXXX
Distribution of Vitamin D in Boys' Diets
(I.U. per day)

<i>Age group</i>	<i>Vitamin D from milk, butter and eggs</i>	<i>Vitamin D from fat fish (averaged over whole group)</i>	<i>Vitamin D from other foods (including cakes and puddings)</i>	<i>Average total intake</i>
1	27	8	12	47
2	29	20	11	60
3	30	0	21	51
4	32	17	26	75
5	32	35	20	87
6	30	59	21	110
7	31	45	20	96
8	32	34	27	93
9	33	46	29	108
10	32	114	22	168
11	33	56	23	112
12	32	73	39	144
13	32	93	35	160
14	31	165	24	220
15	35	147	33	215
16	33	114	34	181
17	34	205	46	285
18	35	104	42	181

TABLE LXXXI
Distribution of Vitamin D in Girls' Diets
(I.U. per day)

<i>Age group</i>	<i>Vitamin D from milk, butter and eggs</i>	<i>Vitamin D from fat fish (averaged over whole group)</i>	<i>Vitamin D from other foods (including cakes and puddings)</i>	<i>Average total intake</i>
1	28	11	14	53
2	29	14	19	62
3	29	25	16	70
4	28	27	18	73
5	29	16	20	65
6	31	68	32	131
7	32	41	27	100
8	32	91	21	144
9	32	35	37	104
10	33	39	26	98
11	31	58	38	127
12	28	21	26	75
13	30	28	28	86
14	32	59	37	128
15	30	83	37	150
16	28	68	40	136
17	31	72	30	133
18	30	77	53	160

eggs (p. 38). Furthermore, fish other than the very fat fish was reckoned to contain some vitamin D, and the extra amounts of these fish eaten by the girls just about counterbalanced the extra milk and butter consumed by the boys.

In Tables LXXX and LXXXI are shown the average total amounts of vitamin D in the diets of boys and girls of all ages, and its distribution between

three classes of foodstuff. In this case the vitamin D in the fat fish has been averaged over the whole age group. These tables show clearly how much the vitamin D intakes of the older boys were raised by their consumption of fat fish, and how similar their intakes from other sources were to those of the older girls.

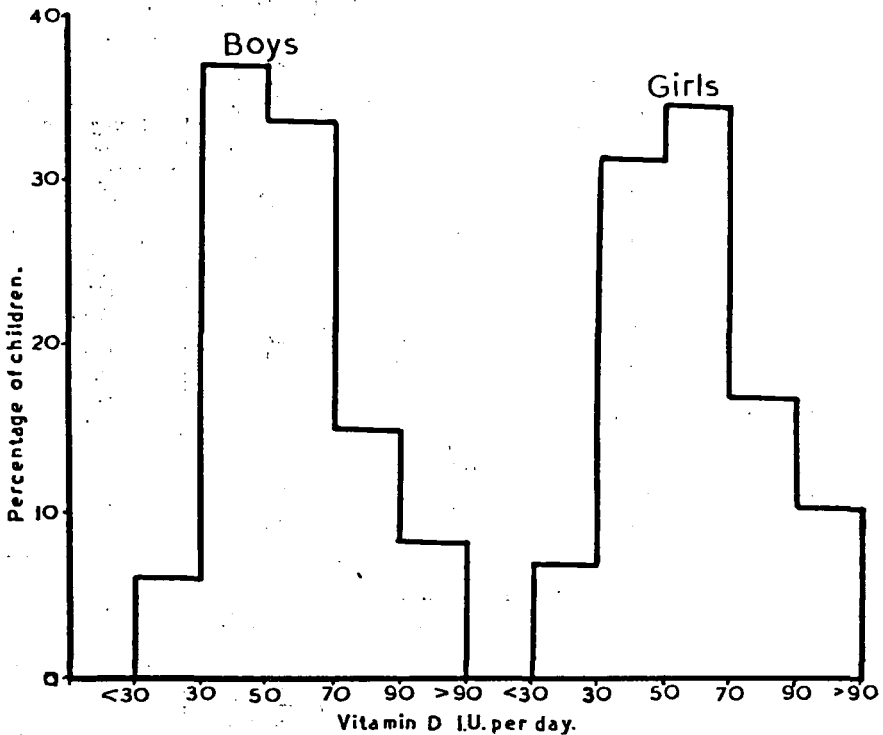


FIG. 72.—Frequency Distribution of the Vitamin D Intakes of Children who did not eat Fat Fish.

Fig. 72 shows the frequency distribution of the vitamin D intakes of the children who did not eat fat fish. The majority had 30–70 I.U. a day, but 40 had less than 30 I.U.

VITAMIN SUPPLEMENTS AND VITAMIN INTAKES

The consumption of medicinal vitamin supplements has already been discussed (p. 58). It is, perhaps, of some interest to consider whether the children who had supplements of vitamins A and D were the children who needed them most, or whether they were the fortunate ones who were having a fully adequate supply from liver and fat fish. It will be recalled that 236 of the children ate liver. Of these, 20 per cent. also had a supplement of vitamin A. Of the 680 children who did not have liver during their particular week of food weighing, 17 per cent. had medicinal vitamin A. Of the 299 children who ate fat fish, 13 per cent. had extra vitamin D, but of the 617 others who had none of this food, 20 per cent. recorded receiving the vitamin supplement. Fat fish were eaten chiefly by the older children, while it was the younger ones who tended to have the vitamin D supplements, and this probably accounts for the figures not agreeing more closely. It is, of course, realized that these results cover only one week's diet for each child. The same children would probably have had the vitamin supplements any other week, but other children

would have had liver and fat fish; equally, those who ate fat fish and liver during the experimental week are unlikely to have had them every week. The fact remains that certain children had these foods during the particular week when they were weighing their food and there is no reason to suppose that a very different result would have been obtained had all the 916 children weighed their food during some other week of the four years during which the data were being collected.

CHAPTER 11

EFFECT OF LOCALITY UPON THE TYPE AND VARIETY OF FOODSTUFFS CONSUMED, AND UPON THE CHEMICAL COMPOSITION OF THE DIET

" Man is by nature suited to a great variety of functions, and, therefore, to a great variety of states and circumstances, and among the rest to a great variety of aliments." (Cullen, 1789.)

Food customs are partly a matter of necessity and partly a matter of habit, and it is well known that a vast number of different combinations of foods can be used to make up an adequate diet. Even within a small land such as our own, eating habits vary considerably from one part to another, and the high teas of the north, for example, may be contrasted with the afternoon teas and suppers of the south. Certain foods may be popular in some districts and not in others. Haggis, for instance, may be a common enough dish north of the Tweed, but it is not often met with in English homes. Furthermore, some foods can be obtained more readily in one place than another, though, before the war, modern transport and commercial keenness had made it possible for most urban areas to be well supplied with all foods for which there was a demand.

The children taking part in this investigation came from many different localities (Table II, p. 7), and it has been possible to group them in various ways, according to the part of the country in which they lived, so that the eating habits of groups may be compared. A few of these comparisons will now be discussed.

Comparison of the consumption of milk, fruit and green vegetables in different parts of the country, and of the intakes of calcium and ascorbic acid

Milk, fruit and green vegetables have been chosen for this comparison, for two reasons. In the first place, whereas children tended to eat more and more of most foods as they grew older (Chapter 3), their consumption of milk, fruit and green vegetables remained approximately the same at all ages above one year. Thus it was possible to group all the children of two years and upwards according to the part of the country in which they lived, and to calculate their average intakes of these foods without having to take account of age as a complicating factor. Secondly, the better the diet as a whole the more of these particular foods were likely to have been included in it, and they, therefore, provide a rough indication of the quality of the entire diet. Milk is children's chief source of calcium (p. 103) and fruit was, before the war, their chief source of ascorbic acid (p. 125). The average intakes of calcium and ascorbic acid have been shown to vary very little with age, and they have, therefore, also been included in the present comparison.

All the children of two years and upwards living in England who took part in this investigation have been divided into four geographical groups. The

London children formed Group 1, and those living in South and South-West England comprised Group 2. Group 3 consisted of children from the Midlands and East Anglia, and Group 4 was made up of those living in the Northern Counties of England. Since income and social status are said to influence the consumption of the foods chosen for this comparison (Orr, 1936), the children have been further sub-divided within each geographical group into their three socio-economic grades (p. 8). A summary of the numbers of boys and girls in each of the 12 sub-groups is given in Table LXXXII. Some of the numbers,

TABLE LXXXII
Numbers of Children in the various Geographical Groups

Geo- graphical group		Professional class		Upper working class		Artisan class	
		Boys	Girls	Boys	Girls	Boys	Girls
1	London	114	70	90	155	28	21
2	S. and S.W. England	38	27	31	24	3	3
3	Midlands and E. Anglia	23	17	41	13	10	6
4	Yorks., Lancs., Northumberland, Durham, Liverpool.	10	10	12	93	16	19

e.g. of boys and girls of the artisan class living in S. and S.W. England, are too small for "averages" to have any meaning, and when Tables LXXXIII-LXXXVIII are studied this reservation must be borne in mind. These tables show the average intake of milk, raw and cooked fruit, cooked green vegetables, and of calcium and ascorbic acid. It has already been shown (p. 35) that economic level made little or no difference to the quantity of milk consumed by

TABLE LXXXIII
*Effect of Locality and Socio-economic Grade on the Consumption of Milk
(oz. per day)*

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	15.2	15.1	17.1	16.5
S. and S.W. England	14.8	20.3	18.0	17.7
Midlands and E. Anglia	13.5	16.9	14.2	14.9
N. England	14.8	14.4	13.8	14.3
<i>Girls—</i>				
London	13.3	14.7	14.8	14.3
S. and S.W. England	17.4	18.1	17.5	17.7
Midlands and E. Anglia	14.9	17.7	15.6	16.1
N. England	20.1	11.2	10.1	13.8

our children and that this is because more children of the artisan class had milk at school. Table LXXXIII confirms the similarity in milk consumption in all three social groups and, as might have been expected from what has already been said (p. 103), calcium intakes paralleled milk consumption very closely (Table LXXXVII), and social circumstances, therefore, did not appear to affect calcium intakes. Had it not been for the school milk, however, they would certainly have done so. Boys and girls living in South and South-West England had most milk, and those living in the North had the least. The difference is particularly striking in the case of the girls of the upper working and artisan classes.

No consistent differences in the consumption of fruit or green vegetables came to light (Tables LXXXIV-LXXXVI). The average calcium intakes of the four geographical groups were very similar. Children in South and South-West

TABLE LXXXIV
Effect of Locality and Socio-economic Grade on the Consumption of Raw Fruit
(oz. per day)

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	3.5	2.8	2.7	3.0
S. and S.W. England ..	3.4	3.6	1.9	3.0
Midlands and E. Anglia ..	4.6	3.1	2.6	3.4
N. England	3.8	3.7	3.6	3.7
<i>Girls—</i>				
London	3.5	4.1	3.0	3.5
S. and S.W. England ..	3.9	3.1	1.7	2.9
Midlands and E. Anglia ..	4.6	4.8	2.1	3.8
N. England	2.7	3.3	2.8	2.9

TABLE LXXXV
Effect of Locality and Socio-economic Grade on the Consumption of Cooked Fruit
(oz. per day)

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	1.6	1.8	2.3	1.9
S. and S.W. England ..	2.1	2.6	0.8	1.8
Midlands and E. Anglia ..	1.9	1.6	1.4	1.6
N. England	1.8	1.3	1.5	1.5
<i>Girls—</i>				
London	1.5	1.7	1.0	1.4
S. and S.W. England ..	1.9	2.8	0.5	1.7
Midlands and E. Anglia ..	1.6	1.1	1.1	1.3
N. England	1.2	1.3	0.7	1.1

TABLE LXXXVI
Effect of Locality and Socio-economic Grade on the Consumption of Green Vegetables
(oz. per day)

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	1.2	1.0	0.7	1.0
S. and S.W. England ..	0.7	1.0	0.8	0.8
Midlands and E. Anglia ..	1.1	1.4	1.6	1.4
N. England	1.1	0.9	0.7	0.9
<i>Girls—</i>				
London	1.2	1.3	0.7	1.1
S. and S.W. England ..	1.2	0.8	0.7	0.9
Midlands and E. Anglia ..	1.1	0.8	0.6	0.8
N. England	0.5	0.3	0.5	0.4

England had slightly more than the other three groups, and the London children slightly less. Locality made little difference to the amounts of ascorbic acid in the diets, but children of the artisan class appeared to have rather less than children belonging to either of the other two socio-economic grades.

TABLE LXXXVII
Effect of Locality and Socio-economic Grade on Calcium Intakes
(g. per day)

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	0.79	0.79	0.69	0.76
S. and S.W. England	0.80	0.95	0.76	0.84
Midlands and E. Anglia	0.74	0.81	0.80	0.78
N. England	0.79	0.74	0.79	0.77
<i>Girls—</i>				
London	0.67	0.77	0.73	0.71
S. and S.W. England	0.82	0.83	0.70	0.78
Midlands and E. Anglia	0.72	0.80	0.75	0.76
N. England	0.91	0.62	0.61	0.73

TABLE LXXXVIII
Effect of Locality and Socio-economic Grade on Ascorbic Acid Intakes
(mg. per day)

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	56	51	39	49
S. and S.W. England	45	55	35	45
Midlands and E. Anglia	63	77	49	63
N. England	65	51	46	54
<i>Girls—</i>				
London	53	61	38	51
S. and S.W. England	50	50	24	41
Midlands and E. Anglia	58	63	38	53
N. England	57	47	41	48

Effect of various factors on variety in the diet

An attempt has been made to obtain some quantitative measure of the variety in the diets of the children taking part in this investigation by counting up the number of different foods that they ate during the course of the week. Fig. 73 shows that when the children are classified according to age, boys and girls of all ages above one year ate an average of 40–50 different foods during the week. When they are classified according to their socio-economic circumstances (Table LXXXIX), it is quite clear that wherever they lived their diets became more and more varied as income increased and they rose in the social scale. This is brought out even more clearly by the results of an investigation into the diets of children of unemployed fathers which will be discussed later (Chapter 17, p. 166). The difference is chiefly in the variety of cooked dishes, puddings and cakes. As income increased, more and more cooking

was done in the home, so that the professional classes were eating nearly twice as many different foods as the unemployed. The difference between the upper working and professional class groups is due to the fact that the latter tended to have two meals of the "dinner" type every day, while the former usually had

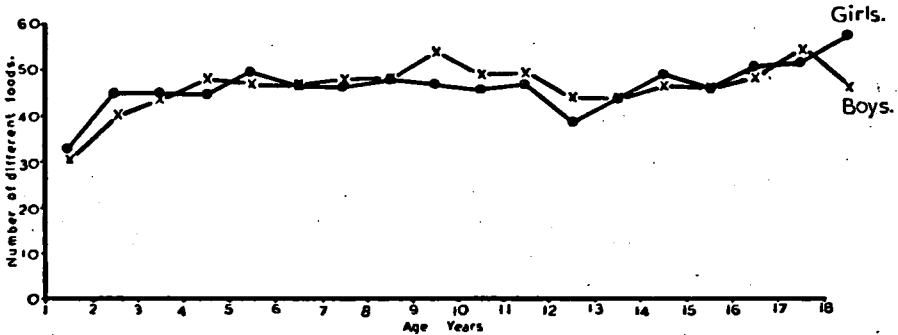


FIG. 73.—Average number of Different Foods eaten by Boys and Girls during One Week

dinner at mid-day and supper in the evening (see Crawford and Broadley, 1938). Meat, vegetables and pudding, perhaps preceded by soup, offer more scope for variety than a meal based on bread with a savoury.

TABLE LXXXIX

*Effect of Locality and Socio-economic Grade on the Variety in the Diet
(No. of different foods eaten during the week)*

	Professional class	Upper working class	Artisan class	Average. All social groups
<i>Boys—</i>				
London	49	47	38	45
S. and S.W. England	49	48	35	44
Midlands and E. Anglia	53	46	43	47
N. England	57	49	38	48
<i>Girls—</i>				
London	51	48	41	47
S. and S.W. England	53	48	42	48
Midlands and E. Anglia	52	43	45	47
N. England	47	43	39	43

The average number of different foods eaten in the four geographical groups seemed to be very much the same, and there were no consistent variations from one district to another within any one of the three social grades.

It must be concluded that economic circumstances make more difference to the diet than locality. The latter, in fact, made surprisingly little difference so far as these particular foods and dietary constituents were concerned.

Comparison of the diets of girls attending secondary schools in London and Preston, Lancs.

Seventy-five girls attending three different secondary schools in London, and 39 girls living in or near Preston and attending a secondary school in that town were available for this comparison. They were all 14–18 years old, and the results for the three yearly age groups, 14, 15 and 16 have been averaged separately.

Girls of 17 and 18 have been treated together. Table XC gives some particulars about the girls themselves, their heights and weights and haemoglobin levels, and the average number of carious teeth. On the whole, the Preston girls appeared to be both shorter and lighter than the Londoners. Their average haemoglobin levels were always slightly lower, and they certainly had worse teeth.

TABLE XC

Comparison of the Heights, Weights, Haemoglobin Levels, and Incidence of Dental Caries among Girls attending Secondary Schools in London (L) and Preston (P)

		No. of girls	Average height (in.)	Average weight (kg.)	Average haemoglobin (g. per 100 c.c.)	Average no. of teeth decayed, missing or filled
14 years ..	L	17	63.75	53.4	14.1	8.3
	P	9	62.0	47.1	13.8	10.1
15 years ..	L	15	63.0	54.1	15.0	9.3
	P	18	62.75	54.3	13.1	12.5
16 years ..	L	20	64.0	56.5	13.7	7.2
	P	4	62.0	50.1	13.4	15.3
17-18 years ..	L	23	65.0	60.6	13.7	10.0
	P	8	64.0	56.2	13.1	14.6

Table XCI shows the girls' mean consumption of various foods, and the most striking thing about these figures is their similarity. All the staple foodstuffs appeared to be eaten in very much the same quantities in the two cities. The London girls, however, had a bigger variety of foods, and they ate more green vegetables. They got more ascorbic acid at all ages, and also a little more calcium (Table XCII). None of the other dietary constituents was consistently higher in one town than in the other, but if the 16-year-olds are omitted because of the small number in the Preston group, the London girls usually had the most of the various dietary essentials. If the differences between the heights and weights, haemoglobin levels and incidence of dental caries are

TABLE XCI

Comparison of the Average Consumption of Various Foods by Girls attending Secondary Schools in London (L) and Preston (P)

	Age 14		Age 15		Age 16		Ages 17 and 18	
	L	P	L	P	L	P	L	P
No. of different foods eaten during the week.	43	42	48	45	53	41	56	46
Bread, white .. oz. per day	5.5	4.5	6.0	5.5	3.8	6.1	4.1	5.0
Bread, brown .. oz. per day	0.9	1.3	0.3	1.1	1.3	0.9	1.2	1.5
Cakes and biscuits .. oz. per day	3.1	2.8	3.1	3.1	3.1	4.8	3.6	3.9
Milk .. oz. per day	12.8	12.3	10.2	11.4	12.1	12.9	12.4	11.1
Cheese .. oz. per day	0.2	0.1	0.3	0.2	0.2	0.2	0.2	0.1
Meat (raw weight) oz. per day	5.4	4.5	5.7	5.0	4.2	4.8	4.8	4.3
Fish (raw weight) oz. per day	1.1	1.5	1.1	1.0	1.0	1.4	1.0	0.8
Fruit, raw .. oz. per day	3.6	2.5	3.2	3.1	4.3	2.8	5.3	3.9
Fruit, cooked .. oz. per day	1.1	1.0	0.8	1.1	1.4	0.8	2.0	1.1
Fruit, tinned .. oz. per day	0.5	0.6	0.8	0.2	0.5	0.5	0.5	0.6
Potatoes .. oz. per day	3.8	5.4	4.5	4.9	3.8	4.8	4.5	4.4
Green vegetables .. oz. per day	1.4	0.5	1.6	0.4	1.9	0.3	1.6	0.4
Sweets and chocolate .. oz. per day	0.7	0.8	1.2	0.7	0.8	1.2	0.7	0.8

real, they may possibly be explained by these slight differences in diet over long periods of time. The results are suggestive rather than conclusive, and a comparative survey on much larger numbers of children would clearly be desirable.

TABLE XCII

Comparison of the Chemical Composition of the Diets of Girls attending Secondary Schools in London (L) and Preston (P)

	Age 14		Age 15		Age 16		Ages 17 and 18	
	L	P	L	P	L	P	L	P
Calories .. per day	2683	2473	2638	2577	2399	2706	2618	2635
Protein .. g. per day	78	74	79	78	69	81	76	71
Animal protein .. g. per day	48	46	49	46	43	48	46	36
Fat .. g. per day	109	95	108	104	101	112	109	105
Carbohydrate .. g. per day	329	312	320	316	286	325	314	334
Calcium .. g. per day	0.74	0.68	0.70	0.66	0.72	0.70	0.75	0.64
Phosphorus .. g. per day	1.23	1.20	1.21	1.22	1.17	1.26	1.27	1.13
Iron .. mg. per day	14.2	13.9	14.5	14.5	12.8	13.1	14.7	12.3
Aneurin .. mg. per day	0.92	0.87	0.80	0.92	0.83	0.93	0.89	0.82
Ascorbic acid .. mg. per day	60	41	50	42	60	38	78	64
Vitamin A .. I.U. per day	2899	3101	3769	4641	3185	1817	3984	2305
Carotene .. I.U. per day	2070	1927	1946	2261	2535	1989	3061	2922
Vitamin D .. I.U. per day	145	116	178	108	139	155	145	76

Comparison of the diets of boys attending secondary schools in London and Dudley, Worcs.

The boys in Dudley who took part in this investigation were, on the whole, younger than the boys who were studied in London and who attended a similar type of secondary school. It has not been possible, therefore, to include all the boys investigated at both schools in the comparison. Four boys of each age, 16, 17 and 18, have been selected from each place and "paired" as far as possible as regards social status, and the results for the intakes of foods and dietary constituents for the 12 boys in London have been averaged and compared with the corresponding averages for the 12 boys in Dudley. The results are set out in Tables XCIII and XCIV.

TABLE XCIII

Comparison of the Consumption of Various Foods by Boys attending Secondary Schools in London and Dudley, Worcs.

	London	Dudley
No. of different foods eaten during the week ..	51	51
Bread, white oz. per day	6.0	6.3
Bread, brown oz. per day	1.6	1.9
Cakes and biscuits oz. per day	4.0	3.3
Milk oz. per day	14.3	16.3
Cheese oz. per day	0.4	0.2
Meat and bacon (raw weight) .. oz. per day	6.7	5.9
Fish (raw weight) oz. per day	1.1	1.0
Fruit, raw oz. per day	3.5	4.3
Fruit, cooked oz. per day	1.7	1.0
Fruit, tinned oz. per day	0.6	0.9
Potatoes oz. per day	5.7	6.4
Green vegetables oz. per day	1.6	1.9
Sweets and chocolate oz. per day	0.8	1.3

TABLE XCIV

Comparison of the Chemical Composition of the Diets of Boys attending Secondary Schools in London and Dudley, Worcs.

	London	Dudley
Weight kg.	67·7	67·7
Height in.	69·2	69·1
Calories per day	3254	3356
Protein g. per day	99	89
Animal protein g. per day	64	53
Fat g. per day	129	133
Carbohydrate g. per day	403	427
Calcium g. per day	0·89	0·89
Phosphorus g. per day	1·57	1·45
Iron mg. per day	19·3	16·7
Aneurin mg. per day	1·13	1·17
Ascorbic acid mg. per day	66	67
Vitamin A I.U. per day	7279	3287
Carotene I.U. per day	2959	2583
Vitamin D I.U. per day	166	233

The average weights and heights of the two groups of boys were almost identical (Table XCIV), and, as in the case of the girls just discussed, the figures for the two groups are very similar. The total protein and animal protein were a little higher in London, chiefly because of the slightly greater consumption of meat. Six of the boys in London, but only three of those in Dudley, had liver during the week of investigation, and moreover those who ate it in London ate more, and this explains the difference in vitamin A. On the other hand six Dudley boys, and four London boys had fat fish so the average vitamin D intake was higher in Dudley. The number of different foods eaten during the week was exactly the same in the two places.

Study of the diets of 23 rural Cambridgeshire children

Most of the children taking part in this investigation lived in towns, but through the co-operation of Dr. and Mrs. T. R. Parsons the diets of a group of rural children attending three "Village Colleges" in Cambridgeshire were investigated. These children were not included in the main survey for various

TABLE XCV

Comparison of the Diet of a group of Rural Cambridgeshire Children with that of a group of London Children of Similar Age, Sex and Economic Status

	Average for rural children	Average for London children
Calories per day	2644	2453
Protein g. per day	71	69
Animal protein g. per day	37	39
Fat g. per day	95	88
Carbohydrate g. per day	358	330
Calcium g. per day	0·65	0·73
Phosphorus g. per day	1·08	1·19
Iron mg. per day	12·2	12·1
Bread oz. per day	7·6	6·4
Milk oz. per day	10·6	14·3
Meat (raw weight) oz. per day	3·2	3·8
Potatoes oz. per day	5·2	4·8
Green vegetables oz. per day	1·4	0·9
Raw fruit oz. per day	2·4	3·1

reasons. The rural children all belonged to the artisan class, and their fathers were employed as agricultural or other labourers. There were 16 boys and 7 girls aged 5 to 13 years, and Table XCV shows the average amounts which they ate. For comparison, 23 London children of the same sex and ages as the rural children, and belonging to the artisan class, have been chosen at random from among those taking part in the main investigation, and their diets have been calculated and averaged in a similar way. The average heights and weights of the two groups of children were almost the same, and on the whole the diets were very similar. The country children had more calories, which they obtained by eating more of all three of the proximate principles, protein, fat and carbohydrate. The London children had more milk, and they consequently had a little more calcium. The rural children ate a little more bread. There is no evidence from these figures that rural children were better or worse fed than urban children of the same economic status, but the numbers studied were too small for any general conclusions to be drawn.

CHAPTER 12

BOARDING SCHOOL DIETS

"Parents have a right to require, and children at school have a right to receive, sufficient food, and of good quality."
(Dukes, 1899.)

The majority of the school children who took part in this investigation were attending day schools, but 56 boys and 38 girls who were boarders at eight different schools weighed their food during term time. The data obtained from them are of interest for two reasons. Firstly, they enable the food provided at these boarding schools to be compared with that set before children of the same ages in their own homes, and secondly, they show the extent to which individual diets varied even when the children were living under the same conditions and eating similar food. Table XCVI gives some details about the schools

TABLE XCVI
Numbers and Ages of Children studied at eight Boarding Schools

<i>School</i>	<i>Description</i>	<i>No. of boys</i>	<i>No. of girls</i>	<i>Age range in years</i>
A	Residential nursery school	10	8	1-5
B	Residential nursery school	3	4	2-4
C	Co-educational boarding school	11	7	7-11
D	L.C.C. residential school	5	5	2-11
E	L.C.C. residential school	3	3	13-14
F	Girls' public school	0	11	7-11
G	Boys' public school	13	0	14-15
H	Boys' public school	11	0	15-18

and the numbers and ages of the children at each who were included in this investigation.

Comparison of the diets of children at eight different boarding schools with each other and with those of children of similar ages living at home

In order to give a concise picture of the boarding school diets, four staple foods were chosen, namely, bread, milk, meat and potatoes, and in Figs. 74 to 77 are shown the amounts of these foods consumed by individual children at the eight schools. The average curves for all the boys and girls in the main survey, nearly all of whom were living in their own homes, are given for comparison.

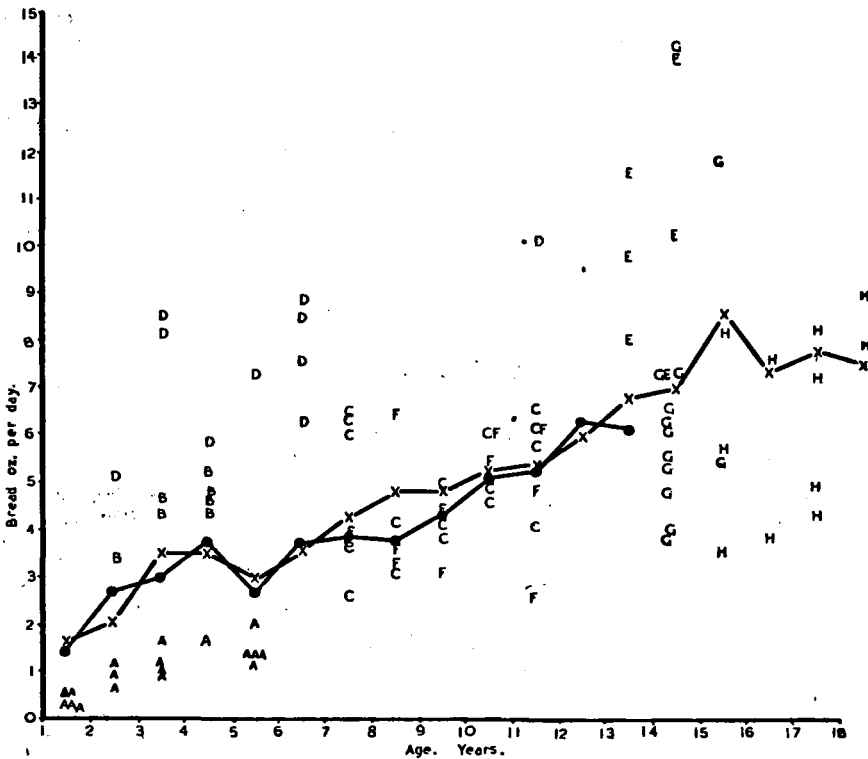


FIG. 74.—Consumption of Bread at Boarding Schools.

- A Residential nursery school.
- B Residential nursery school.
- C Co-educational boarding school.
- D L.C.C. residential school.
- E L.C.C. residential school.
- F Girls' public school.
- G Boys' public school.
- H Boys' public school.
- x — x Average for all boys in the main survey.
- — ● Average for all girls in the main survey.

"A" was a residential nursery school in Kent, and "B" a school of similar kind in Staffordshire, and it is quite clear that the children attending them were receiving very different types of diet. At school "A" they all ate very much less bread than the average, and all the bread eaten was brown. On the other hand, all the children at "B" ate more bread than the average, and six of them also ate more meat. At "A" the children had no meat at all until they were five,

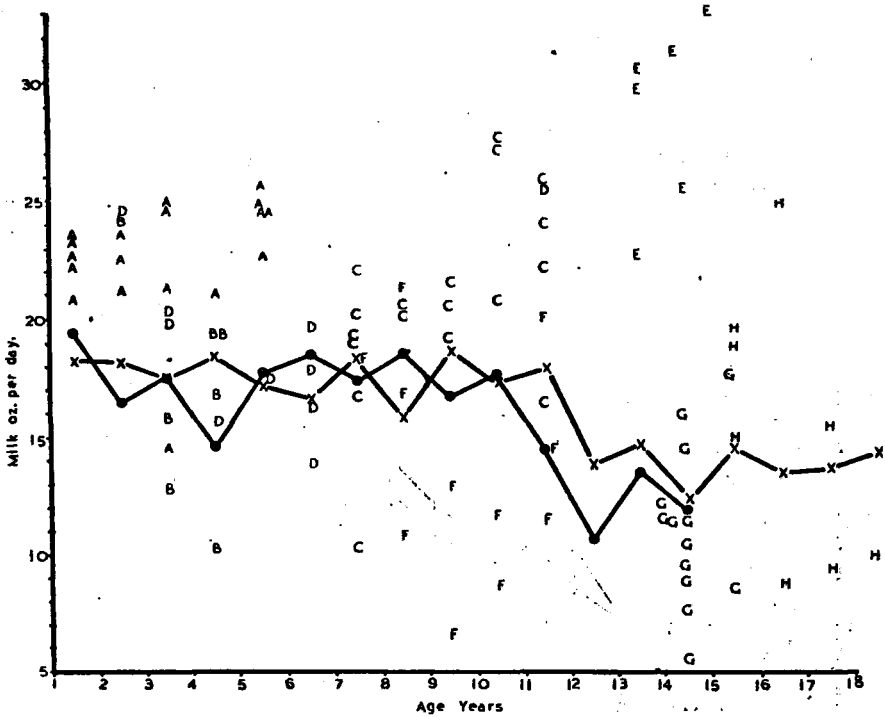


FIG. 75.—Consumption of Milk at Boarding Schools.

- A Residential nursery school.
- B Residential nursery school.
- C Co-educational boarding school.
- D L.C.C. residential school.
- E L.C.C. residential school.
- F Girls' public school.
- G Boys' public school.
- H Boys' public school.
- x → x Average for all boys in the main survey.
- — ● Average for all girls in the main survey.

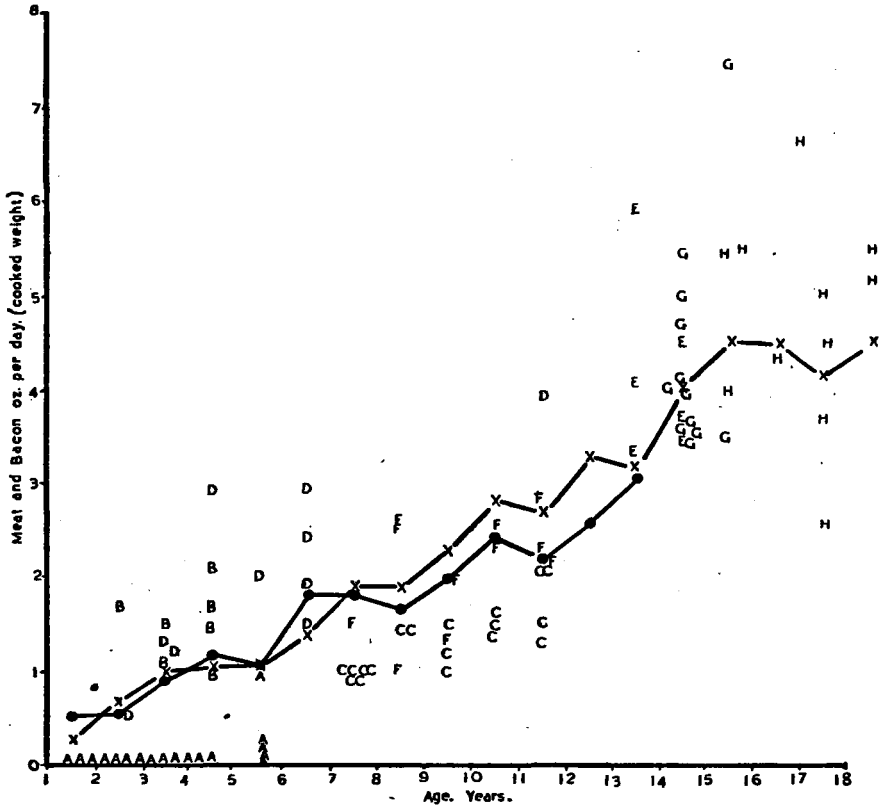


FIG. 76.—Consumption of Meat at Boarding Schools.

- A Residential nursery school.
- B Residential nursery school.
- C Co-educational boarding school.
- D L.C.C. residential school.
- E L.C.C. residential school.
- F Girls' public school.
- G Boys' public school.
- H Boys' public school.
- x — x Average for all boys in the main survey.
- — ● Average for all girls in the main survey.

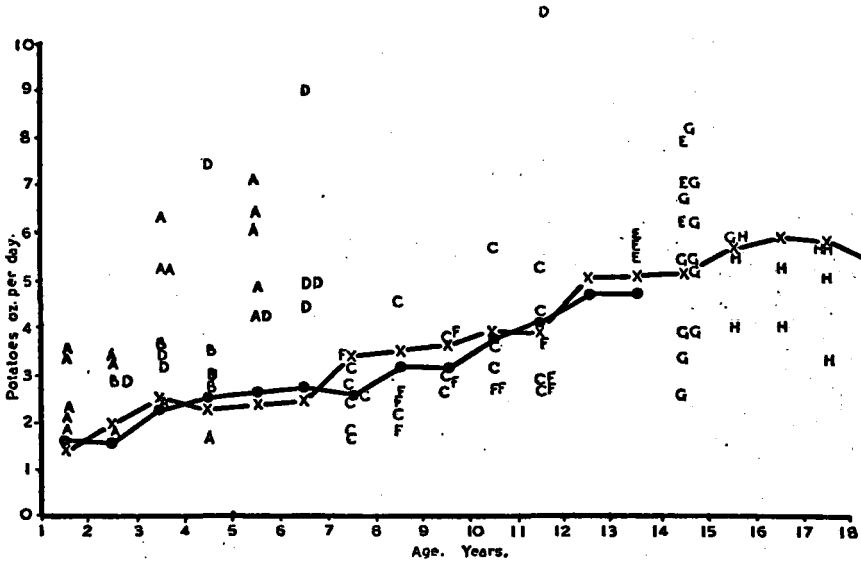


FIG. 77.—Consumption of Potatoes at Boarding Schools.

- A Residential nursery school.
 - B Residential nursery school.
 - C Co-educational boarding school.
 - D L.C.C. residential school.
 - E L.C.C. residential school.
 - F Girls' public school.
 - G Boys' public school.
 - H Boys' public school.
- x — x Average for all boys in the main survey.
 ● — ● Average for all girls in the main survey.

weight. Those at "A" were of average weight, but 13 of the 18 were shorter than the average height for their age. There is no evidence, however, that this had anything to do with their diet, for the numbers are too few for conclusions of this sort to be drawn.

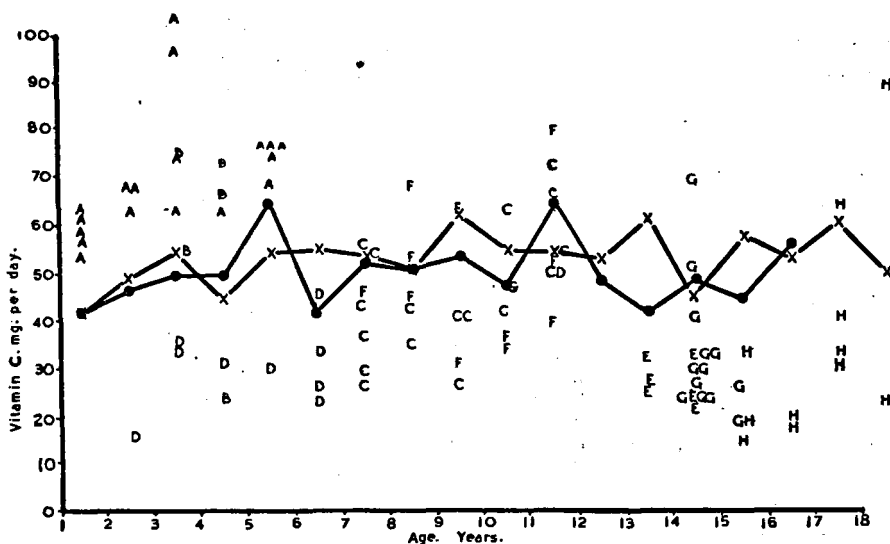


FIG. 79.—Calculated Intakes of Ascorbic Acid at Boarding Schools.

- A Residential nursery school.
- B Residential nursery school.
- C Co-educational boarding school.
- D L.C.C. residential school.
- E L.C.C. residential school.
- F Girls' public school.
- G Boys' public school.
- H Boys' public school.
- x — x Average for all boys in the main survey.
- — ● Average for all girls in the main survey.

The chief points of interest at the co-educational school "C" were the large quantities of milk and the small quantities of meat consumed. Again, all the children had cheese, and their calcium intakes were high. They were not well provided with fruit, however, and most of their ascorbic acid intakes were below average. In spite of their high calorie intakes (13 out of 18 had more than the general average, see Fig. 80), their weights tended to be low; 14 of them weighed less than the average for their age. On the other hand, there were as many above as below the average height. It is possible that these boys and girls took more exercise than children at day schools, and that they required still more calories to enable them to put on as much weight (see Widdowson and McCance, 1944).

At school "D" all but one of the children were short and light for their age, as compared with the general average. These L.C.C. schools cater for unwanted children and orphans, and the inmates probably all had a poor start in life. Their small size may well have been due to neglect and undernourishment before they ever came to the school. It was certainly not due to insufficient calories

at school, for all had more than the average (Fig. 80). It is perhaps worthy of note that the older children at "E", who had presumably been longer at the school, were of average weight, though they still tended to be short in stature. At schools "D" and "E" large amounts of bread were eaten. All the children at both schools took more than the average amount, and many of them were eating twice as much or more. At "E" they were extremely well supplied with milk; all six children had over a pint a day, and four of them had $1\frac{1}{2}$ pints. At "D" the milk consumption was slightly above average and the children there seemed to eat comparatively large amounts of meat.

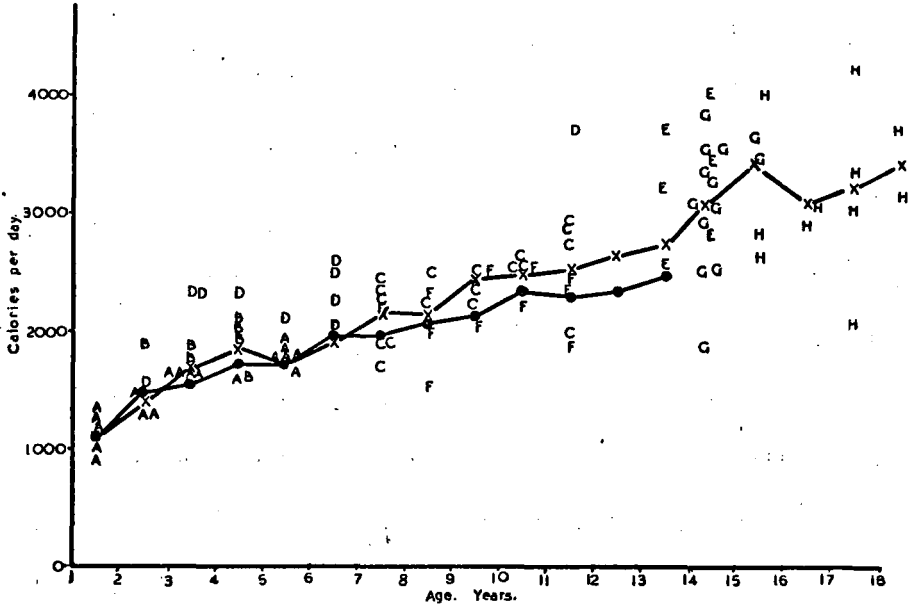


FIG. 80.—Calorie Intakes of Boarding School Children.

- A Residential nursery school.
- B Residential nursery school.
- C Co-educational boarding school.
- D L.C.C. residential school.
- E L.C.C. residential school.
- F Girls' public school.
- G Boys' public school.
- H Boys' public school.
- x — x Average for all boys in the main survey.
- — ● Average for all girls in the main survey.

The Ministry of Health Advisory Committee on Nutrition (1932), who investigated the diets provided in Poor Law children's homes, found that the supply of raw fruit was not very satisfactory, and that fruit generally seemed to be regarded more in the nature of a luxury than as a necessary part of the diet. The children at schools "D" and "E" did not have much fresh fruit, and in consequence all but one of them had less than the average amount of ascorbic acid. The actual intakes were probably lower than the figures shown here, for no allowance has been made for the large losses likely to have been caused by institutional cooking. At both schools the children had more than the average amount of potatoes.

There were no very remarkable features about the diet of the girls at the public school "F", except that the amounts of milk they received, and hence their calcium intakes, were in most instances low. The same was true of the majority of the boys at the public school "G", and it is a serious reflection on these expensive establishments that they should have been providing so much less milk for the children in their care than the charitable institutions "D" and "E". The amount of ascorbic acid in the diets at the two boys' public schools, "G" and "H", was no higher than it was at the L.C.C. institutions, and again it is probable that the intakes have been over-estimated. Only two boys at "G" and two boys at "H" had more than the average amount. The potato consumption also tended to be low at the public schools "F" and "H", particularly at "H".

When other foodstuffs and dietary constituents not shown on these graphs are considered, a few points of interest arise. At the three public schools, "F", "G", and "H", fat fish were provided, and the intakes of vitamin D were consequently high. A number of the public school children also had liver, as did all boys and girls at the L.C.C. school "E" and some of those at "D". This meant that the vitamin A intakes were high.

The calorie consumption will be discussed later in connection with individual variations. So far as the protein is concerned, both total and animal protein tended to be low at schools "A", "C" and "F", and high at schools "D" and "E". The reasons for this will be apparent in the light of what has already been said. At "C" the diet contained less fat and more carbohydrate than the average. At "D" and "E" it contained more of both.

Comparison of the diets of public school boys at home and at school

Eight of the boys at school "H" weighed their food for a week during the holidays as well as for a week during the term. Their home diets are the ones that have been included in the main survey and their school diets in Figs. 74-80. For these boys a direct comparison of school and home diets can be made. Tables XCVII summarizes some of the findings. It shows, for a number of foods

TABLE XCVII
Comparison of the Diets of eight Public School Boys at School and at Home

	<i>No. of boys having more at :—</i>		<i>No. of boys having equal amounts</i>	<i>Home. Average per day</i>	<i>School. Average per day</i>
	<i>Home</i>	<i>School</i>			
Bread	0	7	1	4.6 oz.	7.0 oz.
Milk	1	5	2	7.9 oz.	9.0 oz.
Meat	6	0	2	5.9 oz.	4.4 oz.
Raw fruit ..	3	3	2	2.5 oz.	2.9 oz.
Potatoes ..	6	1	1	5.5 oz.	4.0 oz.
Green vegetables	3	3	2	1.2 oz.	1.2 oz.
Calories ..	4	4	0	3,340	3,208
Total protein ..	5	3	0	101 g.	95 g.
Animal protein ..	5	1	2	69 g.	59 g.
Fat	4	0	4	145 g.	123 g.
Carbohydrate ..	3	4	1	386 g.	408 g.
Calcium	4	2	2	0.64 g.	0.61 g.
Phosphorus ..	3	3	2	1.47 g.	1.40 g.
Iron	4	3	1	19.3 mg.	18.9 mg.
Aneurin	6	2	0	1.07 mg.	0.93 mg.
Ascorbic acid ..	5	3	0	42 mg.	41 mg.
Vitamin A	6	2	0	3,160 I.U.	2,940 I.U.
Carotene	6	2	0	2,218 I.U.	1,903 I.U.
Vitamin D	5	3	0	327 I.U.	301 I.U.

and dietary essentials, whether school or home diets provided the larger amounts and it also gives the average consumption at home and at school, taking all eight boys together. So far as the foods are concerned, the boys had more bread and more milk at school, more meat and potatoes at home, and approximately equal amounts of raw fruit and green vegetables in the two places. When the home and school diets were calculated in chemical terms, it was found that the foods the boys ate at home provided them with just about the same amounts of the various nutrients and the same number of calories as their school diets. This is true of the individual boys as well as of the group-average. The home diet was slightly better all the way through, but by a very small margin indeed. There was nothing in these results to indicate why public school boys should do most of their growing during their school holidays (Widdowson and McCance, 1944). It is generally accepted, however, that the expenditure of energy is considerably greater at school than at home, and, if so, the calorie intake should undoubtedly be higher. If it is not, the boys cannot be expected to grow as fast. Further work on this subject is very desirable.

When the individual boys are considered, each boy seemed to have his own dietary pattern, and to conform to it wherever he was. One 17-year-old boy, for example, had 4,296 calories a day at home and 4,255 calories a day at school. Another boy of the same age had 1,754 and 2,112 calories a day at home and at school respectively. It is true that the first was a bigger boy than the second, but whether the second would have been as big as the first had he eaten more, or whether he ate less because he was smaller, or whether size had nothing to do with it at all remains quite unknown. Size is certainly not the only factor that determines calorie intake (see Ch. 5, p. 64).

Each boy evidently had his own likes and dislikes about food. One had 23 oz. of milk a day at home and 15.4 oz. at school. The corresponding figures for another boy were 3.3 oz. at home and 4.0 oz. at school. Many similar instances might be quoted. For example, there was one boy who had 163 g. of fat a day at home and 166 g. at school, and another who had 85 g. at home and 83 g. at school. All this shows very plainly that variation from one individual to another is a real thing, and this is further brought out in Fig. 80, where the calorie intakes of the individual boarding school children are given. School "G" is perhaps the best example to take, as more boys of the same age weighed their food at this school than at any of the others. The average calorie intake of the eleven 14-year-old boys was 3,047, which agrees very well with the average figure of 3,065 for the age group as a whole (Table XLI, p. 69). Even here, however, at the same school, on the same diet, with the same allowances of time for meals, and with presumably similar opportunities for exercise, the daily calorie intakes of the individual boys varied from 1,840 to 3,832, and even in such a small group as this there was one boy eating more than twice as much as another of all the dietary constituents that were calculated. The boy having 3,832 calories was clearly much hungrier than the other. He had 14.2 oz. of bread a day as compared with 4 oz. for the 1,840 calorie boy, and he ate three times as much potato.

These findings are in accord with the fact already emphasized, that individual variations in calorie intakes are probably physiological in origin. Food habits may play a part it is true, but the fact that the variations occur in individuals at the same institution as well as in different homes, gives strong indication that physiological requirement and not habit is the root of the matter.

CHAPTER 13

SCHOOL MEALS

At the time when this investigation was being made, dinners were provided in most secondary schools for any of the pupils who cared to partake of them, but school meals were regarded as a matter of convenience for children whose homes were some distance away, rather than as playing an important part in their nutrition. This latter conception, as applied to middle class children, only developed during the recent war. It was not always clear, moreover, from the dietary records of the children taking part in this investigation, whether they had had dinner at school or not, so no attempt has been made to discuss the nutritive value of the dinners provided at the schools they attended. Even before the war, however, free or cheap meals were often provided in schools attended mainly by the poorer classes, the object being to make up the deficiencies in the home diets. In addition to the main investigation on middle class children so far described, studies have been made of the diets of a smaller number of children from poorer homes who received meals at day nursery schools, at "Village Colleges" or at a charitable canteen. The results that were obtained will now be considered in some detail. They provide information as to the contribution that school meals made to the total diets of such children before the war, and, moreover, they may be compared if desired with the results of the many similar studies which have been made since 1939 (see Cook, Davidson, Keay and McIntosh, 1944; Bray, Chattaway, Happold, Happold, Kerly, Magill, Morkam, Norris and Thorpe, 1945).

Day nursery school meals

The diets of 28 children attending seven different day nursery schools have been studied. There were 17 boys and 11 girls, and their ages ranged from two to four years. Three nursery schools in South Wales (W1, W2, and W3), two in London (L1 and L2), one in Bristol (B), and one in Middlesbrough (M) co-operated in the investigation. At all the schools the children had a milk drink during the morning, and a midday dinner and tea on five days in the week. Table XCVIII shows the number and ages of the children in each of the schools.

TABLE XCVIII
Numbers of Children studied at Seven Nursery Schools

School	District	Number		
		Age 2	Age 3	Age 4
W1	S. Wales	1	1	2
W2	S. Wales	0	3	0
W3	S. Wales	0	2	2
B	Bristol	2	2	3
L1	London	1	1	0
L2	London	1	2	2
M	Middlesbrough	0	1	2

The fathers of nine of these children were unemployed; those of the others belonged to the poorer working classes.

Below six years of age no sex difference could be discovered in the consumption of any foodstuff or of any of the chemical constituents of the diet, so it was decided not to complicate matters by discussing boys and girls

separately, but to consider both sexes together. Table XCIX shows the averages of the calories, proximate principles, minerals and vitamins in the complete diets of these children compared with the averages for the same age groups in the main investigation. It will be seen that in many respects the diets of

TABLE XCIX

Chemical Composition of the Diets of 28 Children attending Day Nursery Schools

	Age 2		Age 3		Age 4	
	Group average	Nursery school average	Group average	Nursery school average	Group average	Nursery school average
Calories .. per day	1418	1515	1612	1603	1779	1775
Protein .. g. per day	42	46	48	49	51	53
Animal protein g. per day	28	30	31	32	33	35
Fat .. g. per day	57	54	65	61	73	74
Carbohydrate g. per day	175	199	198	203	218	211
Calcium .. g. per day	0.75	0.76	0.77	0.80	0.78	0.83
Phosphorus .. g. per day	0.88	0.91	0.94	0.95	0.98	1.04
Iron .. mg. per day	6.8	6.9	7.5	7.0	8.5	8.4
Aneurin mg. per day	0.63	0.57	0.68	0.58	0.68	0.68
Ascorbic acid mg. per day	48	32	53	33	48	26
Vitamin A I.U. per day	2002	4121	2508	3026	2983	3993
Carotene I.U. per day	1960	1547	1962	1681	2220	1906
Vitamin D I.U. per day	61	43	61	45	74	74

these children compared favourably with those of better-class children who were not receiving food at nursery schools. The point of interest is whether or not this was due to the food the nursery school children received at school. Table C shows the average composition of the food provided per child per day at each of the nursery schools, *i.e.* one-fifth of the total amount provided during

TABLE C

Chemical Composition of the Food provided at each of Seven Nursery Schools

School	S. Wales			Bristol	London		Middlesbrough
	W1	W2	W3	B	L1	L2	M
Average age—years..	3½	3¼	4¼	3½	3½	3½	4½
Calories .. per day	845	762	708	778	755	870	970
Protein .. g. per day	32	31	27	34	32	32	37
Animal protein g. per day	24	22	24	27	25	25	30
Fat .. g. per day	35	27	32	29	28	35	39
Carbo- hydrate g. per day	94	95	73	90	90	100	111
Calcium .. g. per day	0.64	0.65	0.57	0.63	0.42	0.69	0.76
Phosphorus g. per day	0.69	0.65	0.55	0.70	0.57	0.83	0.90
Iron mg. per day	4.2	3.2	3.7	3.9	5.5	5.5	5.0
Aneurin mg. per day	0.41	0.35	0.29	0.44	0.37	0.49	0.58
Ascorbic acid mg. per day	22	8	18	10	11	20	14
Vitamin A I.U. per day	3470	3225	711	865	7850	4920	6350
Carotene I.U. per day	1350	736	850	1210	1230	1340	1110
Vitamin D I.U. per day	27	24	21	32	22	37	37
No. of different foods provided during the week.	32	21	23	23	23	26	28

the week of the survey. Children of 2, 3 and 4 years have been averaged together in compiling Tables C and CI, since the older children did not seem to be getting much bigger helpings than the younger ones, and the average ages of the children who were studied at each school were much the same. Generally speaking, the number of calories, and the quantities of proximate principles and minerals provided at each of the seven schools were fairly uniform, and no one school was outstandingly better or worse than the others. The vitamin figures, however, show considerable differences. At one South Wales school, "W1", the children were given oranges and orange juice, and in consequence they had 22 mg. ascorbic acid a day. At another, "W2", the only "fruit" they had during the week was stewed rhubarb, and their intake of ascorbic acid at school was only 8 mg. a day. At five of the schools the children were given liver, at the other two they were not, so the amounts of vitamin A they received varied enormously. The schools where the

TABLE CI
Chemical Composition of the Nursery School Children's Home Diets

School	S. Wales			Bristol	London		Middles- brough
	W1	W2	W3	B	L1	L2	M
Average age—years..	3 $\frac{1}{2}$	3 $\frac{4}{12}$	4 $\frac{4}{12}$	3 $\frac{1}{2}$	3 $\frac{4}{12}$	3 $\frac{8}{12}$	4 $\frac{5}{12}$
Calories .. per day	1178	580	1272	1265	799	1152	794
Protein .. g. per day	24	13	37	29	21	34	20
Animal protein g. per day	13	5	23	15	15	18	8
Fat .. g. per day	56	20	50	51	24	42	27
Carbo- hydrate g. per day	136	81	160	163	112	151	112
Calcium .. g. per day	0.34	0.11	0.53	0.34	0.36	0.50	0.16
Phosphorus g. per day	0.47	0.19	0.71	0.48	0.44	0.58	0.27
Iron mg. per day	4.9	1.1	6.8	4.8	3.3	4.5	3.2
Aneurin mg. per day	0.32	0.16	0.45	0.32	0.27	0.36	0.21
Ascorbic acid mg. per day	15	15	37	18	25	20	5
Vitamin A I.U. per day	800	349	2013	1954	642	1219	384
Carotene I.U. per day	1056	580	1347	987	707	1080	325
Vitamin D I.U. per day	54	14	74	28	29	26	15

carotene intakes were high provided carrots or tomatoes. None of the schools served fat fish during the week of investigation, and the amounts of vitamin D the children received from their food were small. At five of the schools ("W2", "W3", "B", "L2", and "M"), the children were given cod liver oil, either $\frac{1}{2}$, 1 or 2 teaspoonfuls daily, and at the school at Bristol some of the children had an iron supplement also.

The number of different foods served to the children during the five days while the school meals were being weighed gives some clue as to the variety in the diet itself. The diet supplied at one South Wales school, "W1", was the most varied, and that at another, "W2", the least.

The contribution that the nursery school meals made to the children's whole diets cannot be assessed until the food they received at home has been considered. Table CI shows the average chemical composition of the daily diets that the children at each of the seven nursery schools ate at home. Even when allowance is made for their smaller age, it is quite clear that the children attending the South Wales school "W2" were very poorly fed at

home. The same is true to a lesser degree of the children at the school at Middlesbrough, "M", and the London school "L1". In contrast to these are the South Wales children attending school "W3", who had more than twice as many calories and four times as much animal protein and calcium as those at "W2". The fathers of all four children at "W3" were in employment, whereas at "W2" two out of the three fathers were out of work.

It is not surprising, therefore, that the school diet provided a higher percentage of the total intake of most of the dietary essentials at school "W2" than anywhere else, and at school "W3" it provided the smallest proportion (Table CII). Generally speaking, the food the children received at school

TABLE CII
Percentage of Children's total Intakes of various Dietary Essentials provided at Seven Nursery Schools

School	S. Wales			Bristol	London		Middlesbrough
	W1	W2	W3	B	L1	L2	M
Calories	34	48	28	30	40	35	44
Protein	49	63	34	45	52	40	56
Animal protein ..	57	76	43	56	55	50	68
Fat	31	49	32	29	46	37	42
Carbohydrate ..	33	46	25	28	36	32	42
Calcium	57	81	43	57	46	49	78
Phosphorus	51	71	36	51	48	50	68
Iron	38	52	22	37	54	47	48
Aneurin	48	61	32	49	49	50	64
Ascorbic acid ..	52	28	26	28	24	41	63
Vitamin A	18	87	23	24	90	74	92
Carotene	48	48	31	47	55	47	70
Vitamin D	26	55	17	45	36	50	42

provided a greater proportion of their animal protein and calcium than it did of their calories or carbohydrate. This is as it should be, and it is for such a purpose that school meals for poor children have been designed. The amounts of the vitamins supplied by the schools varied very much from one school to another and from one vitamin to another, and those interested in the matter should consult Table CII.

Diets of eight children having dinner at a charitable canteen

The diets of eight London children, four boys and four girls, from poor homes, whose fathers were unemployed or earning small wages, were investigated for one week. These children have not been included in the main investigation. Three of the boys were brothers and two of the girls sisters. Their ages ranged from four to thirteen years, and they all had free dinners on five days of each week at a charitable canteen. In addition four of them had two-thirds of a pint of milk on each school day, two had one-third of a pint, one had sometimes two-thirds and sometimes one-third, and the last had one-third of a pint only once during the whole week of the investigation. The homes were visited every day during the course of the week and a considerable amount of trouble was taken to be sure that the records of the food eaten at home were correct. A dietitian and an assistant were present at the canteen each day at dinner-time and they weighed all the food that the children ate there.

In order to show the results as concisely as possible, the intakes of each dietary constituent were averaged for the eight canteen children, and the mean intakes for the children of corresponding age and sex in the main investigation

were then averaged and used as the controls. The results for the canteen children have been expressed as a percentage of those obtained for the control group of children, and they are shown in Table CIII. The canteen children

TABLE CIII
Average Chemical Composition of the Diets of Eight poor London Children having Dinner at a Charitable Canteen

	<i>Average composition of a canteen dinner*</i>	<i>Average daily food of "canteen" children†</i>	<i>Average daily food of children of the same sex and age in the main investigation</i>	<i>Intake of "canteen" children as percentage of that of "control" children</i>
Calories .. per day	705	2156	2179	99
Protein .. g. per day	34	65	63	103
Animal protein				
g. per day	24	37	40	93
Fat g. per day	21	73	87	84
Carbohydrate g. per day	91	294	272	108
Calcium .. g. per day	0.39	0.73	0.80	91
Phosphorus g. per day	0.48	0.97	1.11	87
Iron .. mg. per day	4.20	8.70	10.70	81
Aneurin mg. per day	0.27	0.62	0.78	79
Ascorbic acid				
mg. per day	25	27	52	52
Vitamin A. I.U. per day	460	1368	2690	51
Carotene I.U. per day	745	1424	2335	61
Vitamin D I.U. per day	14	72	106	68

* This was only served on 5 days during the week.

† Figures obtained by dividing the total weekly intakes by 7.

were having a little less fat, but more protein and carbohydrate than the control children, and their calories were almost the same. They had about 80-90 per cent. as much calcium, phosphorus, iron and aneurin, but considerably less of vitamins A and D, and ascorbic acid.

Table CIII also shows the average composition of the canteen meal served to these children during the five days of the investigation, and Table CIV the proportion of the various dietary essentials which were obtained during the week from the food eaten at home, at the canteen and from the school milk. The figures need little comment. The home diets provided only one-third or

TABLE CIV
Proportion of the various Dietary Essentials which were obtained from the Home Diets, from the Canteen Dinners, and from the School Milk

	<i>Per cent. at home</i>	<i>Per cent. at canteen</i>	<i>Per cent. from school milk</i>
Calories	71	23	6
Protein	52	37	11
Animal protein	35	46	19
Fat	70	20	10
Carbohydrate	75	22	3
Calcium	29	38	33
Phosphorus	46	35	19
Iron	63	35	2
Aneurin	52	31	17
Ascorbic acid	26	67	7
Vitamin A	55	24	21
Carotene	53	37	10
Vitamin D	82	14	4

one-quarter of the animal protein, calcium and vitamin C, and it is evident that the canteen dinners and the milk at school were playing a very important part in the nutrition of these children.

**Contribution of school dinners to the diets of eight children attending
Cambridgeshire Village Colleges**

The Cambridgeshire Village Colleges were described by H.R.H. the Prince of Wales at the opening of the first of them in 1930 as "an original attempt . . . to show how the English countryside may be given an opportunity for education, social life and recreation equal to those enjoyed by dwellers in great cities". They are in the nature of an experiment, and at the time when this survey was carried out they were in their infancy. Three were then open; each was situated in a large village, serving all the smaller

TABLE CV
*The Contribution of School Dinners to the Diets of Eight Children
attending Cambridgeshire Village Colleges*

	<i>Average composition of a school dinner</i>	<i>Percentage of the total weekly intake derived from the school dinners</i>
Calories	632	16
Protein, g.	19	19
Animal protein, g.	11	21
Fat, g.	19	14
Carbohydrate, g.	92	17
Calcium, g.	0·12	15
Phosphorus, g.	0·32	22
Iron, mg.	4·6	25

villages around. Consequently some of the children came from considerable distances to school, and a midday dinner was provided for them at a small cost. The diets of 23 children who were attending these colleges have already been discussed (p. 142). Eight of these children, seven boys and one girl, aged 11-14 years, had dinner at school on each of the five school days during the week of investigation, and the contribution that school dinners made to the diets of these children has been calculated. In Table CV are shown the average number of calories, and the amounts of the proximate principles and minerals provided by one school dinner, and also the average proportion of each of these constituents in the whole week's diet that the school dinners supplied. It is interesting to compare these figures with the corresponding ones in Tables CIII and CIV for the dinners provided at a canteen in London. The London dinners contained twice as much total protein and animal protein, and three times as much calcium as the Cambridgeshire dinners. Their calorie value, moreover, was higher, in spite of the fact that six out of the eight "canteen" children were younger than any of the eight "Village College" children. Inspection of the dietary records shows why the canteen dinners contained so much more calcium. The London children had milk puddings every day, and these provided each child with about $1\frac{1}{2}$ pints of milk during the week. At the Village Colleges steamed puddings were the rule, and milk pudding was served only once. Furthermore, all the London children had cheese at the canteen, whereas none of the rural children appeared to have had any at all.

The dinners at school provided these rural children with a very much smaller proportion of their diet than the canteen dinners of the London children. It is true that the London children were poorer than the rural Cambridgeshire children, and that their home diets were unsatisfactory. They, therefore, needed the extra food more, but, if general conclusions may be drawn from this

admittedly small group of children, it seems as though the dinners served at the Village Colleges in 1938 were not quite as good as they might have been. It is hoped and believed that since that time the meals have greatly improved, and that now they are much more nutritious.

CHAPTER 14

TWINS

Medically and scientifically twins are nearly always interesting, but their appetites have never been compared. Eight pairs of twins have taken part in this investigation. There were two pairs aged between one and two years, each consisting of a boy and a girl, and another boy and girl aged four. The other pairs were of the same sex—boys of seven and eight, and girls also aged eight. These children all formed part of the main investigation. In addition there were twin girls aged 14, both of whom suffered from diabetes mellitus, and whose diets are discussed from that aspect in Chapter 16. Finally, there were twin boys, aged 12, whose father was out of work, and who took part in a subsidiary study (see Chapter 17).

TABLE CVI
The Chemical Composition of the Diet of Eight pairs of Twins

Age years	Boy and Girl 1½	Boy and Girl 1½	Boy and Girl 4½	Two Boys 7½	Two Girls 8½	Two Boys 8½	Two Boys* 12	Two Girls† 14½
Weight kg.	10.2	15.0	16.9	24.1	31.8	27.7	36.4	40.4
Height in.	9.1	11.8	18.8	22.0	32.7	28.6	35.0	42.6
Calories per day	30.0	32.3	41.5	47.0	52.0	52.8	58.5	64.2
Protein g. per day	935	1377	1547	1892	2168	2325	2691	1942
Animal protein g. per day	883	1328	1563	1791	2186	2252	2515	1983
Fat g. per day	32	39	42	62	56	65	63	82
Carbohydrate g. per day	33	37	41	59	56	67	54	82
Calcium g. per day	25	28	22	44	35	34	20	63
Phosphorus g. per day	26	23	21	42	35	26	14	64
Iron mg. per day	41	55	61	76	85	82	68	102
Aneurin mg. per day	42	52	60	74	86	79	69	102
Ascorbic acid mg. per day	103	172	197	227	280	316	439	160
Vitamin A I.U. per day	87	169	204	210	282	303	403	170
Carotene I.U. per day	0.62	0.86	0.48	0.98	0.86	0.91	0.51	1.08
Vitamin D I.U. per day	0.64	0.80	0.47	0.97	0.86	0.89	0.55	1.08
Weight kg.	0.79	0.85	0.69	1.20	1.04	1.12	1.07	1.40
Height in.	0.74	0.81	0.66	1.18	1.04	1.13	0.85	1.43
Calories per day	3.40	4.70	8.30	11.20	8.20	9.60	13.90	14.60
Protein g. per day	3.20	4.60	8.10	11.10	8.20	9.90	10.30	14.30
Animal protein g. per day	0.44	0.52	0.52	0.80	0.62	0.77	0.83	0.74
Fat g. per day	0.41	0.51	0.56	0.79	0.63	0.77	0.78	0.75
Carbohydrate g. per day	33	46	54	54	58	37	61	81
Calcium g. per day	25	42	44	56	57	36	56	80
Phosphorus g. per day	1006	1380	1040	1586	1706	6480	13234	7423
Iron mg. per day	1001	1239	991	1529	1709	3376	983	8021
Aneurin mg. per day	883	2173	2656	2116	2397	2900	1350	10,787
Ascorbic acid mg. per day	804	2074	2534	2054	2414	3006	1424	9540
Vitamin A I.U. per day	34	30	31	40	280	124	28	613
Vitamin D I.U. per day	35	29	29	47	291	124	22	588

* The father of these boys was unemployed.

† Both these girls suffered from diabetes mellitus.

Table CVI shows these children's heights and weights, and their intakes of the various dietary constituents. The calorie intake of every child

was very close to that of its twin, and the same may be said of the intakes of proximate principles, minerals and vitamins. The eight-year-old girls are particularly striking in this connection. These girls were identical twins and, although one weighed 2 lb. more than the other, their heights were the same. One had $\frac{1}{4}$ oz. more bread and $\frac{1}{4}$ oz. more kipper than the other during the week, and she had an apple for supper one evening while her sister had a banana, but otherwise they ate exactly the same amounts of everything. The seven-year-old boys on the other hand were not identical twins; one was both taller and heavier than the other, and he was obviously slightly hungrier also. He always had just a little more bread, potatoes, cake, pudding and porridge than his brother, which accounts for the difference in calories. At home they were generally given the same amounts of milk, but the smaller boy had a glass of whole milk at school every morning, while the other chose Horlick's malted milk, which was made only partly with milk. This is why the smaller boy had more calcium and vitamin D, but in spite of this, he was the one who had 12 carious teeth while his brother had no caries at all (see p. 108).

Of the twin boys aged eight it was sometimes one and sometimes the other who ate most at a meal. Both of them had liver for dinner one day, but one ate twice as much as the other, and consequently his vitamin A intake, even when averaged over the whole week, was nearly twice as high.

The boy and the girl aged one year and five months had very similar diets, but the boy sometimes ate a little more bread, and he often had a sponge cake for tea, whereas his sister did not, so he had more calories. On the other hand, the girl generally had a little more milk, so she got more calcium. Her vitamin C was lower because she had a little less orange. The diets of the other pair of one-year-old twins, and also of the boy and girl aged four were very similar, and this is also true of the 14-year-old diabetic girls.

The 12-year-old boys who came from a poor home in Lincoln show some rather interesting differences. One was evidently fonder of sweet things than the other, for he had a little more sugar, jam and chocolate. He also ate more potatoes. Further, he liked liver, and had 6 oz. for dinner one day while his brother preferred to dine off potatoes alone. This made all the difference to his vitamin A, for he would have had no more than the other boy if he had not eaten the liver. His brother, on the other hand, had a little more margarine, and he seemed to like cheese, for he had 2 oz. for supper one evening while the first boy had bread and jam.

In spite of these small variations from one child to another, the fact remains that within each pair of twins the diets were almost identical. There is little doubt that both nature and nurture contributed to this. The resemblance is particularly striking when it is recalled that there may be, and often are, huge variations between children of the same age but belonging to different families. Born together, and brought up in the same surroundings, each pair of twins had learned to like similar food, and was given similar food during the experimental week. It is impossible to separate the part played by each of these factors, and all may have done something to make the diets so alike. The provision of similar food during the week of weighing could not be solely responsible, for the boys at the boarding school "G" (p. 152) also had access to similar food but managed to eat very different amounts of it. The twins were never exactly the same height, and one member of each pair always weighed between 2 and 7 lb. more than the other. It is true that in seven out of eight cases the heavier child had slightly more calories than the other, and this may have had something to do with his greater size, but it is impossible to draw a more definite conclusion from the flimsy nature of the present evidence.

CHAPTER 15

NUTRITIVE VALUE OF VEGETARIAN DIETS

Vegetarianism is probably the most widely practised of all dietetic cults, but in Great Britain most vegetarians supplement their diet with eggs, milk and milk products, and it is generally agreed that with these included a first class diet can be devised. There were seven strict lacto-vegetarians among the children who took part in the main investigation, four boys and three girls. Two of the boys were brothers, and a third boy and one of the girls were brother and sister. They all lived in London, and they all belonged to the "professional class" (p. 8). A special study of these children's diets has been made to see how they compared in various respects with those of other children of the same ages.

Table CVII shows their intakes of calories, proximate principles, minerals and vitamins expressed as a percentage of the average intake of all the children of the same ages who took part in the main investigation. It is quite

TABLE CVII

Heights and Weights, and Intakes of Various Dietary Constituents, of Seven Vegetarian Children

(The results are expressed as percentages of the averages for all children of the same age and sex—see Tables VIII–LXXXI and Figs. 1–72.)

Age years	Leo 3	Oliver 4	John 5	Charles 6	Elizabeth 4	Mary 9	Stella 18
Height	100	105	97	102	101	100	94
Weight	110	92	96	100	99	92	93
Calories	74	100	78	59	67	93	112
Total protein ..	69	110	72	47	44	89	88
Animal protein ..	75	117	73	39	37	77	66
Fat	74	102	77	66	64	94	121
Carbohydrate ..	75	95	81	57	74	92	110
Calcium	130	183	135	63	59	145	151
Phosphorus ..	89	141	89	56	60	119	120
Iron	105	108	109	52	62	96	97
Aneurin	100	129	100	59	72	156	113
Ascorbic acid ..	95	106	107	73	80	195	99
Vitamin A	93	142	90	94	81	105	127
(excluding liver)							
Carotene	193	97	207	85	88	307	110
Vitamin D	69	65	69	71	67	74	110
(excluding fat fish)							

Note.—Leo and John were brothers, and Charles and Elizabeth were brother and sister.

clear that some of the children were having very much better diets than others. Charles and Elizabeth, the son and daughter of a solicitor, seemed to be very poorly fed, although they were up to the average as regards height and weight. Their intake of calories and of every dietary constituent was far below the average for children of their ages. On the other hand, Oliver, the son of a lighting engineer, was having more than the average amount of almost every dietary constituent.

In spite of these individual variations certain generalizations can be made. The intakes of total protein, animal protein, fat and carbohydrate and hence of calories, tended to be low and this was also true of vitamin D. Foote and Eppright (1940), who studied the diets of 52 boys and girls attending a boarding school at which no meat was served, also found that the intakes of calories and protein were low on this "lacto-ovo-vegetarian" diet. Our vegetarian children's intakes of calcium were usually high, and the consumption of the other dietary constituents was scattered about the mean. The total protein

and animal protein were low because these vegetarian children were eating no more plant protein than other children, and their consumption of eggs, milk and cheese was not sufficiently high to make up for the protein that the other children obtained from their meat and fish. In fact, only one child had more eggs than the average for her age, and one had none at all (see Table CVIII).

TABLE CVIII

Consumption of various Foodstuffs by Seven Vegetarian Children

(The results are expressed as percentages of the average amounts eaten by all children of the same age and sex—see Tables XV–XXIII and Figs. 9–28.)

Age years	Leo 3	Oliver 4	John 5	Charles 6	Elizabeth 4	Mary 9	Stella 18
Bread	37	100	50	75	51	65	115
Cakes and biscuits	61	40	107	56	72	104	100
Milk.. ..	108	114	110	60	59	127	135
Butter	75	70	60	100	112	118	175
Cheese	300	1600	205	200	100	700	267
Eggs	56	0	69	77	61	92	182
Raw fruit	111	137	111	81	94	467	94
Cooked fruit	92	208	89	47	62	129	184
Potatoes	44	57	50	32	48	65	64
Green vegetables	87	87	90	186	125	580	61
Root vegetables	100	0	125	267	300	200	0
Green salad.. ..	350	125	450	0	50	0	117
Sweets and chocolate	50	0	75	40	50	11	157

Note.—Leo and John were brothers, and Charles and Elizabeth were brother and sister.

The cheese figures expressed as a percentage of the average intakes appear to be high, but this is because the "average intakes" were so small, being the cheese consumption of a few children averaged over the whole age group (see p. 38). The actual amounts of cheese that these vegetarian children ate during the week were:—Charles and Elizabeth, $1\frac{1}{2}$ and $\frac{5}{8}$ oz. respectively; Leo and John, 2 oz. each; Stella, $2\frac{1}{2}$ oz.; Mary, $4\frac{1}{2}$ oz. and Oliver $11\frac{1}{2}$ oz. These amounts of cheese, and the somewhat higher milk consumption were, however, sufficient to raise the calcium intakes of all except Charles and Elizabeth above the average. The fat intakes were low, chiefly because the fat in the extra milk and cheese did not make up for the fat in the meat, bacon and fish which other children ate. Three had less and three more butter than the average. It is, perhaps, rather surprising that the carbohydrate intakes should have been so low. Only one child was having more bread than the average, and most were having very much less. Furthermore, they were all eating very small amounts of potatoes. Potatoes and bread were evidently not the mainstay of these vegetarian children's diets. Nor did they partake at all lavishly of cake and biscuits, and six of the seven had very much less sweets and chocolate than the average.

All the vegetarian children ate some brown bread, and in most instances nearly all the bread they ate was of that kind. The extra iron which they derived from this brown bread was just about sufficient to make up for the iron that other children obtained from meat, so that their total iron intakes were usually close to the average figure. The same principle of compensation stabilized the aneurin intakes. The aneurin derived from the brown bread and other whole cereals made up for the losses caused by excluding meat and bacon from the diets. Surprisingly enough, apart from one girl, Mary, these vegetarian children ate little if any more fruit than non-vegetarian children, and they had no more oranges. Only three of them had more than the average amount of ascorbic acid. The vitamin A intakes were about the same as those of other children who did not eat liver, but it must be remembered that most meat-eating children probably have liver occasionally, while vegetarian

children never have it. Their carotene intakes were not particularly high, but then only three of them had more than the average amount of green vegetables. Again it was Mary who had more green vegetables and more carotene than any of the other vegetarian children. The vitamin D intakes were definitely low, especially in view of the fact that they were never supplemented by supplies from fat fish. None of the children had as much as 100 I.U. a day; five of them had less than 40 I.U. It is clearly advisable to supplement vegetarian children's diets with medicinal vitamin D.

It must be concluded that, while a lacto-vegetarian diet may in theory be a very excellent one, in practice it may fall far short of the ideal. Only one of these seven children was eating a diet which was equal in nutritive value to the average diet of non-vegetarian children of the same age.

CHAPTER 16

COMPARISON OF THE NUTRITIVE VALUE OF THE DIETS OF THIRTEEN DIABETIC CHILDREN WITH THOSE OF HEALTHY CHILDREN OF THE SAME AGES

During the four years in which the main dietary survey was being made, the diets of six boys and seven girls who were suffering from diabetes mellitus were investigated. The co-operation of all these children was obtained through the courtesy of Dr. R. D. Lawrence. They were his patients, and they were living on diets which contained prescribed amounts of carbohydrate, balanced by insulin, but which were unrestricted as regards protein and fat. Although the children were all having insulin, they were leading normal lives, and none of them was in any sense an invalid. There was one boy of five, but apart from him the boys' ages ranged from 13 to 17 years and the girls' from 11 to 17. They all weighed the food they ate for one week in exactly the same way as the healthy children. The foods they consumed and the chemical composition of their diets have been catalogued in the standardized way, but their records were not included with those of the 916 "normal" boys and girls which have already been discussed.

In order to give a picture of the diabetic child's diet as compared with that of a non-diabetic child it was decided to express his intake as a percentage of the average amount eaten by normal children of the same age and sex, instead of giving the absolute amounts of the various foods and dietary constituents. The results are set out in Tables CIX and CX. Heights and weights are also shown in Table CX. By reference to the tables and figures given earlier in this report, showing the average intakes of children taking part in the main investigation, the actual consumption of foods and dietary constituents by these diabetic children can readily be calculated if desired.

If Table CIX is studied, it will be seen that two of the girls were having more bread than the average amount eaten by non-diabetic girls of the same age, and one of them, Beryl, was also having more potatoes; it should, perhaps, be noted that this child was exceeding her prescribed carbohydrate by 50 g. a day. The rest of the children were having about half the normal amount of bread except for one boy who had only 1 oz. a day. He had, however, been prescribed a high protein and fat diet. The diabetic children were not having particularly large quantities of milk. Six of them had less and seven more than the "normal average". Taking them all together, they were having just about the same amount as the non-diabetic children. One 17-year-old girl, however, had very little milk indeed—in fact she had only 3 oz. during the whole week, so she, of course, reduces the average. Seven of the diabetic children had less and six more butter than the normal mean, and it is, perhaps, a little surprising how

TABLE CIX

Consumption of various Foodstuffs by Thirteen Diabetic Children
 (The results are expressed as percentages of the average amounts eaten by normal children of the same age and sex—see Tables XV–XXIII and Figs. 9–24.)

	John	Richard	Edgar	Raymond	Desmond	James	Margaret	Beryl	Beatrice	Caroline	June	Patricia	Dorothy
Age years	5	13	14	15	15	17	11	11	12	13	14	14	17
Bread	71	15	55	61	45	71	102	105	41	50	46	46	54
Milk	159	142	99	93	133	51	71	45	136	135	148	148	4
Butter	39	173	188	78	205	81	169	80	135	104	77	77	48
Cheese	0	358	0	197	143	855	171	0	57	179	0	0	107
Meat	105	149	84	99	125	182	227	174	115	92	89	92	214
Bacon	322	556	418	148	0	730	250	334	0	37	145	145	283
Fish	52	155	358	131	444	91	102	183	512	394	243	223	41
Raw fruit .. .	34	370	500	236	194	156	220	275	47	169	212	213	170
Cooked fruit ..	42	178	285	147	117	0	0	138	197	98	230	276	237
Potatoes .. .	76	59	41	80	41	47	29	109	49	79	67	68	45
Green vegetables	189	239	246	161	107	398	377	89	580	463	450	427	135
Root vegetables	71	287	0	107	161	83	0	420	63	428	0	0	24
Green salad ..	0	257	0	286	0	286	0	0	166	72	76	105	100

Note.—June and Patricia were twins.

TABLE CX

Heights and Weights, and Intakes of Various Dietary Constituents, of Thirteen Diabetic Children

(The results are expressed as percentages of the averages for normal children of the same age and sex—see Tables VIII–LXXXI and Figs. 1–71.)

	John	Richard	Edgar	Raymond	Desmond	James	Margaret	Beryl	Beatrice	Caroline	June	Patricia	Dorothy
Age years	5	13	14	15	15	17	11	11	12	13	14	14	17
Height	101	102	93	91	98	95	96	99	95	99	99	101	98
Weight	113	96	73	80	89	85	87	96	89	84	78	82	110
Calories .. .	102	88	81	60	89	91	91	88	70	73	74	75	59
Total protein	109	133	111	95	140	149	145	116	117	121	107	107	111
Animal protein	142	194	152	118	179	208	182	136	167	169	137	139	144
Fat	121	158	128	77	135	146	119	127	98	91	96	96	72
Carbohydrate ..	83	38	42	40	43	34	59	54	41	50	49	52	37
Calcium .. .	135	152	89	101	146	160	93	62	129	153	156	156	66
Phosphorus ..	124	147	91	92	150	143	126	93	129	138	115	118	94
Iron	91	141	99	84	106	102	113	118	87	103	102	100	130
Aneurin .. .	93	151	103	105	158	138	88	100	87	145	118	121	114
Ascorbic acid ..	61	287	141	150	72	125	120	125	71	222	165	163	162
Vitamin A (excluding liver).	134	192	162	103	198	151	128	106	138	164	155	150	65
Carotene .. .	88	228	273	124	222	207	98	58	127	267	527	465	198
Vitamin D .. .							(see p. 166.)						

Note.—June and Patricia were twins.

variable the butter consumption was. One boy, for example, had ten times as much butter as another, although his bread consumption was not quite twice as great. Five children had no cheese at all, but all except one of the others had more than the average amount. Only one, however, the 17-year-old boy, ate cheese in any quantity, and he had 18 oz. during the week. As might have been expected, these diabetic children tended to eat more meat, bacon and fish

than normal children of the same ages, though five had a little less meat than the normal average, and two had no bacon at all. It is only necessary to glance at the special rations which were allocated to diabetics during the war to realize that these were generally far in excess of the amounts of the same foods eaten by such children before any restrictions were imposed. All had some fish, and only three had less than the "normal average" amount. The consumption of fruit also tended to be high, though two of the children ate only small amounts of raw fruit and two had no cooked fruit at all. All but one of the diabetic children had less potatoes than non-diabetic children of the same ages, but all except this same girl had more than the "normal average" amount of greens. Four had no root vegetables and four had no raw salad. The others had very variable amounts.

The primary object of this study on diabetic children was to discover how their somewhat restricted diets compared in nutritive value with the diets eaten by normal children of the same ages. This can be seen in Table CX. It will first be noticed that in all but one instance the calories were below the "normal average", and it is perhaps worthy of note that the diabetic children's weights also tended to be low. Even when the calories are expressed per kg. of body weight, 10 of the 13 diabetic children were having less than the "normal average". The chief cause of the low calories was the restricted carbohydrate, which was on the average 48 per cent. of the "normal" intake. All but one of the children appeared to be having a little more than their prescribed amount. If calorie intakes are a measure of calorie requirements, one might have expected these children to have made up the calories, which other children obtained from carbohydrate, by eating more protein and fat. Their protein and fat intakes were in fact above the average normal values, but they were not sufficiently above to maintain the calories at a "normal" level. It is possible that the explanation of their low calorie intakes lies in the fact that, although the diabetic children were leading ordinary lives, and were up and about and going to school, they tended to be more sheltered than other children, and not quite so active.

Six of the 13 children had less fat than the normal average, and the diabetic mean was only 10 per cent. above the non-diabetic. All but one had more protein than the average amount in the diet of normal children of the same ages, and they all had considerably more animal protein—in fact, taking them all together, their consumption of animal protein was 60 per cent. higher than that of normal children.

There was nothing striking about the intakes of calcium, phosphorus and iron. Some children had more and some less than the "normal" average. The diabetic mean for calcium and phosphorus was 20 per cent. above the non-diabetic, and for iron there was no difference. The average intake of aneurin was a little higher than the normal average, and of ascorbic acid 40 per cent. higher. Only two children had less than the normal mean. Five of the diabetic children had liver and they had high intakes of vitamin A. Even if liver is disregarded, all but one of the diabetics had more vitamin A than the normal children, and their average intake was 40 per cent. higher. This was chiefly because they had more eggs. Eggs have not been included in Table CIX because the children taking part in the main survey sometimes had eggs in cakes and puddings in addition to the eggs they recorded as such, whereas the diabetic children had little or none of these high carbohydrate foods. It is quite clear that the diabetic children must have been having more eggs than the others, for three of them had 5, two had 6, one 8, two 9, and the other five had 10, 12, 13, 18 and 23 eggs respectively during the week. It will be recalled (p. 38) that the non-diabetic children were having an average of three eggs a week. During the war, diabetics were not able to have their customary eggs, but they were allowed a generous ration of meat.

The carotene intakes of the diabetic children were very variable. All but three had more than the non-diabetic average, and the twin girls had five times as much.

No figures have been given for vitamin D because it is a little difficult to know what to take as the normal average. Eleven of the 13 diabetic children (85 per cent.) had fat fish as compared with 33 per cent. of the normal children, so that, taken as a whole, their vitamin D intakes were very much higher. Even the two children who did not have fat fish had 122 and 144 I.U. a day respectively, and the intakes of the others ranged from 129 to 194 I.U. a day.

It must be concluded that the diets of these diabetic children were at any rate up to the normal average as regards all dietary constituents except carbohydrate and calories, and that they were especially high in animal protein and vitamins A and D.

CHAPTER 17

COMPARISON OF THE DIETS OF 38 CHILDREN OF UNEMPLOYED FATHERS WITH THE DIETS OF MIDDLE-CLASS CHILDREN

The survey described in this report was primarily a study of the diets of children whose parents were sufficiently well off to provide them with an adequate diet. As the collection of the data proceeded, however, and it became evident that the individual method of dietary investigation was no less suitable for children than it was for adults, it was decided to extend the survey somewhat, and to make a subsidiary study, in two depressed areas, of the diets of children whose fathers had been out of work for some time. This extension of the main survey was expected not only to provide interesting results in itself, but also to test once more the flexibility of the individual method.

Lincoln and Merthyr Tydfil, South Wales, were chosen for this investigation, and the method employed was the same in both places. A dietitian stayed in each town while the investigation was being made, and, through the courtesy of Miss A. Cameron in Lincoln and of Dr. D. Stephens, M.O.H., Merthyr, she was able to obtain volunteers for the survey. The same scales and forms were used as for the main investigation, but all homes were visited every day, and a considerable amount of supervision was given to the weighing of the food and the entering up of the results. The investigation in Lincoln was carried out in February, 1937, and in Merthyr in May of the same year, and several weeks were spent in each place so that it was not necessary for more than six children to be investigated at any one time. In Lincoln there were 20 children in all, 12 boys and 8 girls, and their ages ranged from 4-13 years. At Merthyr there was only one boy, aged 12, and 17 girls aged 3-13 years.

At the end of the time in Lincoln the children were given a party, and during the course of it samples of blood were taken for haemoglobin estimation, and the teeth were inspected by the same dentist who co-operated in the main survey. In Merthyr no dental inspection was possible, but blood was collected for haemoglobin determination at the school attended by most of the children. A few children were visited in their homes for this purpose.

In addition to these 38 children, the diets of 13 others whose fathers were unemployed were investigated. They, however, received food at nursery schools or at a charitable canteen, and have already been considered in Chapter 13. They are not included in the present discussion, which is limited to the children in Lincoln and Merthyr who, as far as is known, had no free or cheap meals, and whose only dietary supplement was their school milk.

All but one of the Lincoln children and all but two of those living at Merthyr weighed less than the average child of the same age and sex who took part in the main investigation. Four Lincoln and two Merthyr children were up to the average height, but all the rest were below it. On the whole, therefore,

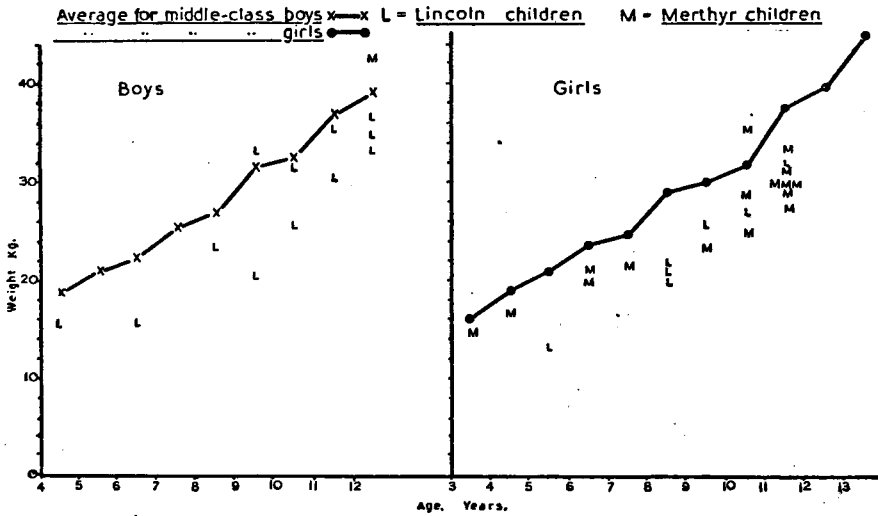


FIG. 81.—Weights of Individual Children of Unemployed Fathers compared with Average Weights of Middle-class Children.

these children were underweight and short of stature, but the defect in weight was greater than that in height, for the "nutrition index", i.e. weight per unit of height, of all but three of them, was below the middle-class average. The weights and heights of the individual children compared with those of middle-class children are shown in Figs. 81 and 82.

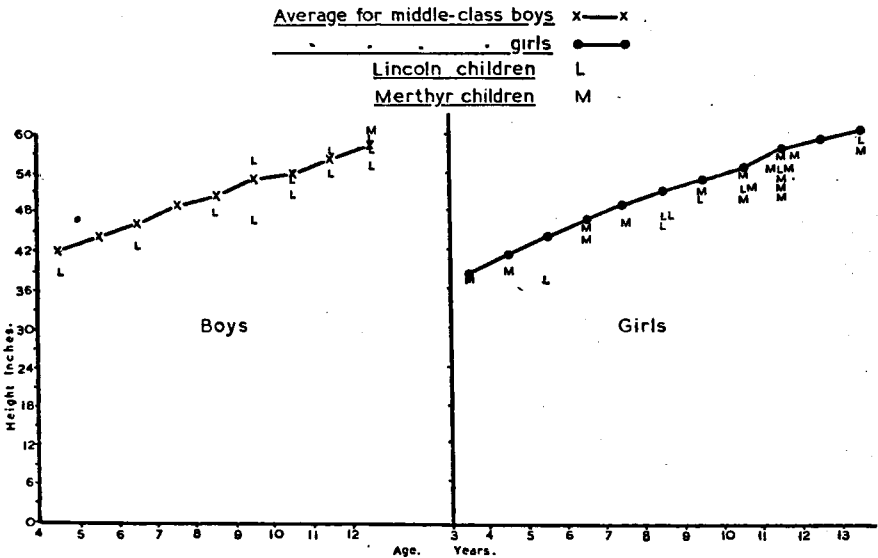


FIG. 82.—Heights of Children of Unemployed Fathers compared with the Average Heights of Middle-class Children.

Figs. 83-86 show the consumption by each individual child of four staple foodstuffs, bread, milk, meat and potatoes, and the average intakes of these foods by middle-class children are given for comparison. Furthermore, in order to give a more comprehensive, but less detailed picture of the "unemployed"

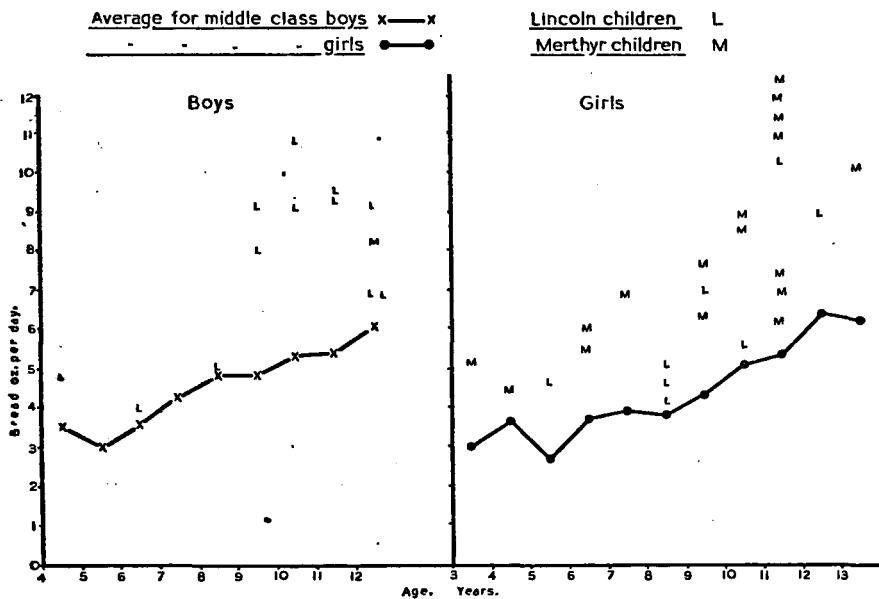


FIG. 83.—Bread Intakes of Individual Children of Unemployed Fathers compared with the Average Bread Intakes of Middle-class Children.

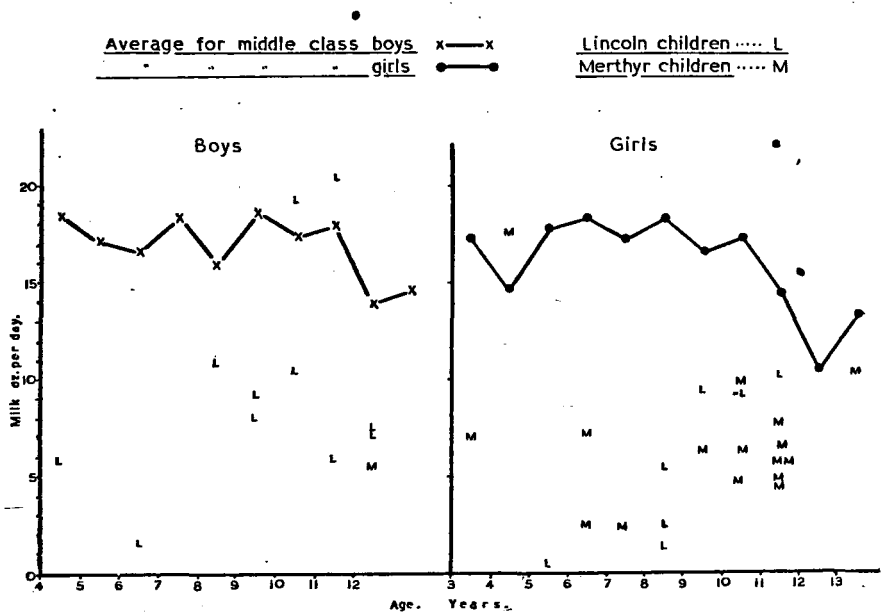


FIG. 84.—Milk Intakes of Individual Children of Unemployed Fathers compared with the Average Milk Intakes of Middle-class Children.

children's diets, Table CXI has been constructed. The average amount of a number of foods eaten by the children living in Lincoln and Merthyr was first calculated. These average figures in themselves had little meaning because

TABLE CXI

Consumption of various Foods by Children of Unemployed Fathers, expressed as percentages of the amounts eaten by Middle-Class Children of the same age and sex.

	Lincoln	Merthyr
Bread	148	167
Cake	68	52
Biscuits	40	91
Milk	49	42
Butter and margarine on bread..	114	134
Cheese	114	200
Eggs	26	71
Meat	62	74
Bacon	39	67
Fish	63	70
Fruit, raw	45	40
Fruit, cooked	6	19
Fruit, tinned	104	50
Potatoes	102	89
Green vegetables	93	52
Sugar (recorded as such).. .. .	126	108
Jam, etc.	54	35
Sweets	112	109
Chocolate	69	36
Number of different foods eaten during the week as per cent. of middle-class average	69	57

the children were of various ages, and both boys and girls were included. The mean intakes of these foods by middle-class children, of the same age and sex, have been calculated from the data given in Figs. 9-28, and the "unemployed" children's average intakes have been expressed as a percentage of these figures.

Every one of the "unemployed" children ate more bread than the middle-class average, and nine of them ate more than any individual middle-class child of the same age and sex. Seventeen of the 26 children aged nine years and over had more than 8 oz. a day. Their average consumption was approximately 50 per cent. higher than the middle-class average. It will be recalled that middle-class children obtained 10-16 per cent. of their calories from bread (Figs. 30 and 31, pp. 59 and 60). In contrast to this, these poorer children derived 20-43 per cent. of their calories from this source. At Lincoln the average figure was 25.4 per cent., at Merthyr 30.6 per cent. None of the Lincoln children had any brown bread. Four of those at Merthyr had some, but only one child ate more brown bread than white.

None of the unemployed group of children ate porridge, though one of them had some "Shredded Wheat". At the time when this survey was carried out oatmeal ranked with sugar and margarine as one of the cheapest sources of calories available, and the fact that porridge was not eaten is a striking example of how food habits and food prejudices effectively hinder the use of a valuable food, though no doubt lack of cooking facilities also played a part. It will be remembered, however, that the number of children of the artisan class who ate porridge was no greater than the number of children of the professional class (p. 28).

All the "unemployed" children had cake and 20 of them had biscuits, but they ate less of these foods than middle-class children, in fact only about half as much. More than twice as many biscuits were eaten at Merthyr as at Lincoln.

All but four of the 38 "unemployed" children had less than the average amount of milk consumed by middle-class children; 30 had less than $\frac{1}{2}$ pint a day and 10 had less than $\frac{1}{4}$ pint (Fig. 84). Had it not been for the school milk, 10 of the children would have had no fresh milk at all, for the only milk they received at home was skimmed, sweetened, condensed milk. Twelve of the Lincoln children and 11 of those living at Merthyr, 23 in all out of a total of 38 children, had condensed milk. With this must be contrasted the 29 middle-class children out of a total of 916 who had condensed milk during their week of food weighing (p. 35). Fourteen of the children at Lincoln and 12 of those at Merthyr had school milk, generally $\frac{1}{2}$ pint a day. One of the children had $\frac{3}{8}$ pint, and some had only $\frac{1}{4}$ pint occasionally. Apart from the school milk the average consumption of fresh milk was 4.7 oz. a day at Lincoln and 3.0 oz. at Merthyr.

The "unemployed" children ate more "butter" on bread than the middle-class children, which is not surprising in view of their higher bread intakes. They also had more cheese. Twenty out of the 38 of them had some cheese, and, at Merthyr particularly, those who had it ate more than the middle-class children. Eggs were cheaper at the time of the survey in Merthyr than they were when the inquiry was made in Lincoln and this is quite sufficient to account for the different numbers eaten in the two places.

The consumption of meat was low, and 31 of the children ate less than the average middle-class intake (Fig. 85). Two children, sisters, belonging to a very poor Lincoln family had no meat at all. Twin brothers, also from Lincoln, had no butcher's meat of any kind, but one had some liver. Liver is evidently much more popular in Lincolnshire than it is in South Wales, for seven out of the Lincoln children had some, while none of the Merthyr children had any at all.

Twenty of the "unemployed" children had bacon, but the average consumption was lower at both Merthyr and Lincoln than it was among middle-class children. The unemployed group also ate less fish, and most of the fish they did eat was bought at the fried fish shop. Of the 20 children in Lincoln, 16 had "fish and chips" and two others, the same two sisters who had no meat, had "chips" without any "fish". In Merthyr 11 children had "fish and chips", and three had "chips" alone. Popular though fish and chips seem to be among the poorer classes, they are not the very cheapest of foods, and in the poorest homes of all money presumably could not be spared for them. It was the children having the worst diets who did not have fish and chips, or who had chips without any fish. Probably they also would have bought fried fish, if they could have afforded it.

Most of the raw fruit that was eaten was orange, but the average consumption was less than half that of middle-class children. Very little home cooked fruit was recorded, but the "unemployed" children at Lincoln ate quite as much tinned fruit as the middle-class children.

So far as the potato consumption is concerned (Fig. 86), about half the "unemployed" children had less, and half more, than the average "middle-class" intake, and their mean consumption was just about the same as the average intake of middle-class children of corresponding age and sex. It might have been expected that the poor children would have eaten more, but potatoes need preparing and cooking, and these results confirm the observations of Orr (1936) and of Crawford and Broadley (1938) that rich and poor eat approximately the same amounts of potatoes.

Green vegetables were usually recorded as "cabbage". In Lincoln the intake was about the same as for middle-class children; at Merthyr it was approximately half. This may have been because cabbages were more readily available in Lincoln in February than they were in Merthyr in May. Both groups of "unemployed" children recorded more "sugar as such" than the corresponding average for middle-class children. Most of this sugar was taken in tea, frequently in addition to sweetened condensed milk. The "unemployed" children also ate more sweets, but less chocolate and less jam. Their smaller variety of foods is due chiefly to the fact that they had so few puddings and other prepared dishes. Often they had none at all. Bread and "butter" and tea formed the mainstay of their diet.

The nutritive value of these diets is shown in Figs. 87-93, where the individual intakes of calories, total protein, animal protein, calcium, phosphorus, iron, aneurin and ascorbic acid are compared with the middle-class average figures.

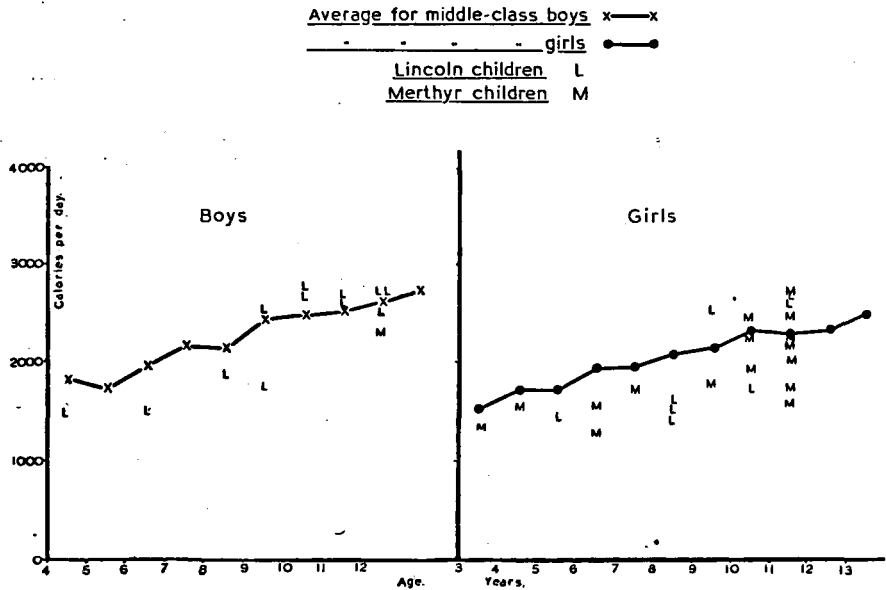


FIG. 87.—Calorie Intakes of Children of Unemployed Fathers compared with the Average Calorie Intakes of Middle-class Children.

All the intakes tended to be low. Figure for fat and carbohydrate are not shown, but 27 "unemployed" children had less fat and 22 less carbohydrate than the corresponding averages for middle-class children. Their mean intakes were 85 per cent. and 98 per cent. of the middle-class averages for fat and carbohydrate respectively. It was the older children who had more carbohydrate than the middle-class average, and this explains why their calorie intakes were in some instances high. It is, perhaps, surprising that any of the carbohydrate intakes should have been low in view of the large amounts of bread eaten, but these "unemployed" children ate less cakes, biscuits, puddings and jam, and these deficits were sufficient to make the difference.

The animal protein was sometimes very low. The five-year-old Lincoln girl who had no meat or fish had only 5 g. a day, and her eight-year-old sister 10 g. Thirteen of the children had less than 20 g. We are not prepared to say that these children were specifically suffering from a lack of animal protein, but it should perhaps be noted that the "unemployed" children who had very little animal protein also tended to have low intakes of protein from plant sources, so they did not have much opportunity for making up the deficiency.

Average for middle class boys x—x
 : : : : girls ●—●
 Lincoln children L
 Merthyr children M

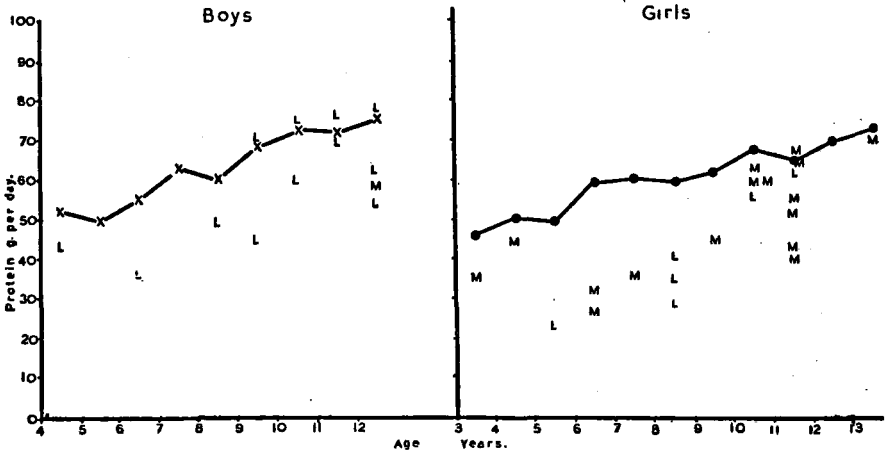


FIG. 88.—Total Protein Intakes of Children of Unemployed Fathers compared with Middle-class Children's Average Intakes.

Average for middle-class boys x—x
 : : : : girls ●—●
 Lincoln children L
 Merthyr children M

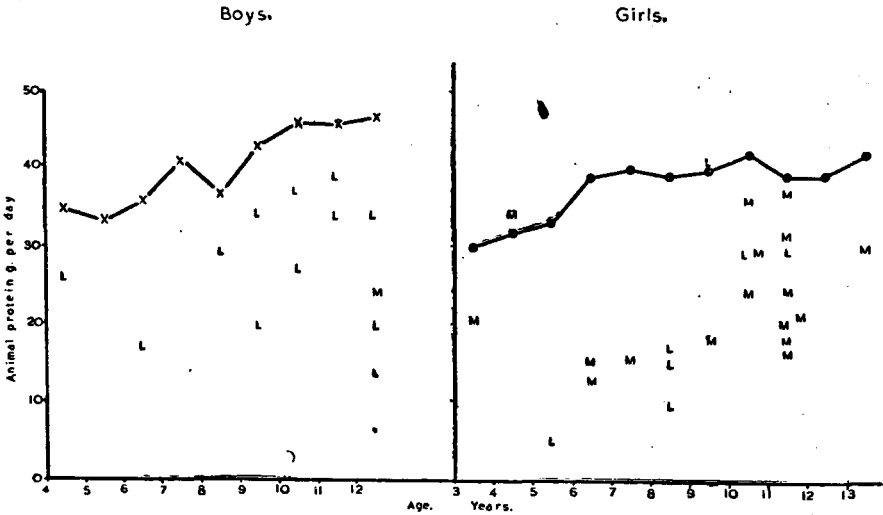


FIG. 89.—Animal Protein Intakes of Children of Unemployed Fathers compared with the Average Intakes of Middle-class Children.

Average for middle class boys x—x
 " " " " " girls ●—●
 Lincoln children L
 Merthyr children M

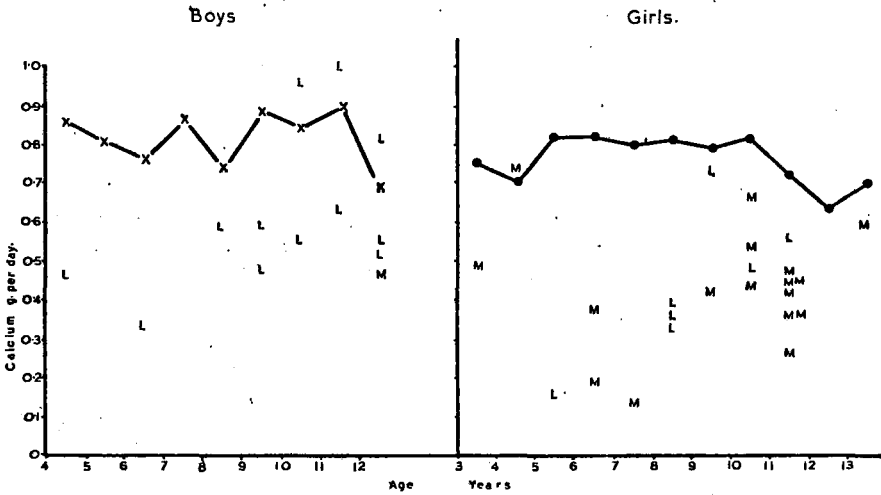


FIG. 90.—Calcium Intakes of Children of Unemployed Fathers compared with the Average Intakes of Middle-class Children.

Average for middle-class boys x—x
 " " " " " girls ●—●
 Lincoln children L
 Merthyr children M

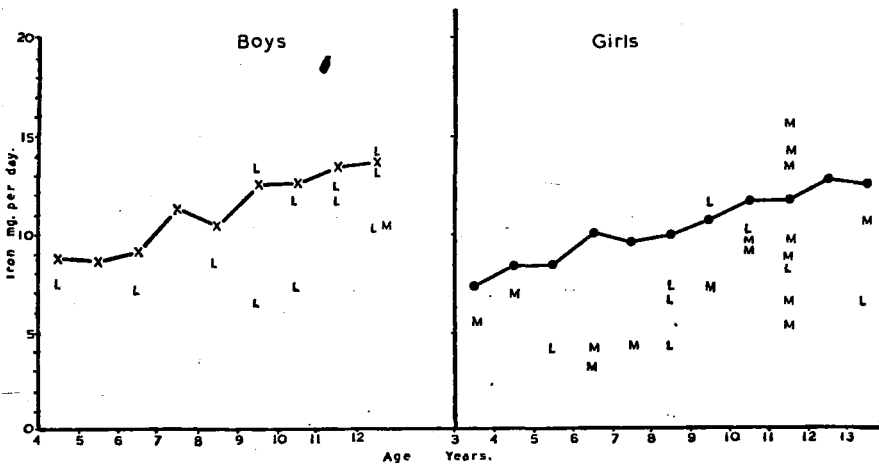


FIG. 91.—Iron Intakes of Children of Unemployed Fathers compared with the Average Intakes of Middle-class Children.

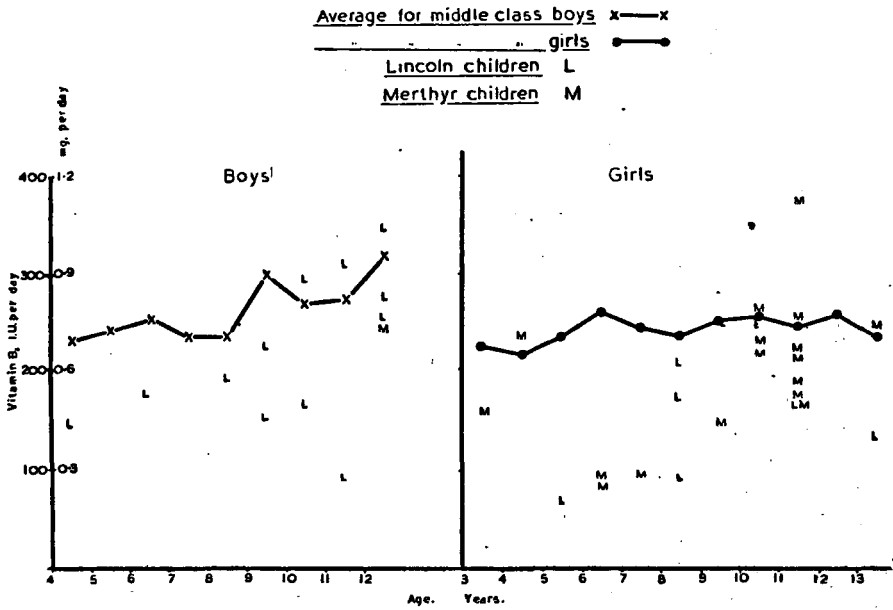


FIG. 92.—Aneurin Intakes of Children of Unemployed Fathers compared with the Average Intakes of Middle-class Children.

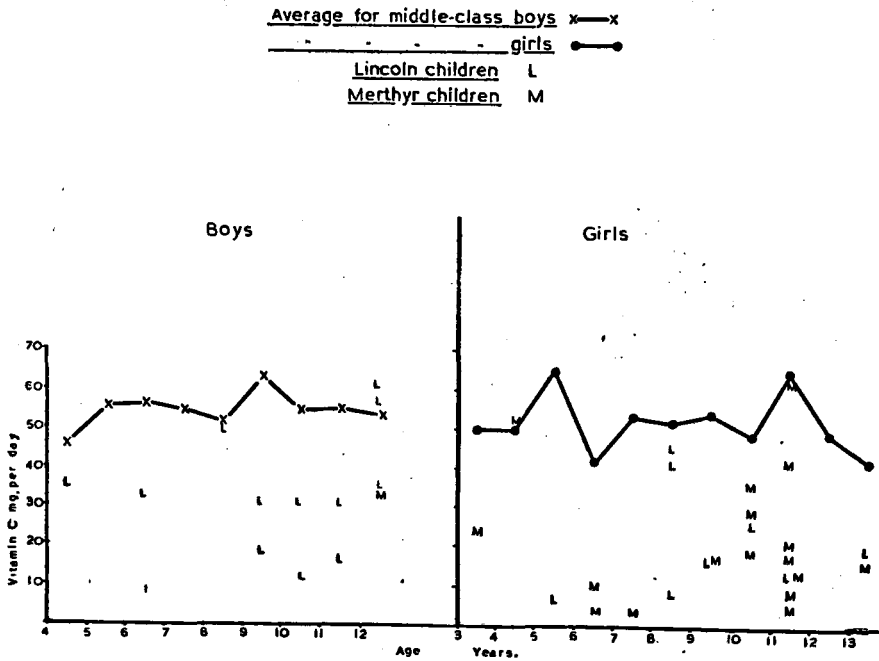


FIG. 93.—Ascorbic Acid Intakes of Children of Unemployed Fathers compared with the Average Intakes of Middle-class Children.

It will be recalled that the children taking part in the main investigation obtained approximately 12 per cent. of their calories from protein, 37 per cent. from fat and 51 per cent. from carbohydrate (Tables LVI, p. 88, and LXIV, p. 95). The corresponding figures for the unemployed group were 11 per cent. from protein, 34 per cent. from fat and 55 per cent. from carbohydrate: the similarity is remarkable.

The calcium intake tended to be lower at Merthyr than at Lincoln, though a Lincoln child had the lowest intake of all—0.17 g. a day. The figures for phosphorus are not given, but the results for this element were very similar to those for calcium. All but two of the Lincoln children and all of those at Merthyr had less than the average middle-class intake.

The teeth of all of the children at Lincoln were examined. Sixteen of the children were between 7 and 12 years of age, and the average number of carious or missing teeth was 4.9 for the 10 boys and 6.2 for the 6 girls; these figures are very close to those which were obtained for middle-class children of the same age group (see p. 19).

None of the children was very anaemic in spite of the low iron intakes as calculated from food tables. There is always the possibility that extra iron was obtained from cooking utensils, but in these children's homes little cooking was done, and certainly very little fruit was stewed. Mackay, Wills and Bingham (1946) found, in a group of 500 Council School children, that the haemoglobin level was related to the standard of living. The lowest haemoglobin level among our children was 80 per cent. on the Haldane scale. Eight of the children had values between 80 and 90 per cent., and 16 over 90 per cent. This would not contradict the findings of Mackay *et al.*, for the number of children whom we investigated was so few. It was not possible to obtain samples of blood from the remaining 13 children. It is, perhaps, worthy of comment that the haemoglobin level of the five-year-old Lincoln girl on the very poor diet was 110 per cent., in spite of an iron intake of only 4.1 mg. a day. It may be that had these children been growing more rapidly they might have shown some degree of anaemia (see Swanson and Smith, 1934), for there is no doubt that the rapid rate of growth in infancy is one of the factors which tend to precipitate anaemia during the first year of life. Unless these "unemployed" children were getting significant amounts of iron from their cooking utensils it is evident that they must have been absorbing a quite unusually high percentage of their iron intakes, and this may be an example of the ability of the body to vary the amount of iron it absorbs in accordance with its needs.

Various causes contributed to the low aneurin intakes. The diets contained smaller amounts of milk, meat and bacon than did those of better-off children, and little or no brown bread was eaten. Furthermore, since the calories were low a high aneurin intake was hardly to be expected (see p. 123). The ascorbic acid intakes were very variable. Six children had less than 10 mg. a day and seven had over 40 mg. The figures would have been lower were it not for the fact that most of the small amount of raw fruit that was eaten consisted of oranges.

With regard to the fat-soluble vitamins, none of the children at Merthyr had liver, and their vitamin A intakes were in some instances very low. The average intake was 1,177 I.U. a day. The highest was 1,783 and the lowest 641. Six had less than 1,000 I.U. a day. At Lincoln, seven of the children had liver, and they had 2,743–13,324 I.U. a day. The intakes of the others who did not have liver were very similar to those of the Merthyr children and averaged 1,063 I.U. a day. Nine had less than 1,000 I.U. and one had as little as 431 I.U.

Most of the carotene intakes were also low. Only one of the Merthyr children had carrots and the average carotene intake at Merthyr was 1,083 I.U. a day. At Lincoln, carrots were more freely eaten, possibly because the survey was carried out there in February when carrots are more plentiful than in May. Ten of the children ate carrots, and the average amount of carotene in the diets was 1,313 I.U. a day.

Two children had tinned salmon, but apart from this no tinned fish was eaten. Of the Lincoln children one had bloater and two had sprats, while of those at Merthyr one had kipper and four had mackerel, and the vitamin D intakes of these children were correspondingly high. The average intakes were 61 and 55 I.U. a day at Lincoln and Merthyr respectively. The lowest was 16 I.U., the highest 201 I.U. The latter was the intake of a four-year-old Lincoln boy who had bloater. Five children had less than 20 I.U.

If generalizations may be made from the study of this small group of children, it must be concluded that during the pre-war years the diets of children belonging to the unemployed classes were inadequate in many respects, whether they are compared with the diets of more fortunate children or with standards of requirements. Without the school milk they would have been more inadequate still. It will be interesting to see if the care now being devoted to children's nutrition will prevent this happening in the future.

SUMMARY

1. Between the years 1935 and 1939 records were obtained of the food consumption of 1,028 individual British children, and these records have been examined in the light of the historical background, of the ages, heights, weights and sex of the children, and of the knowledge which exists today about the composition of food and children's requirements of the separate nutrients.

2. Nine hundred and sixteen of the subjects were healthy middle-class children, and most of them were living at home. Each age from one to 18 was represented by at least 20 boys and 20 girls. The remaining 112 children were diabetics, or the offspring of impoverished parents.

3. The haemoglobin level in the blood of nearly half the children was determined, and the teeth of a similar number were examined for signs of dental caries.

4. Everything that each child ate in one week was weighed, and the chemical composition of the diet was calculated from food tables.

5. Broadly speaking, the results may be applied to the solution of two essentially different problems. The first of these is the effect of age upon the physical measurements of children and upon their intake of foods and dietary essentials. The second is the magnitude and importance of the variations in food consumption among individuals with similar physical characteristics.

6. The consumption of some foods, such as bread, meat, potatoes and sugar, increased till the children were 15, whereas other food, such as biscuits, cheese, fruit and green vegetables, were eaten in similar amounts at all ages. The intake of milk was about four-fifths of a pint per day till the children reached the age of 10, and thereafter it declined.

7. The proportion of the total calories derived from milk fell from about 30 per cent. at one year of age to about 7 per cent. at the age of 18, but age made less impression on the proportion of total calories derived from other staple foods—cereals, sugar, butter, meat and potatoes. The figures for calories from cereals and meat rose slightly, those for butter and potatoes not at all.

8. The energy value of the diets averaged a little over 1,000 calories per day between the ages of one and two. A difference between the sexes was apparent at three years of age and the boys' intakes reached 3,440 at 15. At this age the girls' intakes were 2,588.

9. The protein intakes of the children averaged a little less than 40 g. per day between the ages of one and two. At the age of 15 the boys' intakes were 100 g. and the girls' 78 g. per day.

10. The calcium intakes averaged 0·8 g. per day till the children were 11 years old. Thereafter the boys' calcium consumption rose a little and that of the girls declined.

11. The intakes of phosphorus were between 0·8 and 0·9 g. per day in the youngest age groups, and rose in the case of the boys to 1·56 g. at 15 years and in the case of the girls to 1·21 g. per day at the same age.

12. The intakes of iron averaged 5 mg. per day between one and two years of age. The boys' intakes rose above the girls' at seven years of age and reached 18·5 mg. per day at 15 years. At this age the girls were ingesting some 14·5 mg. per day.

13. The intakes of aneurin were of the order of 0·55 mg. per day in the first age group. The boys were getting an average of 1·13 mg. per day at 16 years and the girls 0·89 mg. per day at 14 years.

14. The intakes of ascorbic acid averaged 42 mg. per day between one and two years of age, and most of this came from citrus fruits. The intake of this vitamin did not rise much as the children grew older, but the bulk of it came from vegetables in the older age groups.

15. The intake of vitamin A depended to a very great extent upon the consumption of liver, and that of vitamin D upon the consumption of pelagic fat fish.

16. The diets of twin children were extraordinarily alike.

17. Seven vegetarian children were up to average in height, but their diets tended to be low in calories, protein, and vitamin C.

18. The diets of diabetic children provided them with fewer calories than those of healthy children, but with more protein and fat. The children, generally, were below the average in height and weight.

19. The children of unemployed parents were generally below the average of the other children both in height and weight. Their diets contained more bread but less milk and meat, and less of most of the dietary essentials.

20. The one outstanding fact, which has been brought out again and again by this investigation, is that similar individuals may differ enormously and unpredictably in their food habits. This applies with great force to the energy value of the diets, but it is equally true of the proximate principles, minerals and vitamins, and still more true of the foods themselves. These extraordinary departures from the average are compatible with normal physical development. These findings indicate that individual requirements must differ as much as individual intakes, and that an average intake, however valuable statistically, should never be used to assess an individual's requirement.

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This investigation has depended upon the active co-operation of thousands of people—the children who ate the food, the parents and teachers who supervised the weighing, and all those who have devoted their time to the calculation of the results. It is impossible to mention each by name, but I thank them one and all. I owe a special debt of gratitude to Mrs. J. S. Ellis (Miss C. M. Verdon-Roe), whose enthusiastic and efficient help made the collection of the data a pleasure; to Mr. R. E. Clarke, who examined the children's teeth; and to Miss D. Cannon, Miss M. W. Odell and Mr. D. Temple for the trouble they took on my behalf.

Only one who has worked as I have for many years in close association with Dr. R. A. McCance can appreciate how much of a "guide, philosopher and friend" he has been to me throughout the whole of this investigation. It is impossible for me to thank him adequately for all he has done.

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