LEAGUE OF NATIONS

Health Organisation

Technical Commission on Nutrition

GUIDING PRINCIPLES FOR STUDIES ON THE NUTRITION OF POPULATIONS

BY

Dr. E. J. BIGWOOD,
Professor at the University of Brussels.

GENEVA, 1939.

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GENERAL INTRODUCTION

Purpose of this Monograph.

The purpose of the present monograph is to indicate what points should be borne in mind in conducting nutrition surveys of populations, in order that the work may be carried out on sound lines and the findings presented in such a way as to facilitate comparison. The need for such comparison is appreciated by all experienced workers in this field. In many cases, however, its potentialities cannot be fully exploited, because the investigations concerned have not been planned in a manner ensuring comparability. In this way, part of the value of much industrious labour is lost ; and it hence becomes necessary to contemplate some standardisation of methods —on a basis which need not, however, interfere with originality of research.

This monograph will include a description of methods of studying the physiological problems connected with nutrition which are suitable for application to population groups of varying size and homogeneity. The variation in size is very considerable, since it ranges from groups of a few persons to a whole nation.

The homogeneity or heterogeneity of the groups will be considered from various points of view—physiological, demographic and social.

It will be seen that our analysis of the physiological factors to be taken into account leads up to certain proposals which should also facilitate the comparisons discussed above.

* * *

The Two Essential Aspects of a Comprehensive Nutrition Survey of a Population.

A complete nutrition survey of a group of persons calls, in the first place, for an investigation of their food consumption ; this purpose is served by *dietary surveys*.

The next point to consider is the state of nutrition of the persons concerned, how it should be defined and how it is affected, *inter alia*, by dietary habits ; in other words, how the state of nutrition should be studied in relation to diet. This question will be discussed in Part II of the present monograph, which will deal with *enquiries into the state of nutrition of populations*.

* * *

Variety of Purposes which Nutrition Surveys of Populations may serve.

Most of the surveys carried out up to the present are not of the comprehensive character indicated above. A very large number relate to food consumption alone ; others are concerned exclusively with the state of nutrition. These partial surveys are, however, highly important, and part of our knowledge of *the physiology of human nutrition is derived from them.*

Nevertheless, at its last session, the Technical Commission on Nutrition of the League of Nations Health Organisation [1] recorded its view that studies undertaken in the future should preferably be of the complete type, covering both the diet and the state of nutrition of the same subjects. This recommendation is warranted by the fact that such comprehensive surveys are rare at the present time, and yet offer the only means of enlarging our knowledge in regard to a physiological question of immediate topical interest—namely, the assessment of bodily requirements in respect of the vitamins and other protective principles. Such research is, however, both difficult and costly, and it cannot be emphasised too strongly that this recommendation, sound though it may be, must not discourage partial studies in cases where available resources permit of

[1] *Bulletin of the Health Organisation* of the League of Nations, 1938, Vol. VII, No. 3, Extract No. 8.

nothing more ambitious. Besides, everything depends upon the object in view, and this may vary considerably. Thus :

(a) It may be to determine statistically from periodical production, import and export returns *what food supplies are available in a given country*, in order thereby to ascertain what possibilities are at hand for feeding the population as a whole. This is merely a matter of compiling figures published by the administrative industrial, banking and commercial organisations concerned with such questions. It does not involve the direct investigation of any group of persons.

(b) The object may be to ascertain by direct investigation *what food is actually consumed by certain groups of persons.*

These are dietary surveys proper. They may be used merely to describe the diet, or to compare it with a diet taken as a norm or simply as a standard of reference.

They involve the qualitative and quantitative investigation of the food habits of well-defined groups of persons, and are usually of small extension compared with the purely statistical, but nation-wide, type of survey defined under (*a*).

(c) *The object may be economic or social.* When enquiries of the type just mentioned form only part of a more comprehensive programme going beyond the scope of nutritional studies, when they fit into a wider investigation of living conditions in general, they call for broader treatment, including the consideration of food expenditure in relation to total cost of living. Enquiries of this kind are undertaken with the object of constructing cost-of-living and retail-price indices and of working out family budgets as a basis for minimum-wage standards and the like.[1]

Food expenditure budgets are undoubtedly of special interest when considered in relation to the physiological characteristics of the diet. This point will be discussed in the present monograph, even though it deals only with investigation techniques for use

[1] A detailed survey of "Methods of conducting Family Budget Enquiries" has been prepared by t h International Labour Office (Studies and Reports, Series N) and is at present in the press.

in nutrition studies. For the fact is that nutrition surveys forming part of a programme of social studies of living conditions generally are not as thorough-going as those which are concerned exclusively with nutrition problems ; they furnish the main outline, but not the detail required for a real nutrition survey.[1]

(d) *The object may be medical or, at all events, connected with public health.* In this case, studies are usually concerned exclusively with the state of nutrition, or physical condition, of populations, but not, as a rule, with food consumption as well. Their object is simply to assess the state of nutrition of population groups.

(e) *Lastly, the object may be to throw further light on purely physiological problems which are still but imperfectly elucidated.* This implies scientific research in the strict sense of the term, and not applied physiology.

Investigations strictly limited either to food consumption or to the state of nutrition cannot contribute towards the solution of one important physiological problem which is of immediate interest—namely, that of the assessment of bodily requirements in respect of the various nutrient principles contained in food, and that of the medical and other factors which are apt to modify these requirements. Only combined research covering both food consumption and the physical state of nutrition can help to solve this problem, to determine the proper qualitative and quantitative balance of the diet, and to define the immediate medical consequences of any slight departure from the standard thus established—in a word, to throw light on the problem of latent pre-deficiencies and their early diagnosis. The purpose which enquiries into the state of nutrition may subserve is thus not merely that of recording outwardly apparent manifestations of severe disturbances of the nutritional state, or signs of well-marked deficiency, but such enquiries also aim at detecting, by sensitive and reliable tests, the first barely discernible signs of milder disturbances.

[1] There are, however, in some exceptional instances, enquiries into living conditions and family budgets in which the part relating to nutrition is treated with some thoroughness.

It should be observed, however, that frank conditions of deficiency or pre-deficiency may point to the operation of various causes. They are not always of exogenous origin—in other words, they are not always the result of defective diet. This means to say that they are not attributable in every case to the total or partial absence from the diet of certain nutrient principles. They may also be due to pathological defective absorption or utilisation of these principles. These may be termed the *secondary* deficiency or pre-deficiency states of endogenous origin, for which the diet is not responsible. This distinction in regard to origin is important. In order to discriminate successfully between the two kinds of deficiency states, the investigator should bear in mind that cases of secondary deficiency are likely to be exceptional isolated observations, whereas investigations directed to the detection of an *average* state of deficiency or pre-deficiency in the population group will make it possible to ascertain how far exogenous dietary causes have been operative. Here again, the real difficulty of enquiries into the state of nutrition of population groups lies in assessing the average. In certain countries, however, secondary deficiencies are also frequent. This applies, for instance, to pellagra in areas in which its incidence is connected with certain widespread parasitic infections. In such cases, only the combined medical and dietary type of enquiry can elucidate the origin of such deficiency conditions.

It is possible, moreover, that, in a more general way, conditions of unapparent sub-deficiency of endogenous origin are more frequent than had hitherto been supposed.

* * *

Difficulties attaching to Nutrition Surveys of Populations.

Dietary surveys also entail certain difficulties. These are of two kinds : first, the collection of data and, secondly, their physiological interpretation.

A food consumption enquiry invariably disturbs family habits. The investigator is an intruder in the household, and he asks the housewife for information which adds to her daily work. These are factors which may disturb the dietary habits of the households concerned. The greater the accuracy which the method seeks to achieve, the more will this factor of error obtrude itself. The best method will be the one which achieves the nicest balance between these conflicting tendencies. It has to be recognised that, in such circumstances, no food consumption study can attain to that level of strict accuracy that might, at first sight, be hoped for. " Leave well alone " is a particularly appropriate motto that should be borne in mind. The lengths to which the attempt at rigorous precision can be carried without defeating its own end will require due consideration.

When this first stage of the food consumption studies is completed and the physiological examination of the diet has to be undertaken on the basis of the data thus collected, the investigator is confronted with further difficulties. The problem of estimating the various kinds of food-waste and that of the choice—and criticism—of food consumption tables will require to be discussed in turn. As regards vitamins, the question of the great diversity of units adopted to express the concentration in products, and the conversion of values from terms of one unit into terms of another will call for careful study. Finally, a chapter will be devoted to the problem of scales of consumption coefficients to be used to determine the probable distribution of the food among the various members of a family in cases where the data furnished give only the total food consumption of households or population groups. So far as these scales are concerned, attempts have already been made to set up international standards in connection with the variation of calorie requirements according to age, sex and type of work ; but no corresponding scales have yet been prepared for nutrient principles other than the energy-bearing substances. Certain isolated attempts have been made, however, and will have to be examined. The question is one of importance, since the analysis of the results of dietary surveys based on one or more particular scales involves a whole series of mathematical operations, and these have to be re-calculated throughout before comparisons can be made between surveys that are based on non-comparable scales of coefficients. It is therefore of obvious practical importance that some form of international standardisation should be established.

There remains the economic aspect of the food problem. There are many purposes for which it is important to know the cost of the diet and the manner in which cost varies with composition. From the point of view of social medicine in particular—that is to say, of the way in which economic and social factors affect the diet—it is desirable to know how the average cost of foodstuffs stands in relation to their energy-bearing or protective properties, and what is the average cost of a well-balanced diet compared with other diets. These questions do not arise in the same way in every country. In some countries, all other economic and commercial factors being equal, the diet fluctuates between the "cheap calorie" and "dear calorie" variety, simply according to the proportion of protective foods it contains. In other countries, this is not so. It is important that such facts should be known.

This economic aspect of the problem of nutrition shows the effect of social factors upon public health and medicine, for instance, in so far as the latter give rise to serious dietary deficiencies in some parts of the world or insidious pre-deficiencies in others.

A study of the relationship between such economic, social and physiological aspects of the nutrition problem will indicate the direction in which the remedy for defective diets may be sought. Thus, the importance of efficient domestic training is well known, and, according to the country considered, this educational factor may occupy a more or less important place in the general setting of the problem considered from the social standpoint.

* * *

On several occasions, it has been noted that an attempt at standardising methods of investigation would be desirable. In many cases, such standardisation would, however, be difficult to achieve, owing to existing divergencies. The present monograph will endeavour to deal with these as objectively as possible, merely stating the contending views without favouring any at the expense of the others.

How future surveys may help to remove such differences will also be indicated. In this connection, indications will be given on a matter which is of some practical importance—that is to say, what essential information should always be supplied in the published results of surveys in order that, despite these differences of outlook, the findings may be made comparable with those of investigations conducted by other research workers.

* * *

One final point which is indispensable in any statistical work will be discussed in this paper. The study of dietary surveys constantly involves the computation of average values. Now it is of the highest importance to judge correctly within what limits such averages are valid or comparable with others. Many faulty interpretations could be avoided if these limits were assessed with more careful observance of certain fundamental rules of calculation employed in statistics. We shall endeavour to deal as briefly and as simply as possible with this somewhat intricate question of the calculation of errors.

* * *

Several persons have kindly assisted in the preparation of this paper by supplying specimens of record cards and other documents used in surveys in various countries and by authorising the reproduction of these documents in the present monograph by way of illustration. In this connection, the Health Section tenders its sincere thanks to Miss Hazel K. Stiebeling, Senior Food Economist at the Bureau of Home Economics, United States Department of Agriculture ; Mme. L. Randoin, Director of the Food Research Centre of the Société scientifique d'Hygiène alimentaire, Paris ; Professor M. Swartz Rose, Columbia University, New York ; Professor H. Pelc, Karlovy University, Prague ; Professor Jacquemyns, of the Solvay Sociological Institute at the Université de Bruxelles.

The author also wishes to thank M. Raymond Olbrechts, Professor of Statistics at the School of Social and Political Science of the Université de Bruxelles, for his kindness in examining Chapter XII, which deals with certain statistical methods as applied to nutrition surveys.

* * *

At the request of the Health Committee, a Sub-Commission of the Technical Commission met at Geneva in August 1938, under the presidency of Sir Edward MELLANBY, F.R.S., General Secretary of the Medical Research Council, London. It consisted of: Dr. W. R. AYKROYD, Director of the Nutrition Research Laboratory, Coonoor (India) ; Dr. E. J. BIGWOOD, Professor at the Université de Bruxelles ; Dr. Lela E. BOOHER, Chief of the Division of Foods and Nutrition, Bureau of Home Economics, United States Department of Agriculture, Washington ; Dr. H. CHICK, Head of the Nutrition Department, Lister Institute, London ; Professor L. S. FRIDERICIA, Professor of Hygiene at the University of Copenhagen ; Professor A. MAYER, Professor at the Collège de France, Paris ; Sir John BOYD ORR, F.R.S., Director of the Rowett Institute of Animal Nutrition, Aberdeen.

After carefully considering Part I of the present monograph, this Sub-Commission adopted it [1]; it recommended it to the National Nutrition Committees of the various countries, as well as to other national institutions responsible for nutrition surveys. It noted that this monograph could be used in Europe, in the countries of America and in the Far East, as well as in tropical countries, subject to the necessary adjustments referred to in the body of the monograph itself.

The author tenders his thanks to the members of the Sub-Commission for the suggestions they made to him in the course of discussion.

* * *

Part I of this publication was also approved by the *representatives of National Nutrition Committees*, who met at Geneva from October 24th to 28th, 1938. [1] The meeting was attended by : Professor E. ABRAMSON, Näringsrådet, Karolinska Institutet, Stockholm ; Dr. A. BEZNAK, Professor of Physiology at the University of Budapest ; Dr. E. J. BIGWOOD, Professor at the Faculty of Medicine at the University of Brussels ; M. A. CEICHNERS, member of the National Nutrition Committee of Riga (Latvia) ; Dr. K. EVANG, Director of the Norwegian Civil Medical Service ; Dr. R. N. M. EYKEL, Chief Inspector of Public Health at The Hague (Netherlands) ; Dr. A. HASSAN, Professor at the Faculty of Medicine, Cairo (Egypt) ; Dr. W. P. KENNEDY, Professor at the Royal College of Medicine at Bagdad (Iraq) ; M. S. MANDECKI, Counsellor at the Ministry of Agriculture, Warsaw (Poland) ; Dr. A. MAYER, Professor at the Collège de France, Paris ; Dr. F. MCCALLUM Department of Health, Australia ; Dr. H. E. MAGEE, Ministry of Health (London) ; Miss S. SMITH, Department of Agriculture (Washington) ; Dr. A. J. VIRTANEN, Professor at the University of Helsinki (Finland) ; and Dr. R. E. WODEHOUSE, Deputy Minister of Pensions and National Health, Chairman of the Canadian Council of Nutrition (Ottawa).

The author also wishes to thank the members of the above meeting for the information supplied in the course of discussion.

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[1] Part II of this monograph is the reproduction of a paper which had already been published and has now been brought up to date (see Introduction to Part II).

Part I

DIETARY SURVEYS

INTRODUCTION

During its third session, held in London in November 1937, the Technical Commission on Nutrition of the League of Nations Health Organisation drew a distinction between four types of nutrition survey, which we shall adopt in this guide. [1] They are differentiated not so much by the extension of the group of persons under examination as by the nature and size of the social unit to which they relate. Thus, these units, in order of decreasing size, may consist of an entire nation ; or particular social groups, such as the army, a school, a prison, a workers' city, etc ; or, more frequently, a family ; or, finally, a single individual.

A survey of the first type, carried out on a nation-wide scale, must always be too vast to be undertaken through the direct study of the groups constituting the nation. The method, therefore, can consist only in the compilation of data from statistical documents published by various official or private organisations ; but the other three types of survey do involve investigations, conducted over a given period of time, of groups of persons selected for the purpose.

These different types of survey will be described in the first four chapters ; their purpose will be defined, and the characteristics peculiar to each from the technical point of view will be described and discussed. As for various considerations which apply to every type of survey, these will be dealt with in turn in a series of later chapters in which they will be considered in relation to the various types of enquiry and in the modified form appropriate to each.

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[1] *Bulletin of the Health Organisation* of the League of Nations, 1938, Vol. VII, No. 3, Extract No. 8.

Chapter I

FIRST TYPE OF DIETARY SURVEY

Statistical Studies of the Food Resources of a Country

Various organisations, such as the Ministries of Agriculture, of Economic Affairs, or of Commerce, and private banking, industrial, commercial or agricultural concerns, periodically publish statistical tables of the production, imports and exports of their particular country. By collating these data, it is possible to draw up a table of the total resources of the country in food products. The fluctuations noted in the periodical inventories of stocks of food products provide still further information which enables us to verify and cross-check our figures.

The resources thus ascertained can in no sense be regarded as equivalent to actual human consumption during the period under review. One part of the supplies is intended for other purposes, and this part is not always easy to estimate as accurately as would be desirable. It includes seed for sowing, products intended for animal food and the material which is nowadays being used in industry in an ever-increasing number of ways. Two instances coming under this last heading may be mentioned : the casein of skim-milk or of whey is extensively used as the raw material for the manufacture of a constantly extending range of articles. A large proportion of the edible fats is used in the soap industry, very often not until the fat has been used several times for cooking—especially in hotels.

An attempt may be made to assess the amount so used and to subtract it from the figure of total food resources. The balance then gives a rough figure of the amount for human consumption. But when the corresponding value per year or per day, and per head or per male adult, is computed on this basis by applying an appropriate scale of consumption coefficients to the detailed population census, values in calories or in nutrient materials other than energy-bearing principles [1] are obtained which do not always agree satisfactorily with the corresponding values ascertained by direct nutritional surveys (see farther on). This is the case even when such surveys have been sufficiently wide in scope and varied in incidence to be considered representative of the whole population in the districts under examination.

The problem which confronts us is therefore to determine the cause of these discrepancies. They may be partly due to the fact that the estimates of the amounts to be deducted in respect of uses other than human consumption are faulty. But there are other sources of error. Production, import and export statistics are often expressed in units whose equivalent in terms of weight is apt to be inaccurately assessed. Vegetables are sometimes measured by the bundle, fruit by the number of cases, and other products by the number of sacks, truck-loads, etc. Information is available, of course, as to the average equivalent weight, but it is clear that errors in estimation may none the less arise. As regards perishable foodstuffs, the proportion which deteriorates before being sold or consumed and the losses which occur through accidents of various kinds or during handling or transport, are sources of error which are difficult to estimate quantitatively.

Nor is wastage due to stocking by any means negligible. Meat consumption statistics may be compiled either by head of cattle or by large quarters of meat estimated by weight, as, for instance, stripped half carcases ready for cold storage. Estimates of the latter kind take account of all kinds of slaughterhouse waste which yield various by-products for industrial use, but other errors are still not eliminated, such, for example, as the waste entailed by cutting up meat into joints, etc., in the butcher's shop. Similar considerations apply to cooking in the home. It is hence clear that to estimate actual consumption by using statistics of the wholesale trade or of production is an undertaking beset with numerous difficulties.

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[1] Or simply in classes of foodstuffs.

In addition to this, there is the further error due to the consumption of home-produced foods (orchards, kitchen-gardens, small domestic animals, etc.); it is difficult to procure information on this.

Yet another source of error—though of a different kind—attaches to the analysis of the results of surveys of the first type. The food resources which are estimated as being used exclusively for human nutrition are expressed in terms of food per inhabitant or per unit of consumption, such as the average male adult. This average value for the whole nation may have some theoretical, statistical significance and may be useful for comparing the total food consumption in different countries, but it cannot represent the actual average daily consumption in the different classes or groups of society. In some it will be above, in others below, this figure. It follows, therefore, that estimates of the food resources of an entire country can give no more than a vague idea—and that in a very general and approximate way—of the real standards of nutrition of the population.

> "An analysis of the resulting data is useful to a Government in framing its nutrition policy, particularly with regard to practical measures affecting the quantity and quality of food materials. These studies are also useful in following the trends of the dietary habits of a country." [1]

But they cannot be used for a physiological and medical study, which requires less extensive but more thorough investigations involving direct and carefully controlled observations. These latter investigations are of the types which we shall now proceed to discuss.

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[1] *Bulletin of the Health Organisation* of the League of Nations, 1938, Vol. VII, No. 3, Extract No. 8.

Chapter II

SECOND TYPE OF DIETARY SURVEY

Studies covering Particular, more or less Homogeneous, Social Groups and Institutions

Dietary surveys of this type are carried out in the army and navy and in institutions with a large number of inmates, such as children's homes, schools, boarding-houses, hostels, prisons, religious communities, etc. Various considerations can be adduced to show the value which attaches to these studies.

1. The dietary habits of these social groups reflect certain traditions. They may vary within a given country, and if the studies extend over a long observation period and are carried out in conjunction with research into the state of nutrition of the same individuals, valuable evidence may be obtained of the effects of dietary habits on the state of nutrition. This is borne out by the experience gained in Norway with the so-called " Oslo breakfast ". [1]

2. The technique of the dietary survey is simplified by the fact that the food is prepared and eaten in common in great kitchens and refectories. The existence of a catering department further facilitates the task of obtaining information. The conditions under which the investigator works do not give rise to the difficulties encountered in family enquiries, where his intrusion into family life creates a disturbance and hence psychological difficulties which do not arise in the impersonally controlled institutional kitchen.

3. Another circumstance which facilitates the physiological interpretation of the findings is that such groups are more homogeneous than either a family or a nation. The total food

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[1] *Bulletin of the Health Organisation* of the League of Nations, June 1937, Vol. VI, No. 2, page 197, Extract No. 5.

intake of the group divided by the number of persons composing it gives, with the minimum of error, an idea of the diet of each individual. Scales of family consumption coefficients are brought into operation to the least possible extent in the calculations. Homogeneity is doubtless not absolute even, for instance, in the army, which consists of young male adults within fairly narrow age-limits. It is difficult, however, to make allowances for individual differences of stature, for instance. This type of investigation cannot therefore entirely serve the purpose of the individual study properly so called; the latter—as will be seen—is the most difficult of all to carry out, and the results may be distorted owing to disturbances of dietary habits caused by the presence of the investigator—a drawback to which investigations covering *relatively* homogeneous institutions are not subject, or are subject only in a much lesser degree.

The technique for these dietary surveys is the same as for family or individual surveys. It will be described in Chapter V.

Chapter III

THIRD TYPE OF DIETARY SURVEY

Family Enquiries

This is the most frequent type of dietary survey.

The social unit which the term "family" is intended to cover comprises all the persons living under one roof and sharing the same budget, including paid personnel living in. It is when we reach this third type of survey that certain difficulties confront us for the first time in serious form.

These are in the first place psychological. The investigator—a stranger—has to live with the family under investigation, or at all events to visit it frequently and perform the thankless task of procuring and checking the information required. He may thereby seriously disturb the habits—especially the dietary habits—of the family, either because the housewife tries to conceal the real circumstances of her family or because, during the survey, the cooking is simplified in order to facilitate the work of enquiry.

The presence of the investigator, who, if he is doing his job, is necessarily inquisitive, may create an atmosphere of hostility which is prejudicial to the success of the enquiry.

A further type of difficulty lies in the heterogeneous character of the households included in the survey. This is due to various causes, and the differences may be so marked that the results of the survey would be very hard to interpret if all the families were taken together. The logical conclusion is therefore that they must be classified into groups.

Classification of Families into Homogeneous and Representative Groups.

This must not be confused with deliberate selection of families. On the contrary, the choice should, so far as possible, be left to chance, so that the statistical value of the survey, as more or less representative of the actual state of affairs, may be safeguarded.

If any deliberate intention is brought to bear in the choice of households, this can only be justified when it represents an attempt to exclude some source of error ; for instance, sickness in a family may call for a special invalid diet, and temporarily or permanently upset the family habits. Any selection that may be indicated thus finds its justification in the end in view.

Selection may also have to be resorted to when conditions of the survey so require. Thus, the investigator may have to take advantage of the fact that one particular family rather than another is willing to submit to investigation.

The factors responsible for the heterogeneous nature of the material under survey fall into two categories :

1. *Physiological factors.* — *i.e.*, differences of age, sex, size, race and state of health. — The influence of the last two can be eliminated by suitable selection. The heterogeneity due to the first three usually subsists, and family consumption coefficient scales are accordingly used to compare the results of enquiries concerning the diet of families of heterogeneous composition. It will be seen, however, in the chapter dealing with such scales, that their use is open to certain objections. In some cases, therefore, efforts are made to reduce to a minimum the heterogeneity of the material and thereby the drawbacks attaching to the use of coefficient scales. To this end, two procedures may be adopted.

The first is to group families of approximately the same type—*e.g.*, consisting of an adult man, an adult woman and two children between five and ten years of age—and to compare *inter se* the results of investigations concerned with families of the same group. It should be emphasised, however, that this procedure, and indeed any classification by homogeneous groups, is not usually practicable unless surveys are carried out on a *very* extensive scale comprising a large number of families.

The second alternative procedure is to try to eliminate the errors due to the use of scales of coefficients by conducting the investigation in such a way as to obtain—side by side with data concerning the food consumption of the family as a whole—details of the dietary habits of its various members. This supplementary enquiry may not always be as thorough as individual investigations proper; it will, however, furnish valuable supplementary data concerning the diet of each member of the households considered, data which can be used to check the purely theoretical findings obtained with scales of coefficients regarding the probable theoretical distribution of food between the different members of the family.

Enquiries of the second type may be planned with a view to studying the diet of adult males of a given stature, children of a given age, and so on.

2. *Social factors.* — From this point of view, families can be divided into homogeneous groups which facilitate comparison. Social factors may be subdivided into:

(a) *Geographical factors.* — A distinction should be made between surveys carried out in low-lying or hilly regions, in hot, cold or temperate climates, in coastal or inland regions, etc. Families should be classified according to whether they live in rural or urban districts, and, in the latter case, it may be desirable to distinguish between different degrees of urbanisation, according to the greater or lesser proximity of sources of supply or centres of production. The type of local production, or the fact of there being none, obviously plays a part in determining dietary habits.

(b) *Pecuniary factors.* — In some countries, families can be classified according to the amount of their means of livelihood and the size of the family budget; the division is roughly into rich, well-to-do and poor families, but the classification may profitably be carried further. It should be noted, however, that the influence of this factor varies in different parts of the world. In certain countries, however, it is difficult to assess the family budget; in such cases, classification according to the occupation of the bread-winner is often a satisfactory solution.

Lastly, classification according to race may also be of value— *e.g.*, the distinction between the white and coloured races in the United States.

Chapter IV

FOURTH TYPE OF DIETARY SURVEY

Exclusively Individual Enquiries

This last type of survey does not involve the collection of data concerning the diet of a family or other group of individuals considered as a whole, except where the subject of the enquiry is a highly homogeneous group (*e.g.*, boys of from 10 to 14 years of age), in which case it will generally come under the second type.

Otherwise, this fourth type of survey is strictly individual and is concerned with the diet of a series of persons considered each by himself. It is by far the most difficult kind of enquiry to carry out, especially if the investigator is to escape the errors which are apt to creep in owing to the fact that the investigation itself tends to modify the dietary habits of the individual concerned. The work involved is extremely elaborate. The purpose is, as a rule, to obtain purely physiological data. The procedure consists in weighing the foods actually consumed by the person concerned. For composite dishes, it is sometimes necessary to make a chemical analysis, or it may be sufficient simply to determine the quantities of constituent foods employed. Difficult and delicate manipulations are thus obviously required, imposing responsibility, not only on the investigator, who has to live with the person under observation—thus compelling the latter to endure the continual presence of a stranger—but on that person himself, who is required to collaborate throughout. For, no matter how ready he may be to assist, such a person is inevitably tempted to simplify his dietary habits as far as possible during this period, which should, of course, be reduced to a minimum. This fact, indeed, constitutes an added difficulty, as the temptation to simplify habits is the greater, the shorter the time the survey is to last.

To sum up. — The more elaborate the technique employed for the nutrition survey, the more likelihood there is of introducing this fundamental cause of error that the investigation tends to modify the dietary habits to be analysed.

Chapter V

METHODS OF MAKING SURVEYS

The expression *monographic method* is generally used to mean a method involving a detailed description of the circumstances and way of life of the persons or groups under investigation and of their dietary habits. Enquiries of the second, third and fourth types call for the monographic method ; for enquiries of the first type, it is obviously not appropriate.

From the physiological point of view, the purpose of nutrition surveys is not only to assess accurately what the body ingests but also to determine how far this is utilised ; in a word, the ratio of *useful* to *total* intake. The latter exceeds the former in a measure which is expressed by a coefficient of physiological utilisation. Viewed from this angle, the problem consists in measuring the resultant of two opposing forces—one a dietary factor pure and simple and the other a factor which may be termed medical, inasmuch as the capacity for utilisation is, roughly speaking, a physiological constant in the normal man. In practice, it is true, there is some fluctuation around a mean value, but when these fluctuations exceed certain limits, they indicate the presence of pathological factors. In Chapter X, we shall see that, in the present state of our knowledge, this aspect of the problem can only be treated satisfactorily in connection with the energy-producing principles of the diet ; whilst it can also be approached to some extent—though much less satisfactorily—in connection with some of the protective principles. So far as the latter are concerned, the usual practice is to take into account only the total amount supplied in the food, without considering what proportion is actually utilised.

It may be asked : Why complicate the problem of nutrition surveys by introducing this capacity for physiological utilisation ? Why not simply measure what is ingested ? But this complication is very necessary, because the result of a survey of consumption is of no interest to the physiologist and hygienist, unless it can be compared with a figure expressing the needs of the body. Is the intake sufficient to cover what is expended? And this comparison implies that consideration has been given to the utilisation of the ingesta. The distinctive feature of the physiological treatment of the problem resides in the fact that it involves the working-out of a balance-sheet showing, on one side, intake and, on the other, expenditure and waste due to incomplete utilisation. Only direct measurement of the values shown in this balance-sheet can be entirely satisfactory in point of accuracy to the analyst.

Two examples will suffice to illustrate the line of thought, for the same considerations apply to exchanges of all nutritive principles :

(1) *Energy exchanges.* — If samples of the foods constituting a person's meal are burnt and the heat of combustion is measured, then accurate measurement of the food consumed will afford a basis for calculating the utilisable energy. If we then collect the urine and fæces and measure the heat produced by their combustion, the amount of energy used by the body can be obtained by subtraction.

(2) *Intake of an inorganic element.* — If samples of the foods making up a person's meal are tested for their content of a given element, and the composition of the meal is then accurately measured, the intake of the element in question can be calculated. A like procedure being applied to the excreta, we should find that among children these elements, such as calcium and phosphorus, are retained for tissue- and bone-building purposes, whereas adults maintain a balance, expenditure being more or less offset day by day by the intake.

Speaking generally, this *direct* measurement of intake by chemical analysis of the foods consumed, though it is the only accurate method, is an experimental laboratory procedure; it is too long and difficult to be considered in social studies. For them, *indirect* methods alone are employed, recourse being had to tables of composition of foodstuffs instead of chemical analysis of the food. Their energy value and their content of inorganic elements and other constituents, as well as the proportion of waste, are calculated from tables giving the mean values of the composition. Naturally, the trustworthiness of the results obtained from such indirect calculations is dependent on the accuracy of such tables. These cannot be other than merely approximate, because they give average figures for values which, in reality, are constantly varying, and varying within different limits according to cases.

The indirect method is thus less accurate than the direct analytical method, but we must be content with it in these studies, since it is the only one which can be used in this type of investigation. Care should be taken, however, not to interpret the results too strictly.

* * *

Let us now consider what methods are used to collect the qualitative and quantitative data regarding the foodstuffs composing the diet of the persons under investigation. These methods may be divided into three categories : the weighing method, the household account-book method and the questionnaire method.

Weighing Method

This consists in making an inventory by weight of the foodstuffs found in the house at the beginning and at the end of the period of investigation, in weighing every kind of food which enters the kitchen or the household during this period, and in weighing daily all parts of these foods, whether edible or not, which the family has not consumed—that is, household refuse, food given to animals or thrown away, etc. An investigator draws up, with the help of the housewife, a list of the food on hand at the beginning and at the end of the investigation. This gives him an opportunity of instructing her in the technique of weighing and of checking with her the completeness of her accounts. He then pays a visit daily, or three to six times a week, during the period of investigation, to keep a check on the work, the frequency of these visits depending on his impression of her carefulness and intelligence.[1]

The investigating staff must provide housewives with the necessary material. This comprises :

(1) A balance, the accuracy of which must be constantly checked by the investigator. Its capacity should be from about 10 to 20 lb.[2] (or 5 to 10 kilogrammes) and its sensitiveness about $^1/_8$ to $^1/_4$ oz. (or 2 to 5 grammes). In order to avoid mistakes, or unnecessary trouble in striving after accuracy, it is preferable to provide spring-balances which indicate the weight directly on a scale, with a minimum graduation of about 1 oz. (or 20 grammes). But if an oscillating balance is used, the housewife must be shown how to use it correctly, and a suitable box of weights must be provided ranging from $^1/_4$ oz. (or 5 grammes) upwards to a total weight appropriate to the maximum capacity of the balance. It must be made clear that for weights below 2 lb. (or 1 kilogramme), the maximum accuracy of weighing is essential—that is, articles must be weighed to the nearest $^1/_4$ oz. (or 5 grammes)—but that with bigger weights a seemingly lesser exactitude will still give the same relative approximation, and that it will be sufficiently accurate to weigh 10 lb. (or 5 kilogrammes) to the nearest ounce (or 25 grammes) and 20 lb. (or 10 kilogrammes) to the nearest 2 oz. (or 50 grammes).[3]

(2) Tarred paper bags.

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[1] In certain countries it is held that, as a matter of principle, the work of weighing should be undertaken exclusively by the investigating staff and that nothing can be left to the housewife in this connection. It is for the director of the enquiry, however, and his staff to judge whether, and if so how far, the work can be entrusted to certain persons of the groups under enquiry. Each case must be judged on its merits and no general rule can be laid down.

[2] The English and metric weights and measures given here are not equivalents ; an attempt has merely been made to give, in the case of each system, a set of values which could be suitably adopted.

[3] A third type of balance is employed in the Scandinavian enquiries. It consists of a very practical device, in which the pan is hung from a beam mounted on an eccentric mechanism, the displacement of the beam showing the weight on a semi-circular scale. Another advantage of this device, apart from the fact that it is quick and easy to handle, is that, by modifying the mass of the beam, the weighing capacity of the scale can be extended to a very wide range of weights.

(3) A measure of 1 to 1½ pints graduated in quarters and eighths (or of from 600 to 800 c.c. capacity, graduated in divisions of 50 c.c.)

(4) A set of forms or account-books to fill up, specimens of which are shown in annexes at the end of this guide.

The inventory by weight of stocks on hand includes only directly accessible foodstuffs, but not the contents of unopened tins or bottles of preserves. These will appear in the housewife's daily accounts as and when they are used in the kitchen.

Foods bought per single article are also weighed and both figures entered in the accounts.

The accounts should show :

A. Whether the foodstuffs are bought, received gratis or produced at home (kitchen-garden, orchard, live-stock, etc.) ;

B. Whether boiled, fried, consumed raw, preserved, etc. ;

C. Gross weight as supplied, or volume if liquid, weight of inedible portion ; weight of edible portion before and after cooking ; and weight of edible waste ;

D. Miscellaneous information : whether the foods are washed or soaked and if so for how long. Method and duration of cooking. Whether the food is consumed raw. What is done with the cooking-water.

E. Number of meals taken per day, whether at home or outside. Number of hot meals taken per week per person.[1]

* * *

The reader will find annexed to this monograph a series of plates, giving specimens of forms, of record cards, or of pages of housewives' or investigators' books. These plates are intended merely to illustrate the text with a few actual specimens of documents used in published surveys or forms which have been officially

[1] It is also important for the investigator to state whether the cooking is done by the housewife herself or by a qualified or unqualified member of the household staff.

adopted in certain countries. They are not proposed as models to be followed, because the appropriate model must vary with the circumstances.

* * *

Investigations by the weighing method can be made with great accuracy and without difficulty if confined to a determination of the aggregate food consumption of families.

Great difficulties arise when the survey is extended to include the measurement of the individual consumption of each member of the family, or when the enquiry is strictly individual.

In such cases, an investigator must live with each family, for only in very exceptional circumstances can the work be entrusted to a member of the family under investigation. The investigator's work will consist primarily in carrying out, with the housewife's assistance, the work which she would be asked to do in a family survey pure and simple (see above), but he will also have to weigh the share of the foods consumed by each member. With simple foods, the operation is straightforward enough (bread, milk, sugar, raw fruit, etc.), but there are all the mixed foods and complex dishes in the making of which a variety of ingredients are used. The investigator will have the difficult task of ascertaining the quantities of the various components used in the preparation of each of these dishes, weighing the whole dish when prepared, weighing the amount consumed by each member of the family, measuring how much goes back to the kitchen, and calculating from these data the percentage of basic foodstuffs which each person receives. Nor is that the end of his work, for he must also keep account of the changes which the food which is left over subsequently undergoes, and of the preparation of warmed-up dishes with the further treatment and mixing which this entails. Lastly, he will have to assess the amount of such composite food which remains as leavings on the plates.

It is quite evident that a survey of this type may in some cases become extremely complicated; it all depends on food habits. In very poor households and in certain countries, the difficulties will be less great than in circles or countries in which the art of cooking is more highly developed. Where the latter are concerned, it would be wise not to entertain unduly high hopes as to the accuracy of the results, or to expect the very complex accountancy of estimated values to be carried through with precision. Simultaneous investigations covering the whole family and its individual members will probably prove a less hazardous venture in difficult cases than purely individual studies, because in the former the investigator can at least check his figures and make certain that no serious errors have entered into his many calculations.

* * *

The Method of Records of Purchases in Special Household Books

There is, in point of fact, more than one method of this kind, and several of them may give good results. In certain surveys, rather rare, it is true, full reliance has been placed in the intelligence, good faith and conscientiousness of the unsupervised housewife in the groups studied. Excellent results have been obtained by this method, but it is always open to criticism, even if the information acquired bears the impress of truth. The absence of any check always arouses distrust, and for this reason the assistance of investigators must be regarded as indispensable. This method demands both goodwill and active co-operation from the groups under investigation, and intelligence and tact from the investigators themselves, as does the weighing method. The investigator must take care, therefore, not to make his presence felt as that of an intruder upsetting the family life. The technique is to take an inventory by weight at the beginning and end of the period of investigation. During the period of enquiry, moreover, the housewife enters in a special account-book, in accordance with the instructions she has been given, a daily record of all food purchases and, generally, of all food products received. This procedure calls for careful supervision on the part of the investigators, who have to check the care with which the housewife does her part of the work. In many countries, this method is regarded as yielding reliable results. In others, the weighing method pure and simple is preferred ; the account-book method is applied only to studies concerned with the aggregate food consumption of families, and not to individual studies or to family surveys combined with individual studies within the family.

Investigators must have a talk with the persons submitting themselves to study. They must make the housewives realise the importance of accuracy in their information. They must show, by examples, that vague statements may completely falsify the results obtained, and that, accordingly, returns must be presented with the maximum of detail. By appealing to the pride of all co-operating in the study, by offering prizes for the best kept books, and especially by pointing out that, by skilful checking, the investigator can discover any signs of negligence, books can be obtained in which the entries have been made with a scrupulous regard for truth. Housewives are asked to note all available details regarding food obtained. A specimen page for each day is reproduced in an annex.

The investigator will take careful note of the following information (as with the weighing method) :

(1) Total number of meals per day, and proportion of hot meals per day or week ;

(2) General particulars of the composition of the various meals taken during the day ;

(3) Quality of the food, importance attached by the housewife to this question[1]—for instance, whether fresh or salt butter is used ; it is also important to ascertain how much butter is used for cooking ;

(4) How much preserved food is consumed ; what preserves are generally used ;

(5) Information about the attention given to the preparation of food ;

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[1] See footnote on page 33.

(6) What members of the family only come home for certain meals, and what meals they take outside ; whether the children receive any food at school ;

(7) Whether the family is in receipt of relief in kind, and if so, what relief ;

(8) Information about the feeding of infants ;

(9) Particulars of medicines taken, if any ;

(10) It is important to ascertain the quality and freshness of certain foodstuffs—vegetables, for instance—and how much is consumed raw ;

(11) Information about the use made of the water in which food is cooked ;

(12) General information about the special dietary habits of each member of the family, or at least some of them.

The officer in charge of the survey should analyse the household books with the help of the investigating staff. This will enable him to judge of the value of these books. It is usually necessary to reject from 30 % to 40 % for various reasons—careless work, failure of the housewife to complete the investigation, etc. This percentage of failures should not be regarded as excessively high. Obviously, this practical, because simple, method is suited only to civilised countries where society is so organised that it can be carried out and where the housewives asked to collaborate can be relied upon to understand and co-operate conscientiously.

Where such collaboration cannot be counted upon, the weighing method applied by investigators is the only feasible method.

* * *

Questionnaire Method

Surveys are sometimes made by means of questionnaires. This enables a certain amount of fragmentary and very rough information to be obtained as to the extent to which certain foodstuffs are consumed and as to certain dietary habits. It does not provide sufficiently full and accurate information for a coherent physiological study of a complete diet.

In some American studies of the general living conditions of a population so large that a full dietary investigation of all the households could not be made, a *preliminary* rough survey was carried out by the questionnaire method, and this provided a basis for the selection of suitable households in which to make fuller surveys (Schedule Method—Food Check Lists).[1] It must, however, be pointed out that such a selection is not without danger, since it may lead to unrepresentative information exclusively concerned with the diet of the type of family in which household management is conscientious and intelligent. The questionnaire of this preliminary investigation (schedule method) is designed to secure information as to the quantity and price of the foodstuffs consumed by the family during the week ending on the day the questionnaire was filled in. The information thus obtained consists of the nearest estimate the housewife can make, and it is clear that its value depends to a very great extent on the way in which she runs her household, on the care and conscientiousness with which she does her work and, in particular, upon whether she keeps accounts of her own accord or not. These printed questionnaires cover 164 types of food, divided into six categories, and there is a blank space for miscellaneous foods. In spite of the uncertainty of methods of this kind, the replies to such questionnaires nevertheless generally afford useful information of a preliminary character, and enable the fuller surveys which must necessarily follow to be pursued under favourable conditions.

These questionnaires also call for information about the origin of the food (purchased or produced at home) and the number and variety of hot or cold meals.

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[1] This method in this case does not involve merely the sending-out of questionnaires to be filled in by one of the persons of the groups under enquiry, but verbal questioning by an investigator who fills in the schedule himself.

Chapter VI

SCOPE OF SURVEYS

On general grounds, surveys should clearly cover as large a section of the population as possible. In the ordinary way, however, limits are set by the material resources available. In practice, the extension of a survey varies inversely with its elaborateness. Usually, the more thorough the programme of study, the smaller the number of people covered. When the methods adopted produce enough data to conform to strictly statistical requirements, they frequently yield only approximations and are hence not suited to the requirements of the physiologist. This applies, for example, to the questionnaire method. It should be added that even official bodies will often have difficulty in enlisting the support of the population on a sufficiently extensive scale for the mathematical properties of large numbers to be fully operative. It follows that surveys sufficiently elaborate to meet the needs of physiologists—and this involves the monographic method defined on page 29—frequently cover too small a population group to satisfy the full requirements of the statisticians. In practice, a compromise between these two claims is necessary. It may be desirable, too, for the purpose of interpreting certain results obtained by the monographic method, to make supplementary but less thorough surveys covering a large number of households; this has been done in certain American studies in which a preliminary and extensive rough survey (schedule method) was made before the more restricted monographic investigation.

In many other circumstances, exclusively monographic studies have been made including, in addition to a description of the family or community, the use of the weighing or household-book method—that is to say, full, but not very extensive, investigations. *In such cases, it is not possible to indicate in* *one single numerical term what the extension of the survey should always be.* Everything will depend on the point of view. The same documentary material may be of sufficient scope in some respects, but not in others. That will depend on how far whichever factor is concerned varies or remains constant. If an average value is to have any significance, it must satisfy certain mathematical conditions. These alone can afford a test as to whether or not the observations have covered a sufficiently large field for the averages to reflect the true facts of the matters under investigation, or indeed, to have any significance of any sort. This question will be dealt with in Chapter XII.

Perhaps the following general statement may be made, with all the reservations which are called for by the foregoing considerations: In many circumstances, a thorough monographic family survey, covering only the *total* food consumption of the household and involving no investigations of individual cases, will begin to be sufficiently extensive for some purposes, though not for all, when it covers at least thirty to fifty families chosen at random in a particular class of the population. It should, however, be emphasised once more that this is but a very rough indication ; its validity will depend on circumstances. In any case, the investigation should always be made to cover as wide a field as possible, for its value will always increase commensurately with its extension.

There is, however, this further consideration to be borne in mind—that the standards which apply will vary according to the object at which the enquiry is aimed. For some purposes, accurate information about a hundred subjects may be more valuable to the hygienist than similar but approximate information about a thousand ; whilst, at the same time, the former may be of less statistical significance than the latter.

It should also be noted that family *and* individual studies, such as those made by Professor Pelc in Czechoslovakia, dealing with *one household* at a time for *a whole year* without a break, provide most valuable information, in spite of their limited extension. Generally speaking, the field covered by a survey varies inversely with its thoroughness or with its length, which, incidentally, is itself one of the ingredients of thoroughness.

In conclusion, no effort, however modest, should be discouraged in nutrition surveys. This in no way invalidates the recommendation that they should be made as extensive as possible. *The significance of the results of limited surveys is dependent upon the requirements of statistical calculation.*

The help of official or professional bodies may be enlisted in inducing families to collaborate. Relief associations, members of the teaching profession, study circles, trade unions and certain political bodies have given particularly valuable help in all the surveys made in a number of countries on varying subjects of social importance. The director of the survey should see that the object of the work is clearly understood by all his helpers. He should always lay special stress on the essentially scientific character of the investigation. He should point out the danger of our present state of ignorance of particular social or economic questions. He should describe the benefits derived from earlier surveys. In some countries, there are official bodies whose business it is to make such studies regularly—for example, the Bureau of Home Economics of the Department of Agriculture and the Bureau of Labor Statistics of the Department of Labor in the United States of America.

Chapter VII

DURATION OF SURVEYS

The general rule should be always to make the duration of surveys as long as possible. This policy is warranted by the fact that, in practice, circumstances always tend to render it too short. The facilities available are usually inadequate in relation to desiderata. But there are lower limits below which it is impossible to go if the results obtained are to have any value at all. The following periods, in decreasing order, may be taken as a guide.

Family and individual surveys covering one or two households at a time have been pursued uninterruptedly for a whole year (*e.g.*, the investigations by Pelc in Czechoslovakia). For elaborate surveys by *records of purchases in special household books*, a period of *one month* is recommended.

For a thorough enquiry by the *weighing* method or rough investigations by questionnaire (the American "schedule method"), *one week* is usually allowed. Some *individual investigations by the weighing method* have been carried out for periods of *two or three days*.

Lastly, it is generally advocated that one-week surveys should be repeated three or four times a year to show the effect of seasonal fluctuations. These are, however, not equally important in all countries.[1]

The factors to be considered in deciding the appropriate length of time for a nutrition survey can be divided into two categories : those which render it undesirable that the period should be too long and those which require that it should not be too short.

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[1] In certain enquiries which are repeated on several occasions during the year in order to trace the influence of seasonal fluctuations, the subsequent observation periods are shorter than the first. Thus, if the first period lasts ten days, the remaining two periods, in two other seasons of the year, are only of five days' duration each.

The factors under the first heading are pecuniary and psychological. The former call for no comment. The latter arise out of the fact that the investigation lays a considerable extra burden on the housewife, who will be disposed to undertake it only if her good-will is not unduly taxed. Thus whether a period is excessive or not depends both on the method adopted and on the conditions in which the investigation is carried out. [1] Generally speaking, the weighing method cannot be applied for as long a period as the household-book method ; and, in this particular respect, the latter may be held to be preferable to it. The weighing method is, however, regarded as permitting of greater accuracy in the day-to-day recording. Again, the constant presence or repeated visits of investigators often become tiresome if continued too long.

The reasons why the survey should not be too short are of three kinds—psychological, circumstantial and physiological.

Psychological. — The shorter the survey, the greater the source of error arising from the temporary simplification of food habits introduced by the housewife to facilitate the work involved by the survey. The more complicated the method adopted, the more pronounced is the effect of this source of error ; the weighing method is hence unquestionably more liable to be affected than any other. The shorter the survey, the more the housewife will be tempted to act in disregard of the established food habits of the family.

Circumstantial. — Temporary sickness or absence of a member of the family, or some commercial factor such as an exceptional shortage or abundance of some food, are among the causes of error whose relative importance increases as the length of the survey diminishes.

Physiological. — The important principle involved here is fundamental to all those methods of dietary survey which we have termed *indirect.* It was shown on page 30 that the only really direct method of estimating the intake of food and

[1] In exceptional cases, a family may be found one of whose members has leisure and intelligent interest enough to be willing to undertake the necessary work himself for a long period.

food constituents—*i.e.*, the various nutritive principles—is that of chemical analysis of samples of the foodstuffs and dishes eaten ; that this direct method cannot, in practice, be applied to social investigations ; and that, for these, the method adopted must be the indirect one, in which chemical analysis is replaced by calculation of the intake of nutritive principles from food composition tables. Now these tables give *average* figures for values which vary continually from sample to sample of any given food. Such variations may be more marked in some cases and less so in others, but they are absent in none. If, therefore, the average figures given by the tables are to be really valid, the majority of the foodstuffs under examination in any given survey must have been purchased on several occasions by the housewife. The greater the number of such occasions, the more will the use of this average composition figure be justified, because the more closely will it approximate to the actual value. If, on the other hand, a particular foodstuff is purchased only once, its composition on the day on which it happened to be bought may have differed substantially from the tabulated values.

If energy-producing foodstuffs are taken as an example, the research of Munk and Slosse[1] shows that, in a one-week survey, in which chemical analysis and indirect calculation from tables were simultaneously employed for purposes of comparison, the energy values yielded by the two methods never differed by less than 10 % or 20 %.

Average food composition tables should accordingly be used only where these averages really apply—that is, where the survey lasted sufficiently long for frequent purchases to be made of all the foods concerned.

In certain circumstances, even surveys lasting a full month are insufficient to determine the true average facts of the position. Some persons do not exactly balance each day's energy expenditure by that day's food intake, but eat more than enough for certain periods and less than enough for others.

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[1] See A. Slosse and E. Waxweiler, *Enquête sur le régime alimentaire de 1,065 ouvriers belges :* Publications of the Institut de Sociologie Solvay, published by Misch and Thron, 1910, No. 9, page 109.

Thus an agricultural worker will accumulate reserves during the winter and draw upon them in the summer, notwithstanding that he may be eating large quantities of food during the period of heavy exertion.

* * *

In short, the absolute minimum period of investigation should be taken as one week. Wherever possible, this period should be exceeded. When the weighing method is used, however, practical considerations make any extension of this period difficult.[1] *With the household-book method, it is advisable to extend the period of investigation to about a month.*

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[1] When one-week enquiries are conducted in large numbers among homogeneous families, and when only group averages, as distinct from the values for individual families, are considered, the extension of the enquiry may to some extent correct the inadequacies due to barely sufficient duration in time.

Chapter VIII

THE INVESTIGATING STAFF

A dietary survey should be carried out by a body of investigators working on the spot under the control of a responsible director who can organise and check the work and examine and classify the data collected by his staff. When the survey is an extensive one, a more elaborate staff organisation can be arranged according to circumstances. So far as the present monograph is concerned, interest centres in the staff directly responsible for the work on the spot, who have to associate with the persons under investigation.

Qualifications of Investigators

It is absolutely essential that the investigating staff shall consist of intelligent, conscientious, pleasant and extremely tactful persons—that is, persons endowed with qualities of character likely to win the confidence of the groups under investigation. The investigator's task, be it repeated, is both delicate and thankless. He may easily come to be regarded as a troublesome intruder in a family, if he is felt to be indiscreet. He must be observant and hence capable of learning much without having to ask questions. A degree is not in the least essential. It is not, of course, a handicap, but what matters is ability to inspire confidence and the qualities of character already emphasised. Experienced woman social welfare workers are often well suited to this work when they possess these qualifications; but there are many others, especially women, well enough fitted for it, whose educational attainments are limited to ordinary secondary-school training. The investigator must, of course, understand the purpose of the survey and be interested in this type of research; it is particularly necessary that he should be prepared for it by a probationary period with trained investigators under the orders of the director. He should, of course, have some grounding in the physiology of nutrition, but this can be provided by the survey staff. When the weighing method is employed, he must understand something of the technique of weighing. He must be able to explain normal weighing procedure to housewives and appreciate the errors to which such operations are liable, and must be alive to the possibility of energy being wasted when over-conscientiousness goes hand in hand with an imperfect understanding of weighing procedure. In other words, investigators must appreciate what is meant, in gravimetric analysis, by absolute and relative weighing errors.

Number of Investigators

With the household-book method, one investigator must be provided for every ten to twelve families. Entries into the books must be constantly checked. Housewives must be made to understand that investigators keep an efficient check and cross-check on their entries. This frequently necessitates long talks and repeated visits, of which several will inevitably be fruitless when the housewife is out shopping, working or visiting. From time to time, the investigator must watch the preparation of the food, and attend meals.

When a family survey is conducted by the weighing method only and is concerned exclusively with the aggregate food consumption of the household, and when the investigators are not themselves required to take part in weighing operations except to demonstrate the technique, approximately the same number must be provided. If, however, they have also to assist in weighing, then their number must be increased.

For individual or family-plus-individual studies, one investigator per family must normally be provided. He will live almost permanently in the household, and must be equipped with considerable chemical and physiological knowledge of nutrition problems. But in a study by the weighing method of individuals forming a homogeneous group and boarding together—as in a school, for instance—one investigator can undertake the necessary weighing operations for eight to ten subjects at a time. It would be well to provide investigators with printed or multigraphed instruction-sheets as a memorandum of the essential factors to be taken into account when compiling their data.

The work of the investigators themselves should be checked in turn by the director of the survey, who may either call for a written report or accompany them on some of their visits or question them from time to time after examining the household-books and returns.

Finally, the returns must be analysed with the director himself. This will serve as a final check and enable him to assess the value of the work done in each household.

This work of analysis consists in drawing up a detailed schedule of the consumption of each basic foodstuff throughout the period of investigation, accompanied by a statement of such supplementary particulars as may be required.

Most of the recommendations already made as to the number of investigators required are applicable to both family and individual studies. So far as investigations of the second type are concerned, something has already been said with reference to a particular case. It is obviously impossible to suggest a single standard for the staffing of surveys of the second type, since these differ so much among themselves. The director of the survey will have to decide each case according to its merits.

For investigations in countries which are not fully civilised or otherwise present conditions not comparable to those of Western civilisation, and in which the same reliance cannot be placed on the intelligent co-operation of the persons under enquiry, weighing carried out by the investigators themselves is the only feasible method. One investigator must therefore be provided for each family, or for a small group of two to six families at the most, at any rate at the beginning of the survey ; and this applies even when the survey is of the family type, pure and simple, without any additional individual study. According to AYKROYD's investigations in India, six families per investigator represent the absolute maximum. Finally, those in charge of the survey will have to decide to what extent the work can be entrusted wholly or partly—and under close periodical supervision—to the groups of persons who are being surveyed.

Chapter IX

LIST AND CLASSIFICATION OF FOODSTUFFS

Method of noting Recorded Quantities

There can be no question of providing a single complete list of foodstuffs valid for all countries. Such a list would be of no practical use, considering the great differences in the foods consumed in each. At most, a standardised classification of foodstuffs can be contemplated. This, however, would be of substantial practical value, inasmuch as it would facilitate the comparison of different investigations.

In 1936, the International Labour Office proposed a very simple list (*Studies and Reports*, Series B, No. 23 : " Workers' Nutrition and Social Policy ", Appendix IV, page 195 : Part A : " Classification of Foodstuffs into Main Groups adopted by the International Labour Office for International Comparisons of Food Consumption ").

This method of classification has been adopted here. A few changes have, however, been effected, in order to make it acceptable to all countries, for the International Labour Office list had been planned more especially for dietary surveys among the workers in countries of Western civilisation.

Method of Classification of Foodstuffs designed to facilitate International Comparison

I. Cereals.[1]

1. *Bread* (specify kind of cereal, degree of milling, whether prepared with water or milk, percentage of yeast or soda, etc.).
2. *Cakes, biscuits, pastries.*
3. *Flour.*
4. *Other cereals and starchy grains* (including colonial varieties, when necessary, such as millet, tapioca, etc.).

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[1] With regard to the principal ways of consuming cereals, the various countries of the world may be divided into three categories—namely, those consuming bread, girdle-cakes (galettes) and boiled cereals respectively.

In countries of advanced civilisation, bread is the basic carbohydrate food. For this reason, the cereals consumed in that form are grouped under a separate heading at the head of the list. In countries where no bread is made, girdle-cakes or boiled cereals should constitute the main item under heading I instead of bread.

II. Animal Tissues.

1. *Fresh meat* (specify whether lean or fat, whether weighed without bone, etc.) :
   Beef, veal, mutton, horse, etc. ;
   Pork, ham, bacon, etc.
2. *Fresh fish* (specify whether whole, cleaned, whether weighed with bone or not, etc.) :
   Haddock, turbot, whiting, salmon, cod, etc.
3. *Other meat and fish products :*
   Salted, smoked, canned or dried meat and fish ;
   Sausages, charcuteries, etc.
4. *Poultry.*
5. *Game* (ground or winged).
6. *Reptiles and amphibians* (frogs, etc.).
7. *Glandular organs, brains, etc.* (liver, kidney, sweetbread, etc.).
8. *Invertebrates* (specify kind, method of preparing, indicate if weight is given unshelled or not, etc.) :
   Molluscs, crustaceans, insects, larvæ, worms, slugs, etc.).
9. *Eggs* (specify kind).

III. Fats.

1. *Animal fat* (lard, suet, fish and liver oils, etc.).
2. *Margarine* (specify roughly if prepared from animal foodstuffs in addition to vegetable foodstuffs ; state also whether it contains vitamins and, if so, how much).
3. *Vegetable oils and fats* (palm-oil, olive-oil, sesame-oil, cocoa butter, etc.).

IV. Milk Products (specify from which animal).

1. *Whole milk* (specify average fat content).
2. *Skim-milk.*
3. *Condensed milk* (specify composition).
4. *Dried milk* (specify fat content).
5. *Buttermilk or whey.*
6. *Cream* (specify percentage of fat).
7. *Cheese* (specify the kinds or specify percentage of fat).
8. *Butter* (fresh or salt), *ghee* (clarified butter), etc.

V. Vegetables and Fruits.

1. *Dried peas, beans, lentils*, etc.
2. *Potatoes.*
3. *Other root vegetables* (carrots, turnips, various tubers, manioc or cassava, etc.).
4. *Fresh vegetables :*
   Green leafy vegetables ;
   Other fresh vegetables.

5. *Fresh fruits.*
6. *Preserved vegetables and fruits and fruit juices.*
7. *Nuts*, etc. (specify shelled or unshelled, etc.).

VI. Sugar, etc.

1. *Sugars* (specify kind).
2. *Syrups.*
3. *Honey* (specify kind).
4. *Jams and marmalades.*
5. *Sweets.*

VII. Beverages.

1. *Coffee, tea, malt, chicory, maté,* etc.
2. *Cocoa.*
3. *Fermented beverages* (specify : wine, beer, cider, etc.).
4. *Distilled alcoholic beverages.*
5. *Unfermented fruit beverages* (to be listed here if sold ready for consumption without dilution, otherwise to be listed under V.6 or VI.2).

VIII. Condiments.

1. *Salt* (specify kind).
2. *Various vegetable condiments* (pepper, paprika, mustard, vinegar, etc.).

IX. Miscellaneous Commercial Preparations with Mixed Contents.

Tinned soups, tinned stews, etc.

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As for the manner in which entries should be made under the several headings, most items will obviously be given in terms of weight or volume. Care should be taken, however, to specify whether the entry refers to the food in the raw condition as purchased, or to the edible portion only. In the latter case, the fullest possible particulars should be given as to the manipulations which the weighed food has undergone in process of preparation (meat with or without bone ; fish cleaned or not, weighed with or without the head, with or without the skin, etc. ; potatoes peeled or not ; peas shelled or not ; peanuts with or without the shell, fresh or dried or roasted, etc.).

Entries concerning articles that are sold as separate units —*e.g.*, eggs—should indicate the number. In the case of fruit, it is well to specify the average weight of the individual fruit or the usual number per unit of weight, such as the kilogramme. If the unit of sale is a special one, such as a bundle in the case of vegetables, it is essential to give the average weight of that unit.

In many cases, moreover, it is absolutely necessary to specify whether the material is weighed in the raw state or cooked. Finally, in some countries, it may be customary to subject a foodstuff to some special treatment. It is important to give the fullest particulars in this connection.

Chapter X

PHYSIOLOGICAL ANALYSIS OF THE DATA OBTAINED FROM DIETARY SURVEYS : FACTORS TO BE CONSIDERED IN THE STUDY OF THE PHYSIOLOGICAL VALUE OF THE DIET

The figures obtained from dietary surveys show the quantities of *foodstuffs* consumed. The physiological analysis of the data consists in converting these results into terms of the corresponding quantities of *nutritive principles.*

This having been done, the data must then be presented in a suitable form for interpretation—*i.e.*, in the form which is most suitable for determining whether bodily requirements in respect of these principles have been met and whether their relative proportions in the diet are satisfactory.

In the case of purely family surveys dealing only with the foods consumed by the family as a whole—the large majority of surveys are of this type—the data obtained have to be reduced to a unit of comparison of such a kind that they may be compared with data relating to other families or social groups. Such a unit corresponds to one of the types of individual composing the groups, such as the adult man of average stature. Scales of family consumption coefficients are used for the purpose. These scales will need to be studied in relation to the various nutritive principles, and their value and utility assessed. The following questions therefore require attention :

What are the varieties of nutritive principles to be considered and what are the units in which the quantities should be expressed ?

How are they distributed in the various foodstuffs ? This question links up with that of household waste and physiological waste of foodstuffs and that of the customary presentation of food composition tables.

How are the gross and useful (net) energy values of foodstuffs to be calculated ?

What is the present position in regard to the problem of scales of family consumption coefficients ?

It is impossible to go into the question of defining the proper diet of the normal man in various circumstances, but a guide for persons carrying out dietary surveys should indicate what data must be obtained to enable the physiologist who analyses the results at least to determine whether the diet is adequate or not.

1. General Classification of Essential Nutritive Principles in the Diet

Up to the end of the last century, attention was paid almost exclusively to *energy-bearing* principles—*i.e.*, those which, by oxidation in the organism, produce the energy, expressed in calories, which is required to cover energy expenditure.

Since the beginning of the present century, there has been an increase in our knowledge with respect to other properties of foods.

It has been found by experiment that animals fed exclusively on a mixture of purely energy-bearing principles ultimately decline in health and contract various diseases; whilst, in young animals, growth is arrested. If small quantities of certain natural foodstuffs containing principles other than energy-bearing are added to such an incomplete diet, the morbid symptoms can be cured if they have already appeared, or prevented if the diet is thus supplemented before their appearance.

In respect of the " protective " action exerted relatively to the quantity administered, the natural foodstuffs are not all of equal value. McCollum therefore proposed that the term " protective " foods should be applied only to those which have this property in a marked degree. Milk, eggs, green vegetables and certain fruits are included in this category for different reasons, some of them affording protection against certain morbid symptoms and some against others. Other foodstuffs have less protective qualities, or none at all—as, for instance, sugar, which is a purely energy-bearing food. In reality, all principles which do not serve as sources of energy, either because their calorie value is low or practically nil, or because the quantities in which they are consumed are small compared with the large intake of the main energy-bearing foods—in other words, all those principles which confer "protective" properties on the foods containing them—may thus be termed *protective principles.*[1] They are of value in the diet, not for the generation of heat, but as essential agents in promoting the normal development of young growing organisms and for the maintenance of a satisfactory state of health. Such principles are indispensable, even if the organism is otherwise assured of an adequate energy supply. For instance, iodine is necessary to prevent goitre. Calcium, phosphorus and vitamin D are at least three principles which are essential in any case for the prevention of rickets ; vitamin C prevents scurvy, etc.

The protective principles consist of certain amino acids, minerals and vitamins.[2] They are supplied in the diet in very small quantities as compared with the *energy-bearing principles*, which are present in the food in great abundance. The latter comprise the *carbohydrates* (or glucides), the *fats* (simple, and lipoids) and all *proteins* regardless of whether these do or do not contain the few special aminoacids which confer protective properties.

2. Food Waste

A distinction should be made between two categories of waste : *household waste* and *physiological waste.* The former includes everything which escapes consumption ; the latter

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[1] The term "protective" is not equally favoured by physiologists of all countries. There is, however, no other really preferable expression. One thing is clear, its meaning, though conventional, is simple, rational and clear.

[2] Proteins and inorganic chemical elements are sometimes called the *body-building* materials of food. It may be that yet other principles, such, for instance, as certain fatty acids, should also be included in the group of protective principles. The three categories enumerated here are to be regarded merely as those which are best known and as the only ones that can be taken into account in enquiries at the present time.

consists of substances eliminated by the organism as the result of imperfect utilisation on its part. Unlike the first category, therefore, the second relates to substances which have been consumed.

Household waste.

This is subdivided into two groups :

(1) *Inedible household waste,* or refuse, sometimes called "*déchets de cuisine*" by French writers.—This type of waste includes bones, potato peelings and orange peel. In countries of Western civilisation, where potatoes form an important part of the diet, the total inedible waste represents on the average 10 % to 11 % of the gross weight of the total foodstuffs (as purchased) in an average mixed diet. In practice, the percentage figure may vary from 7 % to 14 %. It tends to rise above the average when there is a larger proportion (by weight) of potato in the diet than of bread, and to fall below the average when the contrary is the case (BIGWOOD and ROOST). If each foodstuff is considered separately, the amount of waste varies with the condition of the food and the housekeeper's care for economy.

(2) *Edible household waste,* sometimes called "waste" or, by French writers, "*déchets d'assiette*" or "*déchets de table*".—The distinction between the two categories of household waste depends solely on whether it is edible or not. The expressions "*déchets de cuisine*" ("kitchen waste"), "*déchets de table*" ("table waste") and "*déchets d'assiette*" ("plate waste") are ambiguous and should not be taken too literally. "Kitchen waste" in the literal sense of the term includes both edible and inedible waste (for instance, both potato peelings and the food which adheres to kitchen utensils). In the same way, "table waste" and "plate waste" also include waste of both categories (orange peel ; cherry stones ; and the food which adheres to plates and to spoons, knives and forks).

Edibility is the sole criterion for making a clear distinction between the two categories of household waste.

Inedible household waste is expressed as a percentage of the gross weight of each foodstuff, as purchased, whereas edible household waste is expressed as a percentage of the total *weight* or *calories* of the *diet*. Generally speaking, little is known regarding the amount of edible waste. There is no doubt that it varies considerably, and one of the factors of variability is the social circumstances of the families, or the nature of the group under consideration. More data should be obtained regarding the amount of such waste. Here are some figures which may serve as a guide: In poor homes, the amount of edible waste is estimated at from 1.5 % to 2 % of the total food consumption. According to F. G. Benedict, the figure rises to 10 % of the calories in the kitchens and refectories of students' fraternity houses (*Bulletin* No. 261, November, 1931, University of New Hampshire, Durham, N.H., U.S.A.). In middle or high class homes, the figure varies greatly; it may be quite low or it may exceed 10 %. There is very little information available on the subject. That may perhaps partially explain why the average intake of energy-bearing foods in certain middle-class families appears to be particularly high.

Physiological waste.

The term "physiological waste" denotes urinary and intestinal waste; but the connotation of this term is in reality complex, and is not always easy to define. For instance, intestinal waste does not by any means consist solely of substances which have not been absorbed through the intestine and may hence be regarded as never having really penetrated into the organism. Part of the intestinal waste consists of substances secreted by the wall of the intestine—substances, that is to say, which had previously passed into the organism itself and not merely into the digestive tube (the *lumen* of which can be regarded as external to the organism). Nothing has really penetrated into the organism until it has passed through the wall of the digestive tract.

The term "physiological waste" has a precise meaning in two cases only: first, when it refers to substances which have not been absorbed through the intestine ; secondly, when there is faulty, and therefore incomplete, combustion of the energy-bearing elements *in vivo*, resulting in the elimination of only partially oxidised substances which, had they been completely oxidised, would have provided the organism with extra calories. This question will be dealt with again later in connection with the problem of the calculation of the *net* energy-value of diet.

3. Food Composition Tables

Food composition tables sometimes show the composition of foodstuffs in the raw state, as purchased,[1] the average percentage of inedible waste from such foodstuffs, and the quantities of nutritive principles contained in the edible portion of 100 grammes of the raw foodstuff. Thus, if a table shows, for instance, that a foodstuff contains 15% of inedible waste and 20% of carbohydrates, that means that 20 grammes of carbohydrates are contained in 85 grammes of the edible portion of the foodstuff.

Sometimes, however, the tables show the composition in percentages of the edible portion alone. The distinction is a fundamental one, which should be constantly borne in mind in order to avoid mistakes.

In many cases, the composition of the foodstuffs is variable, and the tables give the *average value*. When the variation in composition is very great, the extreme values are given in preference to a mean figure. The investigator will have to judge what figure he considers suitable for the purpose of his calculations. He will, for instance, allow for the season if the variation is attributable to this. The essential point is that he should indicate his choice in his publication.[2]

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[1] The chemical composition of a food as bought varies from country to country, not only for geographical and agricultural reasons, but also for industrial reasons. Thus the cuts of meat supplied by the slaughter-houses may vary in composition for technical reasons connected with slaughter-house practice.

[2] When the tables indicate a possible range of variation in composition—specifying, for instance, that a given food may contain from 10% to 24% of some particular nutrient principle—it is essential that the arithmetic mean of the individual values falling within that range should also be given. This is not usually done and it is regrettable, for this true mean may differ markedly from the mean of the two extreme values. To take the example given above, the true mean of values which ranged from 10% to 24% might be 14% (whereas the mean of the two extreme values is 17%) ; if this were so, it would show that the lower values within the specified range are more frequent than the higher.

Discrepancies as between the values given in two different tables for one and the same foodstuff may reflect an apparent, rather than a real, difference, the number of analyses on which the average figure is based having been different in the two cases. The more reliable figure will, of course, be that based on the largest number of individual findings.

The important thing—be it said once again—is that the investigator should inform his readers of his sources and method of calculation.

Composition also varies according to cooking—a very important consideration in certain cases. The variation is sometimes caused either by the destruction of a given principle or, on the contrary, by the liberation of an extra amount of the principle (*e.g.*, vitamin C in potatoes), a process which produces an apparent increase, through cooking, of the vitamin concentration. Sometimes, again, it is due to an alteration in the volume of the food as a result of cooking. The latter causes the percentage composition of the cooked product to differ from that of the raw substance. The use made of the cooking-water is another factor.

Accurate and complete composition tables showing seasonal and regional fluctuations are very rare. Existing tables vary greatly in value. The information available is much fuller in regard to the energy-bearing principles than in regard to the protective principles. Data concerning vitamins, in particular, are still very incomplete and inaccurate.

A list of older and more recent tables of food composition relating to certain foods only is given below : [1]

In German:

1. "Chemie der menschlichen Nahrungs- und Genussmittel", by J. König (Springer, Berlin).

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[1] In principle, the tables which afford the best guarantee of accuracy are those which specify, not only the methods of determination, but also the number of analyses which have been performed in order to arrive at a mean value for each item. It should be borne in mind, however, that this remark applies more especially to original tables—for some simplified tables have been published which omit information of this kind, in order that they may be more handy for the investigators by whom they are to be used. It would be desirable that some selection and standardisation of these tables should be undertaken on international lines as well as a compilation of the analyses carried out in all countries, by up-to-date methods and at different times of the year.

2. " Handbuch der Lebensmittelchemie ", by JUCKENACK, BAMES, BLEYER and GROSSFELD (Springer, Berlin, 1933-1938).

3. " Shall-Heisler Nahrungsmitteltabelle ", Eighth Edition, revised by Dr. Hermann SHALL (Leipzig : Verlag von Curt Kabitzsch, 1927).

4. BERG, R. : " Die Nahrungs und Genussmittel " (Dresden, 1929).

In English :

1. " Chemistry of Food and Nutrition ", by SHERMAN (Macmillan Co., New York, 1937).

2. Tables of ATWATER and BRYANT (" Chemical Composition of American Food Materials ") (U.S. Dept. of Agriculture (Off. Exp. Stat.), *Bull.* 28, 1906). A new edition is being prepared.

3. " Tables of Vitamin Content of Human and Animal Foods ", by M. A. BOAS FIXSEN and M. H. ROSCOE. *Nutrition Abstracts and Reviews*, 1937/38, 7, 823-867.

4. " A Laboratory Handbook for Dietetics ", by M. SWARZ ROSE (Macmillan Co., New York, 1937).

5. " Applied Dietetics ", by F. STERN (Williams and Wilkins Co., Baltimore, 1936).

6. " Vitamin Content of Foods ", by E. PETTERSON DANIEL and H. E. MUNSELL (U.S. Dept. of Agriculture). Miscellaneous Publication No. 275, June 1937, Washington, D.C.

7. " The Carbohydrate Content of Foods ", by R. A. MCCANCE and R. D. LAWRENCE (Medical Research Council, London: Special Report Series No. 135, H.M. Stationery Office, 1929).

8. " The Chemistry of Flesh Foods and their Losses on Cooking ", by R. A. MCCANCE and H. L. SHIPP (Med. Res. Council, London : Special Report Series No. 187, H.M. Stationery Office, 1933).

9. " Food and Nutrition of African Nations " (International Institute of African Languages and Cultures, Mill Bank House, 3, Wood Street, London, S.W.1. : Oxford University Press, 1937. Memorandum XIII).

10. " The Nutritive Value of Fruits, Vegetables and Nuts ", by R. A. MCCANCE, WIDDOWSON and SHACKELTON (Med. Res. Council, London : Special Report Series No. 213, 1936).

11. " Analysis of Foodstuffs ", by R. H. A. PLIMMER (H.M. Stationery Office, London, 1919). New edition in the press.

12. "Table of Composition of Foods" (*Bull.* No. 10, Imperial Bureau of Animal Nutrition). May 1938.

13. "Proximate Composition of Fresh Fruits", CHATFIELD and McLAUGHLIN (Oct. 1931. *Circular* No. 50, U.S. Dept. of Agriculture).

14. "Proximate Composition of Fresh Vegetables", CHATFIELD and ADAMS (Jan. 1931. *Circular* No. 146, U.S. Dept. of Agriculture).

15. "Iron Content of Vegetables and Fruits", STIEBELING. (Feb. 1932. *Circular* No. 205. U.S. Dept. of Agriculture).

16. "Tables of Food Content : First Report" (Advisory Council on Nutrition. Commonwealth of Australia, 1938, p. 29).

17. *Health Bulletin* No. 23 : "The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets" (Government of India Publications, 1937).

18. "Shanghai Foods", B. E. READ, L. W. YUNG and C. J. KUANG (Published by the Chinese Medical Association, 1937).

19. Further Report on Nutrition in Ceylon : Part I. — "Biological Assays and Chemical Assays"; Part II. — "A Survey of the Diets of Ceylon", L. NICHOLLS (Ceylon Govt. Press, Colombo, 1937).

20. "Chemical Analysis of Malayan Foods", J. L. ROSEDALE (Govt. Printing Press, Singapore, 1935).

21. "Food Values", A. J. HERMANO (Bureau of Printing, Manila, Philippines, 1932).

22. "The Chemical Analysis of Food in Japan." Report of the Imperial Government Institute for Nutrition. Vol. III. No. 1, 1931. There are a number of other similar publications from the same institute. A complete list could be obtained from Professor Saiki.

23. "The Food of Japan", E. Ch. GREY (League of Nations, document C.H. 681, 1928).

In French :

1. Les tables d'ALQUIER pour la France.

2. "Les données et les inconnues du problème alimentaire" by L. RANDOIN and SIMONNET (Presses universitaires de France, Paris).

3. Comparative tables between values in different countries are given in : "L'alimentation rationnelle et les besoins énergétiques d'une population ouvrière", by E. J. BIGWOOD and G. ROOST (Institut de Sociologie Solvay, Université de Bruxelles, 1934).

4. Finally, in the case of the Congo, particulars will be found in " Problèmes de l'Alimentation au Congo belge ", by E. J. Bigwood and C. Trolli : Second International Congress of the Société scientifique d'hygiène alimentaire, Paris, October 1937 (see " Science de l'Alimentation en 1937 " : Imprimerie Alençonnaise, Alençon, France).
5. " Vues actuelles sur le problème de l'alimentation avec *tables de composition des aliments* ", by L. Randoin. *Collection des actualités scientifiques et industrielles*, No. 579, Herman & Cie. Paris, 1937.

In Danish :

" Handbog i Diaetetik ", by A. Faber and A. Norgaard. Published by Levin and Munksgaard, Copenhagen, 1934.

In Dutch :

" Voedingstabellen ", Donath, Koolhaas and Van Veen, (*Geneeskundig Tijdschrift voor Nederlandsch Indië*, 1935, 5, 75).

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Certain valuable data are also contained in the reports of the Technical Commission on Nutrition, *Bulletin of the Health Organisation, 1936-1937.*

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4. The Energy-bearing Principles

The substances concerned are proteins, fats, carbohydrates and, subsidiarily, certain other substances.

Proteins. — The proteins contained in the edible part of foodstuffs are usually estimated on the basis of their nitrogen content. [1] This method of estimation is generally satisfactory, but in certain cases it is much less so. For instance, in the case of the dried meat often eaten by natives in the colonies in a state of partial decomposition, the method is entirely misleading.

[1] Proteins consist principally of amino acids. Their nitrogen content is fairly uniform and corresponds, on an average, to 16% of nitrogen ; 1 gramme of nitrogen thus corresponds, on an average, to 6.25 grammes of protein.

Sometimes, the figure of the total protein intake in the diet is considered in itself (grammes per day); sometimes, the proteins are estimated in grammes per kilogramme of body weight; while, in other cases again, they are expressed in terms of the ratio of their calories to the total calories in the diet. For instance, an adult may be said to need at least 1 gramme of protein per kilogramme of body weight. In our Western countries, where the average weight of a man is 65 to 70 kilogrammes, a protein intake of 100 grammes a day for an adult is about an average figure for a diet of 3,000 net calories, and the percentage of total calories contributed by the proteins thus works out at 13.3 % $(\frac{100 \times 4}{3{,}000})$.

Another approach to this question is to estimate the relative proportions of animal and vegetable proteins. For instance, such facts as that the animal proteins, in a given case, represent 40 % of the total protein intake, may be recorded. It should be noted that the composition of the family may affect this ratio. Fluctuations will accordingly be the more significant the more homogeneous the households under consideration.

The importance of determining this ratio will be seen later, in connection with the protective principles. In the case of children and pregnant women, the protein requirements per kilogramme of body weight are greater.

Fats. — This group comprises all non water-soluble substances that can be extracted by organic fat solvents. They are built up of components of varying composition, some containing phosphorus, others not, etc. In most diets, however, they consist for the most part of simple fats (glycerides). It is usual to refer to the total intake of fatty substances expressed in grammes per day. For instance, in our Western countries, the average diet for an adult (3,000 calories net) will be said to contain from 85 to 125 grammes of fat. The intake tends to rise in cold countries and fall in hot countries. Sometimes the fat intake is expressed in terms of the percentage of the total calories supplied in the diet. In diets rich in fat, this proportion amounts to more than 30 % in temperate climates. When the calories of the fats in the diet represent 27 % to 30 % of the total calories, this is regarded as an average figure in those countries. If the question is examined in terms of the weight of food consumed, less water, it is found that, assuming all other dietary components to be present in adequate proportions, the diet of a child should, in particular, contain at least 10 % of fat if the body is to be protected from the risk of abnormalities of skeletal development. Certain nutrient fats are rich in protective principles (fat-soluble vitamins), while others are not. Certain ratios of values are hence well worth determining. In some countries, it will be the ratio of butter (including that contained in milk) to the total quantity of fat ; and in others, the ratio of palm-oil to the total fat intake ; or again, the ratio between the fats contained in glandular organs to the total fats, etc. The type of edible fat which can be regarded as a good source of fat-soluble vitamins, varies according to the part of the world studied.

Another ratio of special importance is that of fatty foods in which the fats are naturally emulsified to non-emulsified fats. This is of special importance in countries in which large quantities of vegetable oils are consumed. Here it is useful to ascertain what percentage of the total fats in the diet is supplied in the form of oil, for it is important that this figure shall not become too great. Digestibility decreases as the proportion of unemulsified fats rises.[1] This physical factor is not the only one which affects the digestibility of fats ; their chemical composition is also important (differences of melting-point and of iodine index). The proportion unused and eliminated as intestinal waste hence varies. It is influenced by the factors just examined and it increases with the total quantity of fat contained in the diet, and with yet other factors, such as an excess of calcium, etc.

Carbohydrates (*glucides*). — This group comprises only the carbohydrates which can be attacked by the digestive juices and does not therefore, in the case of human nutrition, include cellulose.

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[1] In certain exceptional cases, the consumption of fatty substances, and especially fish liver oils, is very reat, (*e.g.*, among the Eskimos).

When these substances are present in the diet in large quantities relatively to the other energy-bearing principles, the diet is often poor in protective foods. The diets in which carbohydrates predominate are those by which the energy requirements of the body can be met at the lowest cost, and are therefore the diets of poor people. Calorie for calorie, vegetable foods rich in carbohydrates are, in fact, cheaper than most others. An average mixed diet generally contains 400 to 500 grammes of carbohydrates in temperate climates, when the total energy intake amounts to 3,000 net calories. Generally speaking, an average mixed diet in Western countries contains 0.8 to 1.5 gramme of fatty substances and 5 to 4 grammes of carbohydrates per gramme of total proteins. Total energy value being equal, the respective intakes of fatty substances and of carbohydrates usually tend to vary in inverse ratio to each other. The weight ratio of these two groups (that is to say, $\frac{\text{fat}}{\text{carbohydrate}}$) tends to rise for cold climates and fall for hot climates.

Miscellaneous. — Certain substances are not classified in the three groups of energy-bearing foods just enumerated. Take two examples : vinegar (acetic acid) and alcohol. Their energy value (3.5 and 7 gross calories respectively per gramme of the pure substance) differs from that of the three groups, the corresponding values for which are given below. This maximum gross energy value is not of any great moment, since it is not known what proportion of these substances is burnt up in the body. In any case, this proportion probably varies according to circumstances, and it is therefore impossible to indicate the useful value in net calories.

The value of the diet in calories. — It is extremely important to consider carefully the problem of calculating the value of the diet in calories. It is highly delicate and difficult to solve. In theory, it is perfectly clear and simple ; but in practice, when this calculation has to be based indirectly on data derived from a dietary survey and no chemical analysis is possible, the method used is conventional and approximate only. In point of fact, investigators have had recourse to various methods of calculation, so that the results are often not comparable. The fundamental physiological aspects of the question cannot be discussed here, but a few particulars will suffice to show what must be done in any case, whatever the method of calculation chosen.

It is usual to make a distinction between the *gross calories* and *net* (*useful*) *calories* of a diet.

The complete combustion of energy-bearing principles carried out in a laboratory in a calorimeter gives, on an average, the following maximum energy values :

Proteins	5.7 calories per gramme
Fats	9.3 calories per gramme
Carbohydrates	4.1 calories per gramme

In the case of a dish made up from a number of different foodstuffs, the gross energy value may also be measured in the laboratory with some degree of accuracy, thanks to certain methods of calculation. A sample of the mixture of a known weight is dried and then burned, for instance, in an F. G. Benedict oxycalorimeter—a useful method for little-known dishes or foods which are consumed in some particular locality and the composition of which is not given in the tables. [1]

Oxidation in the body is not as complete, however, as it is in the laboratory calorimeter.

This incomplete "*combustion in vivo*" leaves over a certain amount of waste material, which is eliminated through the kidneys and intestine. Laboratory combustion of this material releases calories which the body fails to use. In principle, measurement of the heat produced by the total combustion of *what is ingested* indicates the *gross calories* in the diet. After deduction, from this total, of the heat of combustion of the urine and fæces discharged during the period under consideration, there remains the useful heat (*net calories*) which the body is able to utilise from the incomplete oxidation of the foods ingested. Such is the theoretical, simple and logical definition of these two

[1] *Journal of Biological Chemistry*, 1925, Volume 66, page 783. "Abderhalden's Handbuch der biologischen Arbeitsmethoden, 1929," Section IV, Part 13, page 51. As the value measured is that of the oxygen consumed during the combustion of the sample and as the calculation is based on the use of a coefficient of equivalence in calories per litre of oxygen consumed, it is possible, according to the coefficient employed, to calculate either the total (gross) heat of combustion or the physiologically useful heat of combustion.

magnitudes. In practical surveys, they cannot be assessed, and for this reason other values have to be employed, which, though only approximate and conventional, are at least calculable from the data accumulated in nutrition surveys. Oxidation in the body is specially incomplete where proteins are concerned, whereas in the case of fats and carbohydrates it approaches very nearly the maximum, especially if the diet contains but small quantities of these.

If we study in a dog the calorie output which is obtained through the assimilation of a diet consisting of nothing but lean meat—that is to say, almost exclusively proteins—we shall obtain an energy value for protein of 4.1 calories instead of 5.7, the difference being mainly due to the fact that the nitrogen is eliminated in the form of organic substances still retaining some energy value (urea, uric acid, etc.). The same phenomenon can be observed in man.

If it is assumed that carbohydrate and fat oxidation reaches maximum values in man—though this is only theory and an approximation to the truth—and if therefore the following (Rubner) coefficients of equivalence are taken :

Proteins . . .	4.1 calories per gramme	Rubner's coefficients
Fats	9.3 calories per gramme	
Carbohydrates .	4.1 calories per gramme	

it is possible, by applying them to the edible portions of the foodstuffs used, to calculate what is often conventionally, though arbitrarily, called the *gross calories* of the diet. The convention would be less arbitrary if applied to actual intake.

There is also the fact that neither the digestion of foods nor their subsequent assimilation is accomplished with 100% theoretical efficiency, so that further " coefficients of utilisation " must be applied to Rubner's coefficients. On this basis, Atwater has suggested the following coefficients, which, for the purposes of calculation, have the additional practical advantage of being round figures :

Proteins . . .	4 calories per gramme	Atwater's coefficients
Fats	9 calories per gramme	
Carbohydrates .	4 calories per gramme	

By applying these coefficients to the quantities of energy-bearing principles contained in the food *actually ingested*, as calculable in individual or family-cum-individual investigations by the weighing method, it is possible to obtain a true assessment, requiring no further modification, of the physiologically useful heat—*i.e.*, of the *net calories* in the diet.

If, on the other hand, the data to which they are applied are derived from surveys relating to food as purchased, from which the probable edible percentage can be indirectly assessed, then a further adjustment must be made in respect of edible household waste, in order to obtain the net calories.

Certain writers, like GAUTIER in France, for example, have suggested applying these adjustments to Rubner's coefficients, as ATWATER himself did (see above) ; in this way, the necessity for secondary adjustments would be avoided (GAUTIER proposed the factors 3.7, 8.6 and 3.9, or, alternatively, 3.68, 8.65 and 3.88 per gramme of protein, fat and carbohydrate respectively).

But, in view of the difficulty of estimating the adjustment to be made for edible household waste, and of the variable nature of this value, according to the social conditions under consideration, it seems more reasonable to calculate the diet in net calories on the basis of Atwater's coefficients, and then to deduct from the aggregate figure thus obtained some purely approximate percentage to allow for errors due to household waste.

To sum up:

1. In certain surveys conducted by the weighing method, Atwater's coefficients 4, 9, 4 are applied to the food actually ingested. This gives the net intake with the greatest possible accuracy, provided the weighing of the food actually consumed is itself accurate.

2. In other surveys, Atwater's coefficients are applied as they stand to the edible portion of the food as bought. The net intake calculated in this way is too high.

3. To estimate the net intake as accurately as possible, the figure obtained by Atwater's coefficients as applied in No. 2 above must be reduced by at least 1.5% to 2%, which

represents a minimum for edible household waste in the poorest and most economical groups.

Bigwood and Roost estimate that a correction averaging 5% should be made where there is no needless waste, but that this figure may have to be increased for certain groups of well-to-do middle-class families.

4. Other writers employ Rubner's coefficients (4.1, 9.3, 4.1) and deduct 8% from the total. This method is confined almost entirely to Germany.

The practical conclusion which emerges clearly from these considerations is that any final calculation of the energy value of a diet is of but slight value unless the published report of the survey shows all the data from which the calculation has been made. Another important conclusion is that no statement of estimated mean difference between gross and net calorie intake has any absolute value; it depends on the definitions given of these values. Unless these definitions are known, the value assigned to this difference is of little significance, for investigators have adopted different conventions. The only difference which has an absolute value, independent of convention, is that based on strictly physiological definitions, but it cannot be assessed on data acquired in dietary surveys only, however elaborate these may be.

5. Protective Principles

The biological value of proteins, inorganic elements and vitamins will be considered in turn.

A. *The Biological Value of Proteins.*

Protein matter is composed of amino acids. Most of these molecules act as energy-bearing and body-building material, but some have special physiological properties. Tryptophane, for example, acts as a co-ordinator of nutritive exchanges, especially in the maintenance of nitrogen balance. At all ages, and thus even for adults, some tryptophane is needed in the diet to enable the organism to maintain its nitrogen balance.

When it is missing from the diet, there is always a loss of nitrogen, even if the aggregate intake of nitrogen is more than would be sufficient to keep the organism in nitrogen balance on a normally balanced diet.

Lysine, cystine and cysteine are indispensable for the normal growth of young organisms.

Protein mixtures of equal total nitrogen content may thus be of different *nutritive value* (so-called *biological value*). The proteins of milk, eggs and glandular organs are of the highest value in this sense. The value of the proteins of vegetable foods is much lower. Experiments on animals with simple proteins extracted from vegetable material have yielded very low biological values compared with those of proteins derived from milk or meat. This is true, for instance, of maize zeine. It should be observed, however, that the nutritive value of the mixture of all the proteins contained in a vegetable food is distinctly greater than that of each of them considered separately, when the comparison is made for equal quantities of nitrogen.

A varied diet, even lacto-vegetarian or wholly vegetarian, generally ensures a proper supply of all the different amino-acids. But this necessitates a considerable variety in the food-stuffs composing the diet. Milk, egg and meat proteins appear, however, to supply these requirements most easily, and furthermore their presence in a mixed diet enables the body to turn proteins of lower biological value to better account. Herein lies what is called the *supplementary value of proteins of animal origin*, and this explains why it is important, when making a physiological analysis of nutrition surveys, to calculate the ratio of proteins of animal origin to the total proteins of the diet (see above, page 63).

B. *Inorganic Chemical Elements.*

Definition.

Hitherto estimates of the intake of these elements, and of vitamins also, have been made simply by calculating the content of the edible portion of foods as bought or, in the case of surveys conducted by the weighing method, of the portion actually ingested. No partial utilisation factor has yet been introduced, since our knowledge on this point is not yet sufficiently advanced to permit of quantitative calculations.

These elements are often referred to, for brevity's sake, as inorganic elements or mineral salts, though these terms are inaccurate and lead to confusion. When we speak of phosphorus in a diet, we mean both inorganic phosphorus—*i.e.*, phosphates—and organic phosphorus. The phosphorus in the latter case, as the term indicates, forms part of the organic molecule. The same applies to the iron of hæmoglobin. The group of elements known by these terms are therefore inorganic, as opposed to the four basic elements of organic matter—viz., carbon, hydrogen oxygen and nitrogen. The carbonates, however, belong to the groups of mineral salts properly so called. In short, the term mineral indicates that the elements may be found in the ashes of living matter as the inorganic residue of the complete combustion of such matter. All these elements are therefore taken together whether or not they may be found in the natural state in some organic chemical compound.

The mere fact of determining the quantities of an inorganic element present in the several foods composing a given diet is often far from sufficient to establish the actual amount supplied to the organism. Cooking processes, and the use made of the water in which foods have been cooked, are of paramount importance in this connection. This is also true for certain vitamins, and even for part of the energy-producing components. Generally speaking, where a survey indicates that the diet has a given content of some substance, this should be taken to mean the content of the foods concerned in their raw state. After cooking, however, the said content is often reduced, to a varying and ill-defined extent. In other words, in order that two persons living in surroundings in which cooking processes differ widely should ingest *the same quantity* of an inorganic element each day, the foods which go to make up their daily diet may conceivably have to contain *different quantities* of that element. It is true to say that, in order to increase the intake of a given element, it is often more useful to improve the method of cooking than to alter the selection, or increase the quantities, of the food consumed.[1]

Method of expressing the Content of these Elements in Foods.

Since they are usually determined in ash-residues or by wet combustion, a tendency has developed to express the concentration of these elements in foodstuffs in grammes per cent of the oxides (CaO, P_2O_5, etc.), since it is in this form that they are analysed. From the physiological point of view, however, this is illogical. To avoid confusion, it is better to keep to the one uniform method of expressing the concentration in grammes per cent of the simple element and not of one of its oxides (Ca instead of CaO, P instead of P_2O_5, etc.)

The only elements which will be considered here are *sulphur, phosphorus, calcium, iron* and *iodine;* our knowledge of the other elements is as yet too fragmentary for consideration in nutrition surveys.

This does not mean that it would not be useful in the future to determine the magnesium, potassium, etc., content of the diet.

Sulphur.—Sulphur is supplied to the body almost entirely in proteins (cystine, cysteine and methionine). The amount of this element in the diet depends therefore on that of the proteins. It is usually about 1 gramme of sulphur per 100 grammes of a protein mixture.

Phosphorus.—This element is a very common ingredient of foods. The average intake for a human being, without distinction of age or sex, is about 1 gramme per day (0.5 to 1.5). It is generally considered that the phosphorus in foods of animal origin (milk, cheese, meat, eggs, etc.) is more easily absorbed than the phosphorus in vegetable foods (cereals, potatoes, vegetables, etc.) ; the ratio between these two quantities (animal phosphorus : total phosphorus) will therefore be worth recording.

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[1] These facts show that detailed enquiries into the cooking habits of various countries would be of the utmost value from the physiological standpoint.

Calcium.—The average normal diet for a human being, without distinction of age or sex, varies in calcium content from 0.75 to a little over 1 gramme per day in Western countries. In many parts of the world, it is in fact much less.

According to some authors, the calcium from milk, cheese and eggs is better utilised than that from vegetable foods, and it may therefore be useful to ascertain the ratio of animal to total calcium in the diet.

If only the aggregate food consumption of a family is being investigated, it should be borne in mind that the composition of the family may affect the value of this ratio.

Milk and cheese intake is a preponderant factor in determining the calcium value of the diet.

The Ratio of Calcium to Phosphorus.

It is important to know the ratio between the aggregate quantities of these two elements, not of their oxides. This is expressed either by the quotient $\frac{\text{quantity of Ca}}{\text{quantity of P}}$ or—what amounts to the same thing—by the quantity of phosphorus per gramme of calcium in the diet. If, for example, the diet contains 0.9 gramme of Ca and 1.5 gramme of P, then the ratio $\frac{Ca}{P} = 0.6$ $(\frac{0.9}{1.5})$ or is as 1 : 1.67.

In surveys confined solely to families, where only the aggregate food consumption of the household is assessed, it should be remembered that the value of the $\frac{Ca}{P}$ ratio is affected by the composition of the family.

In countries with a high consumption of milk products, the value of this ratio is generally greater than unity in the case of young children. It usually varies inversely with age; it is below unity for adults and equal to unity at the age of about 3 to 5 years.

The factors which influence the assimilation of calcium and phosphorus are the composition of the diet in respect of fats and fat-soluble vitamins, the acid-base balance, the $\frac{Ca}{P}$ ratio, the more or less vegetarian or mixed character of the diet, etc.

Iron.—The daily intake of iron per head should be about 10 milligrammes. Iron is contained in the food in various forms of widely different assimilability. A record should therefore be made of the proportion of the total iron which comes from the following sources :

(1) Vegetables, including potatoes and roots ; (2) Cereals (whole cereals contain a great deal of assimilable iron) ; (3) Foods of animal origin. So far as the last item is concerned, meat and eggs are important, milk products negligible.

Iodine.—Our knowledge of the iodine content of foodstuffs is not sufficient to permit of the indirect assessment, by means of tables, of the amount of iodine consumed in the diet. Analyses of the water, soil and food products of a given district may disclose a dearth of iodine. In the present state of our knowledge, therefore, the problem of iodine does not arise in connection with the technique of nutrition surveys.

The Acid-base Balance of the Diet.

This question is linked with that of the inorganic elements ; the acid-base balance can be succinctly defined as the ratio, in the ash of the diet, of the acid elements (which form anions) to the basic elements (which form cations).

The predominantly acid foods are, principally : meat and fish, cereals and starchy foods, and eggs.

The predominantly basic foods are, principally : vegetables, roots and tubers, starchy vegetables (dried beans, dried peas, etc.), fruits, milk and cheeses. Sherman's tables provide numerical data on this subject.

Speaking generally, vegetarian and lacto-vegetarian diets are inclined to be predominantly basic, while the predominantly acid quality of mixed diets is the more marked the greater the proportion of meat and eggs. But there is no hard-and-fast rule on this point. The following two ratios (by weight) have a pronounced influence on the balance of acids and bases in the diet : (1) the ratio " bread to potatoes ", (2) the ratio " meat to milk and cheese ".

Instances can thus be found of meat diets in which the acids are neutralised, or more than neutralised, by the bases, if the consumption of potatoes is much in excess of that of cereals. Conversely, cases will be found of vegetarian diets which are predominantly acid where the consumption of cereals largely exceeds that of potatoes.

The question of the acid-base balance may give rise to certain misconceptions. Take the case of a high consumption of fruits such as oranges, grape-fruits, lemons, etc. Their taste is acid because of their richness in acid citrates, and this fact tends to make the intestinal contents acid or, at any rate, but slightly alkaline. But citric acid is destroyed within the body, and its acidifying effect is thereby nullified. Fruit, in fact, falls within the group of predominantly basic foods, because of its richness in potassium. It thus has an alkalising effect on the tissues, unless taken in excessive quantities. In this case, the body's power of assimilation and consequent destruction of the citric acid may be overtaxed, and a surplus of citric acid begins to accumulate and exercise an acidifying effect, not only on the digestive tube, but also within the organs themselves. A moderate "normal" intake of these foods has therefore a basic action on the tissues, whereas excessive consumption may have an opposite and acidifying effect.

Taken as a whole, the question of the acid-base balance of the diet is not of outstanding importance in the physiological study of nutrition.

C. *Vitamins.*

I. Classification and Designation.

Vitamins are widely differing chemical substances having the most varied physiological properties. Several of them can nowadays be prepared by chemical synthesis. They are divided into two classes according to their solubility :

1. *Fat-soluble vitamins.*—These are substances soluble in organic fat solvents ; they are soluble in the nutrient

fats themselves, which act as their vehicle. They are insoluble in water.

2. *Water-soluble vitamins* are soluble in water as their name indicates, but not in fats or in organic fat solvents.

At the present time, a fairly large number of vitamin substances are recognised. Only those for which some quantitive data are available will be considered here, as only these lend themselves to any sort of exact study in the course of dietary and nutritional surveys.

Such vitamins are A, D and E in the fat-soluble group, and B_1, those of the B_2 [1] complex and C in the water-soluble group.

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II. *Greater or Lesser Stability of Vitamins.*

Vitamins may be either sensitive or resistant to the oxidising action of the air. The degree of sensitiveness is considerably affected by heat, and they may, in this respect, be divided roughly into two groups:

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[1] *Terminology of the B_2 Vitamin Complex.*

By B_2 complex is meant a group of water-soluble nutrients, relatively thermostable, present in yeast, in liver and in the bran and germ of certain cereals. This group contains the following:

1. Three nutrients adsorbable on fuller's-earth:
   - Lactoflavin (= riboflavin of the American terminology);
   - Nicotinic acid or its amide;
   - Vitamin B_6.
2. One nutrient non-adsorbable on fuller's-earth:
   - The filtrate factor.

In the United States, the term vitamin *G* was formerly used to express the vitamin-B_2 complex as well as the anti-pellagra factor P.P. of Golberger, and recently to signify only lactoflavin. In some quarters, the above three terms have been considered to be synonymous, which is not the case, and this has led to much confusion. Nicotinic acid or its amide has been reported to be effective in treatment of human pellagra and also in cases of analogous disorders of dogs and pigs. It seems, however, probable that human pellagra may be the result of a multiple deficiency, of which that of nicotinic acid may be one.

Vitamins B_5 and B_3, reported as being essential for nutrition of pigeons, are probably identical respectively with vitamin B_6 and the filtrate factor.

The term "vitamin H" has been used by György and others to designate a heat-stable nutrient present in yeast and liver, which prevents the dermatitis and absence of growth shown by rats maintained on some special diets, and is considered by some workers to be related to certain types of skin disorder in children. Since, however, the principle is not soluble in water, it is not here included in the vitamin-B_2 complex. In the United States, on the other hand, the term "vitamin H" has by certain workers been used to designate the constituents of the vitamin-B_2 complex, other than lactoflavin.

It is not certain that the principle termed B_4 has ever existed. It is thought that it may consist of a rat-growth principle independent of B_1 and of the aforesaid principles of the B_2 group.

Finally, the letter *W* has been used by certain authors to describe a rat-growth principle precipitable in alcohol-ether.

1. *Group more affected by heat (thermolabile) on contact with air.* — These are, in decreasing order of sensitiveness, vitamins C, B_1 and A.

2. *Group more resistant to heat on contact with the air.* — Vitamins D, E and those of the B_2 complex.

For dietary surveys, the main question of practical importance, so far as the action of heat on vitamins is concerned, is the manner in which this takes effect in cooking. In this connection, vitamins may be classed as follows:

(a) *Vitamin seriously affected by cooking : Vitamin C.* — With the usual methods of cooking, vitamin C is, to a great extent, if not entirely, destroyed (*e.g.*, in the case of vegetables or milk).

In one exceptional case, that of the potato (the only one so far known), cooking appears to *increase* the concentration of vitamin C, allowing for the difference in volume of the food after cooking. When calculating the vitamin-C content of a diet, the investigator should use the figures tabulated for the composition of cooked foods whenever it is necessary or possible to do so. [1]

(b) *Vitamins slightly affected by cooking :* Vitamins *A and B_1.*—The fact that normal cooking processes only slightly affect these vitamins may be due to a really greater insensitiveness to heat in the conditions mentioned (vitamin A), or to the vitamin being encased in material which shields it from contact with oxygen during cooking (*e.g.*, vitamin B_1 in lightly milled flours). Thus the vulnerability of a vitamin during cooking (B_1, for example) may vary according to the food in which it occurs.

(c) *Vitamins unaffected by cooking* (or affected only to a negligible extent).—Such are vitamins D, E and the B_2 complex.

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[1] It should be noted, however, that cooked potatoes rapidly lose their vitamin C if they are kept hot for long, or heated up again. This shows how important it is, in conducting a survey, to record as much information as possible concerning cooking habits and technique.

The content of unstable vitamins falls as the freshness and the commercial quality of perishable foods decreases. Certain industrial processes may destroy them ; cold, on the other hand, helps to preserve them.[1] Pasteurisation and drying of milk reduces vitamin C content, but scarcely affects vitamins A, D and those of the B_2 group[2], at any rate when these industrial processes are carried out under the best possible conditions and the time of storage is limited.

* * *

III. *Variability of the Vitamin Content of Raw and Fresh Foods.*

The vitamin content of raw and fresh foods may vary considerably with the season. The investigator must therefore decide, when making his calculations, whether he should use the average, maximum or minimum values of the food composition tables. The composition of a foodstuff may also vary considerably even at one and the same time of the year (*e.g.*, according to the ripeness of a fruit, or according to its variety ; strawberries or oranges are a case in point). Calculations are thus approximate in any case.

Here again, as in the case of many other assessments, published surveys must always contain the information necessary to show the reader how the data concerning the vitamin contents of the diet were drawn up, and how he may, if necessary, adjust them in order to make certain comparisons. It cannot be too strongly emphasised that the vitamin content of a diet can only be very roughly estimated at the present time.

The experimental scientist is beset with great difficulties at every turn when he has to adopt a vitamin-content value for each item of food. It follows that the absolute value of the findings for the diet as a whole is always questionable. If, however, the same values are used throughout a given enquiry, the aggregate results

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[1] It must be remembered, however, that the mere fact that the food has been preserved at a low temperature is not in itself a sufficient guarantee, as the condition of the food when it was put in cold storage is an important factor.

[2] B_1 is lowered.

nevertheless possess a better relative value when the diets of individuals or families are compared. On the other hand, when the figures show that the vitamin content of a diet certainly does not exceed some given value, that in itself may be a valuable result.

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IV. *Provitamins.*

Some foods contain *preformed vitamins*, others *provitamins*, which are physiologically inactive but are more or less readily changed into active vitamins in the organism. Intake records in some cases express both kinds together, without distinguishing the relative amounts of each. The investigator may, however, supply some additional information by indicating what portions of the total are derived from various classes of foodstuff. Two examples are given below.

The active *vitamin A* is found only in foods of animal origin (milk, butter, glandular organs) ; it does not exist in foods of plant origin. Vitamin A is formed in the organism from some members of the carotene group, which thus have provitamin properties. β-carotene is by far the best provitamin A.

In the human body, these provitamins are transformed into active vitamin A more or less easily, but to an extent which is ill defined and probably varies from one person to the next—nay, in the same person at different times. Provitamins A are found in yellow-, red- brown- or green-coloured foods of animal and plant origin, particularly in the latter ; the ratio between the intake of provitamin A from vegetable food and vitamin and provitamin A supplied in animal foods hence furnishes information which, though incomplete, is yet of some value.

Vitamin D is formed by irradiation from ergosterol, which is an inactive provitamin.

Various principles possessing vitamin-D activity can be formed from a number of inactive sterols. Tests for vitamin-D content cover only the active principle ; they do not include the proportion of inactive sterols in the preparation tested.

Vitamin D in its preformed condition is found only in fish-oils, in the liver of a number of animal species, in eggs, and, finally, in whole milk and butter produced under certain conditions.

The human organism obtains vitamin D from two sources, one exogenous—that is, food containing preformed vitamin D—the other endogenous—when the vitamin is formed *in vivo* from inactive ergosterol, particularly in the skin when the latter is exposed to the ultra-violet rays of the sun in the summer (or the corresponding rays from an artificial source—*e.g.*, a special lamp). The portion which is of endogenous origin cannot be quantitatively estimated.

Vitamin C.—Animals may be divided into two classes: those producing this vitamin themselves, and those which are incapable of synthesising it and therefore have to rely on their food to supply it. Man belongs to this second class, though it has not been finally demonstrated that he is entirely incapable of synthesising vitamin C. What is certain is that he is quite unable to produce enough this way to be able to dispense with a supply of vitamin C in his food.

These various considerations show that the personal factor is important in influencing the vitamin requirements of the normal organism. Such requirements can probably never be expressed in exact figures of food intake. Enough margin must be left to allow for these individual differences.

* * *

V. *Avitaminosis and Hypovitaminosis.*

Principle of assessment of the vitamin requirements of the organism.—A serious deficiency in vitamins or provitamins produces well-marked pathological conditions, and characteristic diseases. These are the frank forms of avitaminosis, viz:

Avitaminosis A.—Xerophthalmia. The various forms of keratomalacia. Hemeralopia or night-blindness.

Avitaminosis B_1.—Beriberi.

Avitaminosis C.—Scurvy.

Avitaminosis connected with the B_2 complex.[1]—Pellagra and certain types of dermatitis and anæmia.

Avitaminosis D.—Rickets.

General growth disturbances (B_2, A and C), certain forms of anæmia (A and C), and dental defects (A, D and C) also fall within this category of avitaminosis with frank symptoms, which are, however, still very imperfectly known.

In certain animals, vitamin E is connected with the functions and growth of the sexual organs. The morbid symptoms in human pathology which are probably due to avitaminosis E are only just beginning to be recognised.

There are, however, various slight, vague and ill-defined symptoms, on the border-line between normal and abnormal conditions, which are thought to be connected with a slight partial deficiency in vitamins.

These are the more or less unapparent conditions of *pre-deficiency*, of latent *hypovitaminosis*, which are much more difficult to define on account of the vagueness of their manifestations.

In practice, therefore, the vitamin requirements of the organism may be thought of as comprising a series of levels. Such requirements are slight if one considers only the very small quantity necessary to avert severe symptoms of marked avitaminosis, which ultimately appear when the deficiency is very severe. The requirements appear higher if the criterion is the prevention of certain less well marked and earlier symptoms, which is found to call for a larger vitamin intake. The real aim of social medicine is to detect these reliable and delicately discriminatory signs, which give timely warning of slight and insidious deficiencies in the diet.

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[1] See footnote on page 76.

VI. *Deficiencies and Pre-deficiencies of Exogenous and Endogenous Origin.*

The problem is complicated by the fact that a total or partial deficiency of vitamins in the organism is not a condition that can arise from one single cause only—namely, a deficiency in the diet (an exogenous cause) ; such absence may also be due to a special endogenous cause in the case of a person whose diet is normal but who suffers from a defect of absorption or physiological utilisation.

A lack of fats in the diet is an indirect exogenous cause. Disturbances in the digestion or absorption of fats interfere with the absorption of fat-soluble vitamins. Other causes of a digestive character, or of some other kind, may prevent the absorption of water-soluble vitamins. An excess of calcium prevents the absorption of fat-digestion products and is another indirect cause of avitaminosis. Lastly, there may be an abnormal increase in requirements of vitamins or provitamins, because either of excessive destruction or of faulty utilisation in the body. *Any and every symptom of deficiency is not therefore necessarily to be attributed to a defective diet; and even when this is the case, the defect may be of many different kinds. The blame cannot always be attributed solely to an insufficient supply of vitamins. Even when the organism is normal, the quantity of a given vitamin supplied in food may sometimes be sufficient, sometimes insufficient; this will depend upon the composition of the diet in respect of its other components—that is to say, its balance. One example, which has now become classic in this connection, has reference to the variability of vitamin B_1 requirements in accordance with the carbohydrate content of the diet.*

It should be observed that where the deficiency of the diet is but partial, the appearance of manifest morbid symptoms may be retarded, the more so the slighter the deficiency concerned. In some cases, this period of latency may be of very long duration indeed.

VII. *Tables showing the Vitamin Content of Foodstuffs: Units used to express the Concentration of Vitamins.*

As already stated, the tables show an average food composition or a margin of possible variations in the composition. The causes of these variations, and the considerations that must govern the choice of average, maximum or minimum values when making calculations, have been noted.

The question of the units to be adopted for dealing with the quantitative aspect of the vitamin problem must now be considered. Unfortunately, many units have been used, and, as a result, the work of the investigator has been greatly complicated and, what is worse, causes of error have been introduced into the quantitative estimations.

Standardisation of the conventions adopted has hence become indispensable and urgent.[1]

In future, use should be made only of units of mass (gammas or milligrammes) when appropriate modern physico-chemical methods of determination are applicable—or the international units recommended by the Permanent Commission on Biological Standardisation when biological methods of vitamin assay are used.[2] Accordingly, the only tables of food composition used should be those giving the results of direct determinations effected by one of the above methods.

An example of an appropriate table is that recently published by FIXSEN and ROSCOE. The bibliographical reference is given on page 60.

It should be noted, however, that there are many publications and food composition tables in which the vitamin contents are still calculated and expressed in various other—older—units, by methods now no longer regarded as adequate; coefficients of equivalence as between various units have also been given for purposes of conversion. It must be realised that such equivalences are only very approximate. In principle,

[1] The reader will find useful indications on this subject in a memorandum by COWARD published in "Nutrition Abstracts and Reviews", 1935.4.705, and in COWARD's paper "Biological Standardisation of Vitamins". London, 1938.

[2] *Bulletin of the Health Organisation*, League of Nations, 1934, Vol. III, No. 3, pages 428 *et seq.* and Vol. VII, No. 5, pages 874 *et seq.*

conversions are not justified because the definitions of the various units rest upon different criteria; strictly speaking, therefore, they are not comparable *inter se*. If, however, use is still made of units other than the international, and a coefficient of equivalence is adopted for conversion of the results into terms of international units, the results of such calculations should be regarded as only approximate and provisional. Many of the figures in tables expressed in international units ought probably to be revised in the light of new rational measurements; they have probably been obtained indirectly by means of such conversion, and were originally based on methods now recognised as obsolete.

We will therefore now explain the differences of principle which distinguish the international from the other units, we shall also indicate the approximate equivalences already referred to, in order that our statement of this question, which is of great practical importance, may be complete, though it remains a fact that the use of these equivalences must be dropped at the earliest possible moment.

1. The old *units*, known as *physiological*, were the least accurate. They were established as follows: Animals of a species suitable for the purpose were given diets containing all the nutritive principles in sufficient quantities, except the vitamin concerned, which was entirely absent from the diet. By including varying quantities of food containing this vitamin in the diet of various groups of such deprived animals, the average vitamin content of that food could be determined. Sometimes the curative and sometimes the preventive dose per animal was measured. It was thus possible to determine that 100 grammes of the food contained so many physiological *rat*, *pigeon* or *guinea-pig* units—that is, so many times the physiological curative, or preventive, dose in question. The criterion was therefore a pathological symptom of avitaminosis (xerophthalmia, beriberi, scurvy, etc.). The experimental conditions and the characteristics of the animal used were, of course, specified.

Physiological *rat* units were used for vitamins A and D (anti-xerophthalmic and anti-rachitic units), physiological *pigeon* units for vitamin B (anti-beriberi units), physiological *guinea-pig* units for vitamin C (anti-scorbutic units), etc.

2. Other criteria were subsequently proposed by American investigators. Thus, in the case of vitamin A, SHERMAN based his unit on the amount necessary to ensure a certain rate of growth in the rat, rather than on the prevention or cure of xerophthalmia. For example, he determined, in well-defined experimental conditions, the dose necessary to produce a growth of 3 grammes a week, during four to eight weeks.

There are a number of special physiological units of the same kind which are based upon a definite rate of growth (vitamins A, B and G), or upon the prevention of a well-marked vitamin deficiency for a specified period of time in animals of a particular age, weight, etc. (vitamin C), or again by signs of recovery from avitaminosis defined within strict limits (vitamin D), viz. :

Sherman unit for vitamin A ;
Sherman-Chase unit for vitamin B ;
Sherman-Lamer unit for vitamin C ;
Steenbock unit for vitamin D ;
Sherman-Bourquin unit for lactoflavin.

3. It soon became apparent that, in spite of every attempt to lay down very strict rules as to the choice of animal, breed, age, weight, time of year, etc., assays are not always made under comparable conditions. Moreover, some vitamins began to be prepared in a pure form, sometimes even synthesised. A new principle of titration was then adopted, as in the case of hormones. This led to the definition of *international units*, the method followed being to adopt a *standard preparation* supplied by particular institutions, to define the unit as the activity of a specific amount of the standard product, and to use the latter to determine the strength of unknown preparations or the content of a food. If x grammes of a given product are required to produce the same physiological effects as are obtained with one unit of the standard preparation—or it may be one of these effects only—the said x grammes contain *one*

international unit. The results thus obtained will therefore always be comparable, even if the animals used do not constitute perfectly uniform reagents in the various tests.[1] Particulars of the definition of each international unit are given in a report published by the Health Organisation (*loc. cit.*, page 83). There is no need to repeat them here, especially as we have omitted details of the other units mentioned.

There are hence two types of methods for performing vitamin assays : (1) biological methods and (2) physico-chemical methods :

1. Of the available biological methods, only those which are based upon the recommendations of the Permanent Commission on Biological Standardisation should be accepted, to the exclusion of all other biological methods. The principle involved is that an assay carried out by a biological method is only recognised as properly performed if the unit is related to the activity of a given weight of the substance accepted as a standard, and not to some particular physiological response of an animal possessing certain characteristics of breed, age, sex, etc. In any biological assay carried out in accordance with the recommendations laid down in 1934 by the Permanent Commission on Biological Standardisation, the measurements effected on a batch of animals treated with a preparation of unknown vitamin content should therefore be compared with measurements taken simultaneously on a comparable batch of control animals treated with the standard preparation.

2. As for the physico-chemical methods, specific tests have recently been developed for some vitamins which enable the content of the substance under investigation to be estimated in terms of milligrammes or gammas per gramme or 100 grammes. In the case of vitamin A, the latter methods enable the active vitamin and the carotene to be separately determined. The conversion into international units of the quantity of vitamin A thus determined can only be made by a conventional calculation, the value of which may be questioned.

[1] This is also true as regards the various assays carried out in the same laboratory at different times.

Vitamin A. — 1 international unit is defined as the vitamin-A activity of 0.6 γ of β-carotene.

1 Sherman unit is equal, on the average, to about 0.5 of an international unit (not 1.4, as stated before in publications on the subject[1]).

1 former *rat* physiological unit (see section 1 above) = 3 to 5 international units.

Vitamin B_1. — 1 international unit is defined as the vitamin-B_1 activity of 3 γ of pure crystalline vitamin B_1 (aneurin).

1 Sherman-Chase unit is equal to about 0.5 of an international unit.

1 former *pigeon* physiological unit (see section 1 above) = 2 to 3 international units.

Vitamin C. — 1 international unit is defined as the Vitamin-C activity of 0.05 milligramme of *l*-ascorbic acid.

1 Sherman-Lamer unit is equal to about 10 international units.

1 former *guinea-pig* physiological unit (see section 1 above) = about 4 to 10 international units.

Vitamin D. — 1 international unit is defined as the vitamin-D activity of 1 milligramme of the standard solution of vitamin D_1—that is to say, 1 milligramme of a standard solution of irradiated ergosterol.

This unit also corresponds to 0.025 γ of vitamin D_2 (crystallised calciferol).

1 Steenbock unit = 1 international unit = 1 former physiological unit. This equivalence is very approximate.

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[1] The correction of this error was announced by Dr. E. M. Nelson (Food and Drug Administration, United States Department of Agriculture). See in particular the article by L. E. Booher of the same department, in the *Journal of the American Medical Association* of June 4th, 1938, Vol. 110, pages 1920-1925. Despite this correction, the equivalence still remains very approximate, for the reasons stated above. It may be expected to fall into disuse in due course.

Vitamin B_2 Complex. — Since pellagra is probably due to a deficiency of several factors, no anti-pellagra unit can be proposed. As regards lactoflavin, the SHERMAN-BOURQUIN unit was proposed in the United States. Up to the present, however, no satisfactory biological method of determining the content of this principle in foods is available, for no basic diet can be made up which is devoid of lactoflavin. As for the physico-chemical methods that have been put forward, these have been held to be imperfect. They yield values which are inaccurate, and involve an under-estimate.

As regards *nicotinic acid and its amide*, there is no simple biological or chemical method of determination.

VIII. *Method of expressing the Vitamin Content of the Diet.*

The question does not arise in individual studies : the intake per day per person is given in international units. In family surveys, it is probably advisable under present circumstances to calculate the intake per head.

It may, however, be advisable also to relate the vitamin content to the calorie content (for instance, per 100 calories). This comparison is useful on the ground that badly balanced diets may show a far greater deficiency of protective than of energy-bearing foodstuffs.

Sometimes, as in the case of vitamin B_1, requirements depend to some extent on the amount of energy-giving principles, particularly carbohydrates, in the diet ; that is all the more reason why, in this case, the vitamin intake should be reckoned in terms of the quantity per 100 calories of the diet.

In certain other cases, it would seem that the vitamin content should be expressed in terms of the amount per kilogramme of body weight ; this seems indicated for vitamin C, in the case of adults. Not enough is yet known, however, to warrant the establishment of strict rules. It seems useful, however, to indicate what ratios may be usefully computed in the present state of our knowledge.

* * *

6. Problems of Scales of Family Consumption Coefficients

As has been shown, most of the surveys made in the past have been family surveys, without any supplementary information as to how the total food consumed by the family is divided among the different members. Consequently, if the results obtained for different families of dissimilar composition are to be compared, family coefficients are necessary, by means of which the total consumption may be reduced to terms of one unit—for instance, the diet of an adult male. Systems of family coefficients are based on a comparison—from one particular standpoint (*e.g.*, calories) and that only—of the requirements of normal organisms of different age and sex under varying conditions of work.

These scales of family consumption coefficients thus show the relative nutritional requirements of the various members of a family. They indicate how the total family supply of the different nutrients should be divided among the members of the family. They do not, of course, show how they are actually divided. When applied to needy, under-nourished families, faced with economic difficulties, these scales may produce erroneous results, for very often the parents sacrifice themselves for the sake of their children. Calculations based on these scales consequently lead, in such cases, to an over-estimate of the deficiency in the diet of the children and an under-estimate of the deficiency in the diet of the parents ; in other words, the results give too gloomy a picture for the children and too bright a picture for the adults. Moreover, these scales do not allow for the fact that one person eats more than another, all other factors of comparison being equal ; nor, again, do they take account of differences in stature, at all events when they are used uncorrected.

However, in spite of these disadvantages, the scales in question have to be used, for want of a better method, when the enquiry is of the type of a family survey pure and simple.

Even without these special sources of error, it is never possible entirely to eliminate every differential factor. Some exclusively family surveys seem to show that, the effects of all other differential factors being, so far as possible, excluded, the intake per unit—per male adult, for instance—tends to be lower the larger the number of children in the family (*cf.* the results obtained by ABRAMSON in Sweden, for instance), and this is said to be the case even in well-to-do families. However, it still remains to be seen how far certain errors of assessment may operate—for instance, errors due to the variation of household waste with the size of the family. It is easier to use up leavings, and to use them more economically, in a large family ; and we know too little as yet about the effect of such factors on the accuracy of the results.

Up to the present, most physiologists have been concerned solely with fixing scales for the energy requirements of the body, and their variations according to age, sex and work. It is clear, however, that these same scales cannot be used for other nutrients. If a child of a given age requires from 30% to 40% of the calories needed by the average adult male, the percentage as regards calcium or vitamin requirements may be very different. Indeed, it may amount to nearly 100%.

Different scales are therefore required, in principle, for the different nutritive components.

Scales of Family Coefficients for Calories.

These scales have their origin in a system of family coefficients for consumption in general, suggested by ENGEL in 1883 (*Bulletin* of the International Institute of Statistics, Rome, Vol. 9, Book I). They were given the name of " Quet " in memory of the Belgian statistician, QUÉTELET. They showed consumption values rising with the increasing weight of the child during growth. The unit value of the Quet scale was that for a *new-born* child. The scale rose by 0.1 per year of age. The coefficients assigned to the adult man and woman were 3.5 and 3 respectively.

ATWATER was the first to propose, at the beginning of the present century, a system of physiological coefficients based on the variation in *calorie requirements* and not on variations in weight. The unit taken was the requirements of an average adult man doing moderate work. He was estimated to require 3,500 calories. *It is clear that a system of this kind is meaningless, unless the calorie value corresponding to the unit is specified. It is not enough to say that the unit is the requirements for a particular subject; the amount of the requirements thus taken as the unit must be given.*

The figure of 3,500 calories appeared to be too high. LUSK, in 1918, suggested another scale in which the unit also represented the allowance for the average adult man, whose energy requirements were estimated at 3,000 net calories (or 3,300 gross calories).

In 1932, a Commission of the Health Organisation of the League of Nations suggested yet another (Conference of Experts held in Rome in 1932—*Bulletin of the Health Organisation*, Vol. I, No. 3, page 480). The unit again corresponded to the allowance for the average adult man, the energy value being fixed at 2,700 net calories (3,000 gross calories).

It was realised, however, that in some cases there might be drawbacks in using scales which took the man's allowance as the unit, especially if the optimum amount for a man is regarded as liable to considerable variation according to the kind of work done and to certain social circumstances, such as unemployment, for instance. If the calorie allowance of a child of from 4 to 5 is assessed at 0.4 of that of an adult man, which is represented by 1, and if, in a given case, an adult male is held to require only 2,500 calories because he is engaged in a sedentary occupation, whereas, in another case, 5,000 calories are allowed because he is engaged on very heavy work, it is clear that the use in both cases of the same coefficients—0.4 and 1—will greatly modify the calorie allowance for the child. In 1934, in a study of nutrition in families of partly or wholly unemployed workers, BIGWOOD and ROOST adopted a system of coefficients designed to overcome these difficulties. They took as the unit of the scale of family coefficients the allowance for an adult woman keeping house, whose work might be regarded as fairly uniform from one household to another.

The Technical Commission on Nutrition of the Health Organisation of the League of Nations approached this question again from a similar angle during sessions held in November 1935, June 1936 and November 1937 (*Bulletin of the Health Organisation* of the League of Nations, 1936, Vol. V, No. 3, and June 1938, Vol. VII, Extract No. 8). In the scale proposed by the Technical Commission, the unit represents the allowance for an adult male of average stature leading a sedentary life—that is to say, 2,400 net calories. In these circumstances, the coefficient of the male adult at work is above unity, and, by the adoption of different values above *1*, the same basic scale can be readily adjusted to different circumstances. In other words, the scale is more flexible and easier to adapt. It can also be easily brought into line with different views of the physiologists who use it. It is not universally agreed that an allowance of 2,400 calories is sufficient in the long run for a man of average height exerting little physical effort. Some physiologists believe, at all events, that a certain rate of expenditure represents an optimum for health, that the rate represented by 2,400 calories for an adult man of average stature is below this optimum and is inconsistent in the long run with a proper state of health, even though the requirements of mechanical work should be reduced for a while to a minimum and could be covered by this allowance of 2,400 net calories. However that may be, the same basic scale, with 2,400 calories as a unit, will serve, in practice, in all circumstances and enable the results of surveys to be readily compared. The figure taken for reference may be unity (2,400 calories net) or 1.25 (3,000 calories), or again 1.3 (3,100 calories), etc., as preferred by the observer.

If, however, it is accepted that, for the majority of occupations and in countries with a temperate climate, the optimum rate of expenditure for an adult man of average height weighing 65 to 70 kilogrammes is nearly always in the neighbourhood of 3,000 net calories per day, then the scale in which unity corresponds to 3,000 net calories may also be used and is undoubtedly of more practical value to the investigator, since it entails a minimum of calculation.

The last proposal of the Technical Commission (*Bulletin of the Health Organisation* of the League of Nations, June 1938) is reproduced *in extenso* below :

" The following supplements for muscular activity should be added to the basic requirements : [1]

" Light work: up to 75 calories per hour of work ;
" Moderate : 75 to 150 calories per hour of work ;
" Hard work : 150 to 300 calories per hour of work ;
" Very hard work : 300 calories and upwards per hour of work.

" The muscular activities characteristic of every healthy child and adolescent necessitate additions to the basic requirements. It is suggested that the activities of children of both sexes from 5 to 11 years be considered equivalent to light work ; of boys from 11 to 15 years, as moderate work ; and of girls from 11 to 15 upwards, as light work.

" It is obvious that the appraisal of the muscular activity of a given individual, as well as of the energy supplements involved, is but approximate at best. It is impossible to suggest a single set of figures which are internationally applicable, since the energy requirements of men, women and of children of different ages differ greatly from country to country and even within one and the same country, due to such factors as differences in the length of the working-day, differences in the intensity of activity, in average body size, in climate, etc. Therefore the Commission makes no attempt to suggest single figures for the total energy requirements of each category of individuals.

" Since, however, such figures are needed in connection with dietary surveys for constructing scales of relative requirements, the energy supplements required in addition to the basic allowances should be noted by the nutrition experts responsible for the dietary surveys. When the total energy requirements have thus been determined, scales of relative requirements can easily be developed, using as unity either 2,400 calories, the allowance for a sedentary man, or 3,000 calories, the allowance for a moderately active man.

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[1] The term " basic requirements " is understood to mean the allowance of 2,400 net calories for the sedentary man. This figure should not be confused with the basal metabolism rate, which involves, in particular, a state of fasting.

Schedules for recording Relative Energy Allowances.

Individual	Energy allowance for basic diets (without work) in net calories	Supplementary allowance for special activity		Total energy allowance in net calories [1]	Scale of relative allowances [2]	
		Number of hours of special activity	Number of calories per hour of activity		Total, 2,400 = 1.00	Total, 3,000 = 1.00
	1	2	3	4	5	6
Men (20 to 59 years) :						
Sedentary	2,400	—	—	2,400	1.00	0.80
Light work	2,400					
Moderate work	2,400	8	75	3,000	1.25	1.00
Hard work	2,400					
Very hard work	2,400					
(60 years and over) . . .	2,400					
Women :						
Ordinary life	2,400					
Housework	2,400					
Pregnant housework . .	2,400					
Nursing housework . . .	3,000					
Boys :						
Between 15 and 19 years .	2,400					
,, 12 ,, 15 ,,	2,400					
,, 11 ,, 12 ,,	2,160					
,, 9 ,, 11 ,,	1,920					
,, 7 ,, 9 ,,	1,680					
,, 5 ,, 7 ,,	1,440					
Girls :						
Between 15 and 19 years	2,400					
,, 12 ,, 15 ,,	2,400					
,, 11 ,, 12 ,,	2,160					
,, 9 ,, 11 ,,	1,920					
,, 7 ,, 9 ,,	1,680					
,, 5 ,, 7 ,,	1,440					
Children :						
Between 3 and 5 years	1,200					
,, 2 ,, 3 ,,	1,000					
,, 1 ,, 2 ,,	840					
Under 1 year [3]						

[1] Computed to nearest 100.

[2] Computed to nearest 0.05.

[3] To be computed on basis of weight.

"The preceding schedule (page 94) may be of use in drawing up such scales. *Column 1* contains the Commission's allowances for energy requirements in average basic diets. *Columns 2* and *3* provide space for the investigator's entry of the average number of hours during which the subjects are especially active, and the average number of calories per hour needed to support this activity. In *column 4* can be entered the total daily allowances. In *column 5* or *6*, the totals given in column 4 should be expressed as decimal fractions of the two values of unity—*i.e.*, 2,400 or 3,000 calories respectively.

"The decimal coefficient which is to be given in one of these two colums expresses the relation of the total ration (column 4) to the value of unity chosen.

"Scales based on either value of unity may be used in appraising the calorie value of diets, provided that the value of unity and the scale used are stated along with the results."

In order to illustrate the way in which the scales should be computed, the Commission cites the following arbitrary example :

Individual	Energy allowance for basic diets (without work) in net calories	Supplementary allowance for special activity		Total energy allowance in net calories	Scale of relative allowances	
		Number of hours of special activity	Number of calories per hour of activity		Total, 2,400 = 1.00	Total, 3,000 = 1.00
	1	2	3	4	5	6
Man, weighing about 70 kilogrammes, aged 20 to 59 years :						
Sedentary	2,400	0	—	2,400	1.00	0.80
Light work	2,400	8	35	2,700	1.15	0.90
Moderate work	2,400	8	75	3,000	1.25	1.00
Hard work	2,400	8	150	3,600	1.50	1.20
Very hard work . . .	2,400	7	300	4,500	1.90	1.50

As an illustration, a complete double scale of family coefficients (1 = 2,400 net calories and 1 = 3,000 net calories) is given on page 96, and this will serve in the great majority of cases, where the man of average size weighs from 65 to 70 kilogrammes.

	Net calories (to the nearest hundred)	First scale of coefficients, 1 = 2,400 net calories (round figures)	Second scale of coefficients, 1 = 3,000 net calorics (to the nearest 0.05)
Adult man, average height, engaged in an exceptionally fatiguing occupation (weight 65 to 70 kilogrammes)	3,400 to 4,000	1.4 to 1.7	1.1 to 1.3
Adult man, average size and height (great majority of occupations [1]) . . . . (Average energy expenditure ; weight 65 to 70 kilogrammes)	**3,000 (to 3,100)**	**1.25 (to 1.3)**	**1.0**
Adult woman, average height (housewife or worker [1]) ; pregnant, partially resting . .	2,600	1.1	0.85
Nursing woman, if not completely or partially resting	2,900	1.2	0.95
Theoretical standard : Average adult man not engaged in muscular work, occupational or other . .	2,400	**1.0**	0.80
Children over 14 years of age :			
Boys	2,400 to 3,000 (and over) [2]	1 to 1.25 (and over) [2]	0.80 to 1 (and over) [2]
Girls	2,400 to 2,600 (and over) [2]	1 to 1.1 (and over) [2]	0.80 to 0.85 (and over) [2]
Children without distinction of sex :			
12 to 14 years	2,400	1.0	0.80
11 to 12 ,, . . .	2,200	0.9	0.75
9 to 11 ,, . . .	1,900	0.8	0.65
7 to 9 ,, . . .	1,700	0.7	0.55
5 to 7 ,, . . .	1,400	0.6	0.45
3 to 5 ,, . . .	1,200	0.5	0.40
2 to 3 ,, . . .	1,000	0.4	0.35
1 to 2 ,, . . .	800	0.35	0.25
0 to 1 ,, . . .	600 [3]	0.25	0.20

[1] These figures should be reduced by at least 10%, and eventually by 20%, for subjects aged 60 years and over.

[2] Figures higher than the maximum shown must be adopted where adolescents follow a fatiguing occupation or expend a great deal of energy in a general way.

[3] For a child aged from 6 to 12 months, the ration is from 80 to 90 calories per kilogramme ; from 3 to 6 months, 90 to 100 ; from 0 to 3 months, 100 to 110.

As regards the first item of the table—*i.e.*, subjects of average size whose requirements admittedly exceed the average because their work is particularly fatiguing, the problem still awaits solution. Many investigations into the nutrition of workers engaged in extremely fatiguing occupations deal with subjects above the average stature, whose higher calorie requirements are due, in part at least, to this circumstance ; or, again, they relate to occupations in cold climates. Moreover, *abnormally* fatiguing occupations which cannot be followed without an eventual loss of normal health are becoming increasingly rare. Where they still exist, it is hard to say for how many hours the greatest exertion is actually continued. Consequently, daily calorie requirements cannot be easily assessed in these exceptional cases, in which they tend to diverge from the mean. In deciding which coefficient to adopt as between 1.4 and 1.7 (for the first scale) or as between 1.1 and 1.3 (for the second), the investigator must rely on his own judgment ; in either case, the figure he selects is bound to be more or less arbitrary. It is probable that in extreme cases the following approximate estimate is more or less reasonable : an additional 200 calories per hour of work over and above the 2,400—*i.e.*, 4,000 net calories for the man of average size doing exceptionally fatiguing work (8-hour day) ; or 3,800 net calories per day for a 40-hour week. The corresponding coefficients are : 1.7 and 1.6 for the first scale ; 1.3 and 1.25 for the second. The arbitrary, conventional and approximate nature of these scales should be emphasised.

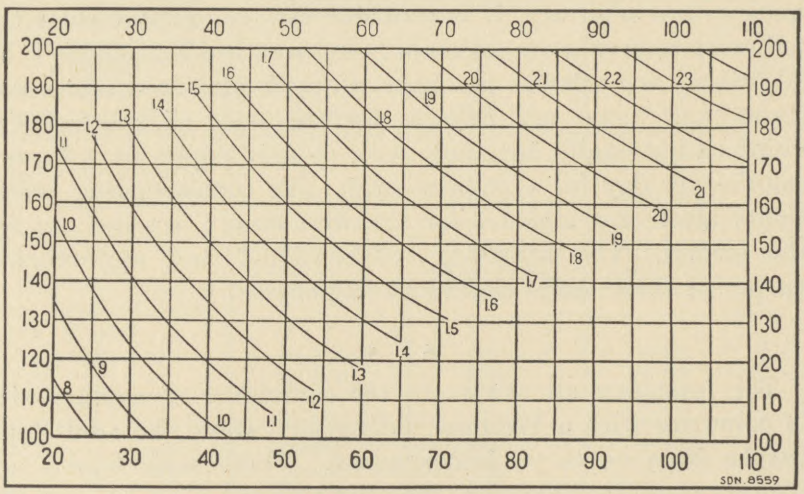
* * *

The foregoing all relates to the individual of average size in countries with a Western civilisation, where the adult man weighs from 65 to 70 kilogrammes. These scale figures are therefore appropriate for the comparison of mean results calculated from data relating to a sufficiently large number of families.

For surveys covering one family or a few families considered singly, the stature of the individual should, however, be taken into consideration as far as possible.

Take first the case of the adult.

Insufficient data are available for determining precisely how the energy requirements of a man at work vary in relation to his size, so that nothing more than a theoretical and conventional calculation can be attempted in order to obtain an approximate idea of this relation. Energy requirements may be related either to weight, or—more rationally—to body surface-area. In the latter case, the line of approach is the same as that generally adopted in dealing with the basal metabolism rate. It is preferable, in fact, to consider these values as proportional to the variations of the active mass of the body—*i.e.*, those parts only which use up an appreciable amount of energy (to the exclusion of the skeletal system for instance). The physiologist knows from the law of surfaces that the surface-area of the body varies according to the active mass. This surface-area can be calculated as a function of the height and weight by means of Dubois-Lusk's diagram reproduced below.



Dubois-Lusk's Diagram.
Ordinate Scale : Height in centimetres.
Abscissa Scale : Weight in kilogrammes.
The curves show the surface area of the body in square metres.

Example : height, 1.63 metre ; weight, 65 kilogrammes ; body surface-area, 1.7 square metre.

If it is agreed that the deviation of requirements from the mean varies approximately as the deviation of the surface-area from the mean, then, within a very wide range of variations of size, the calorie requirements are modified more or less as follows :

Adult male. — Average height about 1.65 metre. Average weight about 65 kilogrammes. Average surface-area, 1.7 square metre.

Possible normal variation of surface-area, 1.4 to 2.3 square metres (for a weight variation of 50 to 100 kilogrammes). That corresponds to a margin of variation of from —17% to +35% around 1.7 square metre. The same margin of variation for energy requirements can be shown as follows :

Moderate work. — 3,000 net calories for a subject of average size. Margin of from —17% to +35% = *2,500* to *4,000* net calories in round figures, according to size.

Very fatiguing work. — 4,000 net calories for a subject of average size. Margin of from —17% to +35% = *3,300* to *5,400* net calories, according to size.

The corresponding coefficients can easily be calculated on a basis of 2,400 or 3,000 as unity.[1]

Adult woman. — Average height about 1.5 metre. Average weight about 55 kilogrammes. Average surface-area about 1.5 square metre. Possible normal variation in size : 1.3 to 2 square metres (for a variation in weight of from 45 to 85

[1] Here are two examples of the calculation of an appropriate coefficient :

(1) Take the case of a man whose occupation is such that, if he is of average size (1.7 square metre), his energy requirements must be put at 4,000 net calories per day instead of 3,000. His coefficient will be 1.7 instead of 1.25 on the first scale ; or 1.3 instead of 1 on the second scale, in the table on page 96. Suppose now his size were 2 square metres instead of 1.7 (*i.e.*, height 1.80 metre, weight 80 kilogrammes), then his theoretical calorie requirement will be 4,000 × $\frac{2}{1.7}$ = 4,700 net calories, and his corresponding coefficient will be 1.7 × $\frac{2}{1.7}$ = *2.0* on the first scale, or 1.3 × $\frac{2}{1.7}$ = *1.53* on the second scale, in the table on page 96.

(2) Take the case of a man of average occupation as regards fatigue. His calorie requirements will be 3,000 net calories if his size is average (1.7 square metre). But suppose that he were small (say, height 1.60 metre and weight 58 kilogrammes—*i.e.*, a surface of 1.6 square metre instead of 1.7 square metre), then his theoretical requirement in net calories would be 3,000 × $\frac{1.6}{1.7}$ = 2,800 net calories, and his corresponding coefficient would be 1.25 × $\frac{1.6}{1.7}$ = 1.18 on the first scale, or 1.× $\frac{1.6}{1.7}$ = 0.94 on the second scale in the table on page 96.

kilogrammes). That corresponds to a margin of variation of from —13% to +34% around 1.5 square metre. The same margin of variation for energy requirements can be shown as follows:

Average work. — 2,600 net calories for a subject of average size. Margin of from —13% to +34% = *2,300* to *3,500* net calories. The corresponding coefficients for a basis of 2,400 or 3,000 can easily be calculated.[1]

Those are extreme theoretical variations, for experience shows that the basal metabolism rate of short and stocky subjects is relatively slow compared with that of tall and slender subjects. Account must also be taken of individual variations among subjects of the same size; for it is a question of endocrine equilibrium. There are large and small eaters among individuals of the same size, so that, having adopted a norm for a given individual, it will certainly be advisable to allow a further margin of from —5% to +10% for deviations from this theoretical figure caused by the individual factor.

Lastly, if the calculation of individual divergences from the mean owing to differences of size is based on their weight instead of on their surface-area, a slightly wider margin is obtained than that shown above.

Take now the case of children.

The table on page 96 gives the figures for a child of average size.

(1) *For children aged* 14 *years and over,* the table gives different figures according to sex and the nature of the work done, if any. The coefficient adopted must, as with adults, be adjusted to the extent to which the child's size exceeds or falls below the mean. The surface-area should be used in such calculations. Biometric tables suited to the country under consideration should be employed for this purpose. Tables of this kind are appended as an example. They show the

[1] The principle of this calculation is the same as that for a man (see note on page 99.)

variations of weight and height in children of both sexes in the United States, in Belgium and in the Netherlands (schools at The Hague).

The body surface-area corresponding to the figures for height and weight given by these biometric tables can easily be ascertained from Dubois-Lusk's diagram, and a calculation made of the percentage deviation of any particular surface-area from the surface-area given for the average size for a given age.

Either the survey provides particulars of the height and weight of the members of the family, and the body surface-area is then calculated direct from the Dubois-Lusk tables, or the survey only provides particulars of height. The biometric tables show the corresponding average weight, and from this a calculation can be made as to what the average body surface should be for a particular height. A similar calculation can still be made if the survey only provides particulars of weight. Lastly, in the case of unusually thin subjects, it is possible from the biometric tables to calculate what the coefficient should have been had the figure been normally plump. It is accordingly possible from the adjusted coefficient to form a fairly close estimate of the amount of extra nutrition required.

(2) *For children under* 14 *years of age*, the only point to be considered is whether they are big, average, or small for their age, and the coefficient given in the table on page 96 should be adjusted accordingly. Here are a few examples based on the first scale in this table:

Coefficient 0.6 : Big child of 5 years
Average child of 6 years
Small child of 7 years

Coefficient 0.65: Big child of 6 years
Average child of 7 years
Small child of 8 years

For very young children (under 2 years), the coefficients given in the table should be adopted as they stand.

It has just been shown that recent scales of family calorie coefficients sometimes adopt as their unit the allowance of the adult male of average stature, doing moderately fatiguing work (3,000 calories), and sometimes the 2,400 calories unit, which is the allowance of the adult man of average stature not engaged in muscular work. Is the following inference justified ?

In all family surveys made hitherto, the total intake of the household has been reduced by coefficients to terms of that of a man doing moderately fatiguing work. Should this practice be discontinued for the future ?

This question must certainly be answered in the negative. Whatever the circumstances, and whatever the scale employed, it is reasonable to express the aggregate allowance of a family in terms of that of the theoretical adult male of average size doing moderate work, even if no such person exists in the household under consideration. In other words, the standard figure remains at 3,000 calories, and this serves as a basis of comparison for all nutrition surveys concerned solely with families. Here are three examples to illustrate this idea (the calculations are based on the two scales given in the table on page 96) :

First Example :

Family consisting of one adult man of average size, engaged in moderately fatiguing work ; one adult woman (housewife) of average size ; and a child of 4. The nutrition survey shows that the daily intake of the family corresponds to 6,370 net calories :

	First scale 1 = 2,400 calories	*Second scale* 1 = 3,000 calories
Family coefficient	$1.25 + 1.1 + 0.5 = 2.85$	$1 + 0.85 + 0.4 = 2.25$
Family intake figure reduced to terms of intake of the adult man of average size engaged in moderately fatiguing work (to the nearest hundred)	$6{,}370 \times \frac{1.25}{2.85} = 2{,}800$	$6{,}370 \times \frac{1}{2.25} = 2{,}800$
	Basis of comparison = 3,000	

Second Example:

Family consisting of one adult male of average size, engaged in fatiguing work and requiring a ration of 4,000 calories; one adult woman (housewife) of average size, and no children. The daily family intake is *6,950* net calories.

	First scale 1 = 2,400 calories	*Second scale* 1 = 3,000 calories
Family coefficient	$1.7 + 1.1 = 2.8$	$1.3 + 0.85 = 2.15$
Family intake figure reduced to terms of intake of an adult man of average stature engaged in moderately fatiguing work (to the nearest hundred)	$6{,}950 \times \frac{1.25}{2.8} = 3{,}100$	$6{,}950 \times \frac{1}{2.15} = 3{,}200$
	Basis of comparison = 3,000	

Third Example:

Family consisting of a woman (housewife) of average size, a child aged 13, and a child aged 4. The daily intake of the household amounts to 6,150 net calories.

	First scale 1 = 2,400 calories	*Second scale* 1 = 3,000 calories
Family coefficient	$1.1 + 1 + 0.5 = 2.6$	$0.85 + 0.8 + 0.4 = 2.05$
Family intake figure reduced to terms of the intake of an adult man of average stature engaged in moderately fatiguing work	$6{,}150 \times \frac{1.25}{2.6} = 2{,}950$	$6{,}150 \times \frac{1}{2.05} = 3{,}000$
	Basis of comparison = 3,000	

The results obtained by calculation with the first and second scale respectively are not exactly the same, because the coefficients are round figures, and so are not absolutely accurate. They are, however, sufficiently exact for such purposes.

This method of calculation enables comparisons to be made between families of different composition, but a calculation can also be made of the intake of any particular member of a family, instead of that of a theoretical person such as the adult male of average stature engaged in moderately fatiguing work.

* * *

The scales of family calorie coefficients just discussed are accordingly valid for all countries subject to the following three conditions :

(*a*) That an adult man shall weigh on the average 65 to 70 kilogrammes ;

(*b*) That the rate of basal metabolism in the adult shall be that of countries of Western civilisation in temperate climates ; and

(*c*) That the mean weight and height of new-born infants, the rate of growth and the average age at which maturity is reached shall correspond to those recorded in countries of Western civilisation.

In those parts of the world—the Far East, colonial territories, etc.—in which one or more of these conditions are not satisfied, the scales of coefficients discussed above can be employed only after certain adjustments.

Let us, in this connection, refer back to the table on page 96 and take a country such as the Netherlands East Indies, in which the adult man of average stature weighs about 50 kilogrammes instead of 65 to 70 kilogrammes.

Under conditions of moderately fatiguing work, his energy requirements would be something approaching 2,400 net calories instead of 3,000, and the scale would have to be re-adjusted accordingly. It would similarly have to be modified for children, bearing in mind : (1) the difference between the average size of new-born babies in that country and in those of Western civilisation ; (2) the rate of growth as well as the age at which maturity is reached. It may be observed that there are some countries in which like considerations apply, notwithstanding the fact that the average stature of the adult man corresponds more or less to that of a man weighing 65 to 70 kilogrammes.

By way of example, we subjoin two types of scales published in the Report of the Intergovernmental Conference of Far-Eastern Countries on Rural Hygiene, held at Bandoeng in August 1937, under the auspices of the League of Nations Health Organisation (pages 81 and 85 of the report).

1. *Scale adopted in the Southern Parts of India.*

SCALE OF AVERAGE CALORIE REQUIREMENTS

	Coefficient	Calories required
Adult male (over 14)	1.0	2,600
Adult female (over 14)	0.8	2,080
Child 12 and 13 years.	0.8	2,080
Child 10 and 11 years.	0.7	1,820
Child 8 and 9 years.	0.6	1,560
Child 6 and 7 years.	0.5	1,300
Child 4 and 5 years.	0.4	1,040
Child 2 and 3 years.	0.3	780
Child 0 to 2 years	0.2	520

2. *Scale adopted in Japan.*

CALORIE AND PROTEIN REQUIREMENTS IN VARIOUS AGE AND SEX GROUPS

Age	Male			Female		
	Coefficient	Calories	Protein grammes	Coefficient	Calories	Protein grammes
0-2	2	480	20	2	480	20
3-4	4	960	40	4	960	40
5-7	5	1,200	50	5	1,200	50
8-10	7	1,680	70	6	1,440	60
11-14	8	1,920	80	8	1,920	80
15-20	10	2,400	100	9	2,160	90
21-50	10	2,400	80	8	1,920	60
51-60	10	2,400	60	7	1,680	40
60-above	9	2,160	45	6	1,440	30

* * *

Scales of Consumption Coefficients for Nutritive Principles other than Energy-bearing.

The scales of consumption coefficients just examined can be used only for calories and are therefore concerned with the amount of energy-bearing nutrients considered as a whole. They cannot be employed for proteins, mineral elements or vitamins. Though, for example, the normal calorie allowance of a child of 4 is on the average 60% less than that of its father, the normal calcium allowance would only be 30% less than its father's, at the outside. Hence, generally speaking, different scales should be drawn up for every kind of nutritive principle other than energy-bearing principles considered as a whole. But this is an ambition which is still unattainable in the present state of our knowledge. In the case of vitamins especially, a long time must still elapse before definite exact data are available as to the mean values of bodily needs in relation to age, sex and energy expenditure. The following brief notes show the limited extent of our knowledge on this subject.[1]

Vitamin A. — The allowance which is probably adequate for an adult is assessed at a figure somewhere between 2,000 and 4,000 international units (I.U.).[2] No indications are available for children.

Vitamin B_1. — An allowance of 10 I.U. per 100 calories would appear to be sufficient in the case of adults—*i.e.*, 300 I.U. for a man weighing 65 to 70 kilogrammes consuming 3,000 net calories. The pregnant or nursing mother would probably require more, and children of pre-school age about 200 to 250 I.U. a day. Infants would require 10 to 15 I.U. per 100 calories.

Vitamin C. — Adults require at least 30 milligrammes a day.[3] For infants, the normal amount would be 5 to 15 milligrammes.

Vitamin D. — Fairly accurate values have been obtained only in the case of children (400 to 500 I.U. a day).

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[1] *Bulletin of the Health Organisation* of the League of Nations, Vol. VII, 1938, Extract No. 8.

[2] The few observations so far published on this subject differ as to results, partly because they use different vitamin-A units.

[3] Many authors are of opinion that this figure should be raised to an average of 50 milligrammes.

The few data given above are insufficient to enable a scale of family coefficients to be drawn up, though an attempt to do so has been made by American physiologists (see tables, page 110). In other countries, such an attempt is regarded as premature. Little is known of the factors on which vitamin requirements depend ; in any case, these requirements appear to vary in different individuals.

It would seem preferable at the present stage to express vitamin intakes in international units per day and per head.

* * *

So far as the *proteins* are concerned, the following table gives figures calculated from the tables published by the Technical Commission of the *Bulletin of the Health Organisation* of 1936 (Vol. V, Extract No. 6, C.H.1197(2)) :

	Grammes of protein per day	Coefficient (to nearest 0.05)
Adult man	70	1
Adult woman	60	0.85
Nursing or expectant mother	105	1.5
Children 12 to 14	69	1
,, 5 to 7	64	0.9
,, 3 to 5	53	0.75
,, 2 to 3	46	0.65
,, 1 to 2	37	0.55

A scale of this kind is, however, not thought to be adequate for all countries. The reader will find in the tables on pages 110 to 112 other protein scales adopted in certain countries of Western civilisation.

Page 105 sets forth the protein table which is in use in Japan, the scale which has been adopted in India (report of the Bandoeng Conference, document A.19.1937.III, page 81) is as follows :

	Grammes of protein per day	Coefficient
Man, 18 to 60	65	1
Woman, 18 to 60	55	0.85
Boy, 10 to 17	80	1.20
Girl, 10 to 17	70	1.10
Child, 6 to 9	60	0.90
Child, 2 to 6	40-50	0.6 to 0.8

* * *

Scales for calcium and phosphorus have been proposed in certain countries. It is difficult, however, at the moment to propose an internationally valid scale.

In the case of calcium and phosphorus, estimations of intake per head are at present probably at least as satisfactory as those based on more detailed scales. The normal calcium intake of an adult male weighing 70 kilogrammes varies between 0.75 and slightly more than 1 gramme, according to the country (in countries with a Western civilisation). The intake of a pregnant or nursing mother should be somewhat higher ; that of children, from 0.8 to 1 gramme (except in the case of breast-fed infants). An assessment per head is therefore suitable for rough estimates.

A difficulty in drawing up multiple scales of coefficients for the various nutritive principles in a diet is that such scales must have a common standard—*i.e.*, the unit of each scale must refer to some specified standard diet. The units of all these scales provide the key to the whole ; but there are many problems having a bearing upon the whole set of scales which are still unsolved. Thus, it is recognised that energy requirements vary in proportion to the amount of energy expended, so that the food intake must vary accordingly ; but the question whether the bodily requirements of protective principles also vary, and, if so, to what extent, is still unanswered. If an adult of average size needs only 2,500 calories and another of the same size needs 4,000 calories because he expends much more energy than the first, should the protein, calcium, phosphorus, iron and vitamin intake remain the same in both cases, or should it also vary ?

The system of combined scales which is in use in the United States of America is based on a scale of the variation of the optimum composition of the diet in that country (Grade-A diets of the American classification) according to age, sex and conditions of work. This scale is shown on page 110. Part of it is reproduced on page 111. The values have been converted into a corresponding system of coefficients. In this way, the American system of family coefficients is presented in a form which renders it more easily comparable with another type of coefficient system, which is shown on page 112.

The American scale suggests that the variation of the calorie requirements should not entail a concomitant variation of requirements in protective principles. Thus the table shows that, for an adult man, whose calorie intake may vary from 2,400 to 4,500 calories according to the energy expended, needs in respect of proteins and other protective principles remain unchanged.

In other countries, physiologists and health experts are not of opinion that this must be the case. It is, moreover, difficult, if the balance of the diet is to be maintained, to make any substantial change in the calorie intake without, at the same time, varying the supply of protective principles. The further scheme of combined scales following the American system, which is shown on page 112, suggests that, so far as the requirements of protective principles are concerned, the values corresponding to the units of each scale are, on the average valid only if the energy allowance of the adult male is 3,000 net calories. The two systems are reproduced here for purposes of comparison, without any preference being shown for either, as it is still difficult to reach a decision in the matter. The author of the present monograph is of opinion, however, that the last system (page 112) is probably the most suitable at present, in the case of such countries as Belgium, for example.

SUMMARY

The state of our knowledge permits only of the adoption of scales of calorie coefficients at present.

In the case of dietary constituents other than energy-bearing ones, it is preferable at present to make assessments per head, regardless of age or sex.

Nevertheless, systems of scales for calories, for the various protective principles, and for cost of diet have been proposed. *No matter what system is adopted, however, it is essential to indicate in detail the values respectively adopted as scale units for the several nutritive principles.*

* * *

UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF HOME ECONOMICS, WASHINGTON, D.C.

Minimum Quantities of Specified Nutrients to be furnished by Grade-A Diets of the American Classification.

	Calories	Protein[1]	Inorganic elements (in grammes)			Vitamins (in Sherman units)			
			Calcium	Phosphorus	Iron	A	B1	C	Lactoflavin
Child under 2 years	900	35	1.00	1.00	0.005-0.007	4,000	200	75	400
Child 2-3 years	1,200	45	1.00	1.00	0.006-0.009	4,500	240	105	450
Boys: 4-6 years	1,500	55	1.00	1.00	0.008-0.011	4,500	300	105	450
7-8 ,,	2,100	65	1.00	1.00	0.011-0.015	5,400	420	105	540
9-10 ,,	2,400	75	1.00	1.20	0.012-0.015	5,400	480	120	540
11-12 ,,	2,500	75	1.00	1.20	0.013-0.015	6,000	500	135	600
13-15 ,,	3,000	75	0.88	1.32	0.015	6,000	600	150	600
16-19 ,,	3,000-4,000	75	0.88	1.32	0.015	6,000	720	180	600
Girls: 4-7 years	1,500	55	1.00	1.00	0.008-0.011	4,500	300	105	450
8-10 ,,	2,100	65	1.00	1.00	0.011-0.015	5,400	420	105	540
11-13 ,,	2,400	75	1.00	1.20	0.012-0.015	5,400	480	120	540
14-19 ,,	2,500	75	1.00	1.20	0.013-0.015	6,000	500	135	600
Men 20 years or over:									
Active work	4,500	67	0.68	1.32	0.015	6,000	600	150	600
Moderate work	3,000	67	0.68	1.32	0.015	6,000	600	150	600
Women 20 years or over:									
Active work	3,000	67	0.68-1.00	1.32	0.013-0.015	6,000	600	150	600
Moderate work	2,500	67	0.68-1.00	1.32	0.013-0.015	6,000	500	135	600

[1] 40% or more to be derived from foods containing proteins of high biological value.

American Scale of Coefficients

	Calories [1]	Calories [2]	Protein [3]	Calcium [4]	Phosphorus [5]	Iron [6]
Men 20 years or over:						
Active work	1.90	1.5	1	1	1	1
Moderate work ..	1.25	*1.0*	1	1	1	1
Sedentary condition	*1.00*	0.80	1	1	1	1
Women 20 years or over:						
Active work	1.25	1.0	1	1 to 1.5	1	1
Moderate work ..	1.05	0.85	1	1 to 1.5	1	1
Boys: 16-19 years.	1.25 to 1.65	1 to 1.3	1.1	1.3	1	1
13-15 ,, .	1.25	1.0	1.1	1.3	1	1
11-12 ,, .	1.05	0.85	1.1	1.5	0.9	1
9-10 ,, .	1.00	0.80	1.1	1.5	0.9	1
7-8 ,, .	0.90	0.70	0.95	1.5	0.75	1
4-6 ,, .	0.65	0.50	0.80	1.5	0.75	0.75
Girls: 14-19 years	1.05	0.85	1.1	1.5	0.9	1
11-13 ,, .	1.00	0.80	1.1	1.5	0.9	1
8-10 ,, .	0.90	0.70	0.95	1.5	0.75	1
4-7 ,, .	0.65	0.50	0.80	1.5	0.75	0.75
Children: 2-3 years	0.50	0.40	0.65	1.5	0.75	0.60
0-2 ,, .	0.40	0.30	0.50	1.5	0.75	0.45

[1] 1 = 2,400 calories.

[2] 1 = 3,000 calories.

[3] 1 = 67 grammes of protein.

[4] 1 = 0.68 gramme of calcium.

[5] 1 = 1.32 gramme of phosphorus.

[6] 1 = 0.015 gramme of iron.

E. J. Bigwood's System of Scales

	Net calories	Proteins	Calcium	Phosphorus	Cost
Adult male of average size, performing moderately heavy work	1.00	1.00	1.00	1.00	1.00
Adult female	0.85	0.85	0.85	0.85	0.85
Pregnant or nursing mothers	0.90	0.90	1.4	1.1	0.9
Children over 14 years of age	0.90-1.0 and over	0.90-1.0 and over	1.1 and over	1.0 and over	0.90-1.0 and over
Children :					
12 to 14 years . . .	0.80	0.80	1.0	0.85	0.80
11 to 12 ,, . . .	0.75	0.75	1.0	0.80	0.75
9 to 11 ,, . . .	0.60	0.60	0.9	0.75	0.70
7 to 9 ,, . . .	0.55	0.55	0.9	0.70	0.65
5 to 7 ,, . . .	0.45	0.50	0.85	0.65	0.60
3 to 5 ,, . . .	0.40	0.40	0.80	0.55	0.40
2 to 3 ,, . . .	0.35	0.35	0.80	0.50	0.35
1 to 2 ,, . . .	0.25	0.30	0.80	0.45	0.25
0 to 1 ,, . . .	0.20	—	—	—	—

The units of the first four scales of the above table represent the following values :

Net calories . . 1 = 3,100.
Proteins . . . 1 = 110 grammes.
Calcium. . . . 1 = 1 gramme.
Phosphorus . . 1 = 1.5 gramme.

Chapter XI

ECONOMIC VALUE OF FOODSTUFFS AND DIETS

The cost of foodstuffs naturally varies a great deal between one country and another. The question of nutrition presents as many economic problems as there are countries on the surface of the globe.

Certain general indications may, however, be given regarding the economic aspect of the problem of nutrition, which are of universal application.

I. Comparison of the Cost of Different Foodstuffs in One and the Same Country

Each foodstuff is considered separately for purposes of comparison. The unit of comparison may be the unit of weight —*e.g.*, the kilogramme; but from the physiological point of view, the unit should preferably be a common value relating to certain nutritive principles such as calories.

The following table sets out, by way of example, a list of various foodstuffs consumed in Brussels during the winter of 1932 and their prices expressed in terms of the cost of 100 gross calories provided by these foodstuffs (5 francs = 1 belga of that period)[1] (Bigwood and Roost, *loc. cit.*):

	Cost Belgian francs
100 gross calories derived from eggs	1.00
,, ,, ,, ,, ,, vegetables	0.95
,, ,, ,, ,, ,, fruit	0.90
,, ,, ,, ,, ,, pork chops	0.83
,, ,, ,, ,, ,, fresh beef	0.77
,, ,, ,, ,, ,, liver paste	0.74

[1] 100 Belgian francs, or 20 belgas, were roughly equivalent at that time to 16*s*. 10½*d*., $2.77, or 70.95 French francs.

		Cost Belgian francs
100 gross calories derived from	chilled beef	0.72
,, ,, ,, ,, ,,	black pudding (boudin noir)	0.48
,, ,, ,, ,, ,,	white liver sausage (boudin blanc)	0.37
,, ,, ,, ,, ,,	milk	0.28
,, ,, ,, ,, ,,	pork sausage	0.24
,, ,, ,, ,, ,,	butter	0.24
,, ,, ,, ,, ,,	skim-milk	0.21
,, ,, ,, ,, ,,	margarine	0.18
,, ,, ,, ,, ,,	potatoes	0.13
,, ,, ,, ,, ,,	lard	0.12
,, ,, ,, ,, ,,	white bread	0.06
,, ,, ,, ,, ,,	beef suet	0.05

By means of such comparisons, it is possible to show the return in calories which can be obtained with each kind of foodstuff. In many countries it is found that the cost per calorie is often proportionately higher, the greater the content of protective principles in the foodstuff considered ; thus, the calories of vegetables and fruit are dearer than those of beef suet or lard. Foods containing both kinds of nutritive principles will be found halfway down the list. If foods having roughly the same energy value are compared, those containing most protective principles will generally be found to be more expensive (compare butter and margarine or potatoes and white bread in the above list). There are, however, exceptions to these rules.

Speaking generally, it is preferable to consider the cost of a diet as a whole rather than that of each foodstuff separately, since in this way allowance is made for the varying proportions in which the several foodstuffs enter into the diet.

II. Cost of Diet

The total cost of the diet of a group of people—*e.g.*, a family—may be considered first.

In this case, too, calorie value in relation to cost may be taken as a basis for comparison.

Dietary surveys enable the cost of diets to be ascertained (see Annexes), and their energy value may be calculated by analysing them from the physiological standpoint. Conditions differ, it is true, from place to place, but in some countries experience has shown that the cost of the calorie may vary considerably even in the case of food bought by persons of the same class from the same type of tradesman in the same district and during the same period. During the winter of 1932, among families of insured unemployed in Brussels, the return in calories per franc spent on food varied, for example, from 370 to 670 net calories. A detailed analysis of the data showed that the diets containing a large number of calories per franc—that is, " cheap calorie " diets—were those which provided the consumer with little protective principle. Such diets contain little meat; few eggs, if any; little fruit or vegetables; a great deal of bread as compared with potatoes; and, in general, many starchy foods. In respect of fats, they are the diets which contain little butter as compared with margarine, beef suet and lard. The converse is true of diets with a low energy-yield per franc. These facts are shown in the table on page 116 (Bigwood and Roost, *loc. cit.*; see also Bigwood, *Revue de l'Institut de Sociologie*, Institut de Sociologie Solvay, Brussels, 1936, sixteenth year, No. 3).

It is no doubt true, and should be emphasised once more, that the situation is far from being the same everywhere; nevertheless, these conditions are frequently encountered in many countries. A large proportion of the poorer classes generally satisfy their hunger at small cost by doing without foodstuffs rich in protective nutrients. The poor man's diet usually contains a superabundance of carbohydrates, as compared with fats and proteins. Such conditions are most marked in certain oriental and tropical countries, where serious forms of deficiency disease are widespread and frequent; but the same phenomenon is observed, though in a less marked degree, in many Western countries. It is therefore essential to consider the economic problem from this angle.

	Cheap calorie diets			
	Household IV		Household VII	
Calories per franc	610		670	
Carbohydrates	33%		37%	
Fats	13%	80%	9%	52%
Milk	34%		6%	
Meat and fish	5.5%		33%	
Eggs	0%	20%	0%	48%
Vegetables, fruits, miscellaneous	14.5%		15%	
Bread/potatoes	4/3		3.3/3	
Butter	33%		0%	
Beef suet, lard	67%		20%	
Margarine	0%		80%	
Fat-soluble vitamins	R		R	
Vitamin C	R		R	

	Dear calorie diets			
	Household I		Household IX	
Calories per franc	370		380	
Carbohydrates	18%		16%	
Fats	16%	48%	9%	30%
Milk	14%		5%	
Meat and fish	18%		32%	
Eggs	6%	52%	7%	70%
Vegetables, fruits, miscellaneous	20%		31%	
Bread/potatoes	1.4/3		1/3	
Butter	71%		75%	
Beef suet, lard	29%		25%	
Margarine	0%		0%	
Fat-soluble vitamins	A		A	
Vitamin C	R		A	

R = rare. A = more abundant.

The group of carbohydrates, fats *in general* and milk, comprises the less expensive foods. It occupies a more prominent place in the "cheap calorie" diets than in the "dear calorie" diets.

The converse is true of the group of more expensive foods (meat and fish, eggs, vegetables and fruit).

In these parts of the table, the figures express percentages of total expenditure on food.

It will be observed that, as regards the proportions by weight of bread and potatoes, the former preponderates in the first type of diet, the latter in the second.

In the group of three alimentary fats, the figures denote percentages by weight of the group as a whole.

* * *

Another way of approaching the same problem is to distribute the total cost of the diet among the main foods or groups of foodstuffs composing the diet. The object is to ascertain the percentage of the total cost of the diet which is accounted for by purchases of meat, milk and its derivatives, bread, vegetables, etc. Separate studies of such distribution must be made on the diet of adults and that of children of various ages. By way of example, the reader will find below a table showing such distribution in the case of the normally balanced diet of an adult in Brussels, prices being quoted for three different classes of tradesmen (A, B and C).[1]

Such studies may yield conclusions that will be of value in different ways, according to the country considered. The following example can be given in the case of Belgium : Green vegetables, the consumption of which is so apt to be inadequate, are nevertheless a far less expensive item than meat or milk and its derivatives, even when the diet is well balanced and contains appreciable quantities of this class of foodstuff (only from 6 % to 7 % of the total cost of a normal diet). The reason for any deficiency of vegetable food is therefore probably not the cost but the amount of trouble involved in the preparation and cooking, and the expenditure of fuel entailed. The importance of observations of this kind when studying nutrition from the economic or educational standpoint will be readily appreciated.

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[1] E. J. Bigwood : " Importance de l'alimentation rationnelle en hygiène sociale ", Eleventh National Child Welfare Congress, *Revue belge de Puériculture*, No. 3, September 1937.

It is important to determine what proportion of the food budget should be allocated to foodstuffs poor in protective constituents ; it is similarly important to know what proportion of the total energy supply of the diet should normally be furnished by foods of this type.

Approximate Mean Cost of a Normally Balanced Diet in Brussels.

March to May 1937.

Adults.

(Average expenditure per day in Belgian francs.) [1]

	Average for both sexes, including children over 14 years of age			Pregnant or nursing mothers		
	A	B	C	A	B	C
Milk	0.85	0.95	0.95	1.25	1.45	1.45
Butter	2.20	2.20	1.80	2.20	2.20	1.80
Meat, fish, etc.	2.20	2.90	2.90	1.85	2.40	2.40
1 egg	0.65	0.65	0.45	0.65	0.65	0.45
Cheese (Dutch)	0.50	0.50	0.50	0.50	0.50	0.50
Green vegetables	0.75	0.75	0.75	0.75	0.75	0.75
Potatoes and roots	0.40	0.40	0.40	0.40	0.40	0.40
Dried legumes	0.10	0.10	0.10	0.10	0.10	0.10
Fruits	0.75	0.75	0.75	1.00	1.00	1.00
Cereals, bread						
Sugar	1.35	1.35	1.35	1.20	1.20	1.20
	9.75	10.55	9.95	9.90	10.65	10.05
One extra half-egg per day				10.20	11.00	10.30
Plus 10%	*10.70*	*11.60*	*11.00*	*11.20*	*12.10*	*11.35*
General approximate average	*11.10*			*11.60*		

[1] 100 Belgian francs (20 belgas) were roughly equivalent at that time to 13*s.* 8½*d.*, $3.37, or 74.55 French francs.

III. Scales of Family Coefficients for Cost of Diet

There remains one last point to consider in connection with the relative cost of the food consumed by various members of a social group and, in particular, of a family. How much does a child's diet cost relatively to that of an adult ? Here, again, the scales will differ from one country to another. Reference may be made, by way of example, to the scale which applies to the normally balanced diet in Belgium (see page 112).

* * *

IV.

In various countries, numerous investigations have also been carried out on the variation in the composition of the average diet of population groups considered in relation to income. A typical example of such an investigation is afforded by Sir J. B. Orr's monograph : "Food, Health and Income" (McMillan, London, 1936).

Chapter XII

STATISTICAL CONSIDERATIONS

When the physiologist or hygienist is examining a phenomenon from the quantitative standpoint and considering some particular magnitude in different persons, he generally expresses the order of this magnitude by a mean value. But in reality the actual values obtained by observation show a dispersion around the mean which may vary considerably both in kind and in extent. By itself, the mean value gives no idea of this dispersion ; one and the same mean value may be recorded for phenomena showing a very different distribution of individual values. Accordingly, the mean value obtained by calculation must be supplemented by another value expressing the type of distribution.

Again, when a quantitative phenomenon is to be studied in relation to an entire population—or, as the statistician would say, universe—investigation must, in practice, be restricted to a small number of persons, taken at random. But rarely can the investigator cover all the persons composing the universe concerned. The question therefore arises, will the chosen group yield observations of which the mean is representative of the whole universe—say, an entire population ? This will clearly depend both on the variability of the phenomenon under examination and on the adequacy of the number of persons comprising the group—*i.e.*, on the size of the sample of population chosen. The larger the group, the more nearly will the mean approach the real mean value of the whole. In practice, the investigator always has to gauge the latter from the former.

There are therefore two requirements to be met :

(1) To indicate the distribution of a phenomenon around a mean ;

(2) To determine whether the mean of a particular group is or is not representative of the whole.

To clarify these problems, a concrete example will be taken, but, first, a few definitions essential to an understanding of the subject must be given.

I. *The distribution of a phenomenon around the mean* may be represented by a graph known as a *frequency distribution curve.* Suppose a phenomenon can occur in ways that can be expressed by the figures 15, 20, 25 . . . 50.[1] To represent this phenomenon as a graph, let us plot these numbers on the abscissa scale and, on the ordinates, the frequency of their occurrence.

FIGURE 1

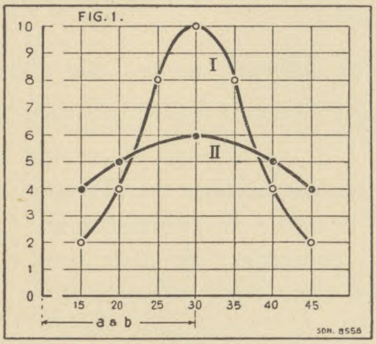
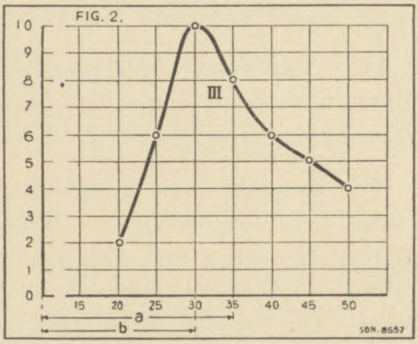


FIGURE 2



Consider the phenomenon represented by curve I. It is constructed from *38* observations, with values occurring as follows :

The value	15	occurs	twice	$2 \times 15 = 30$
,, ,,	20	,,	4 times	$4 \times 20 = 80$
,, ,,	25	,,	8 ,,	$8 \times 25 = 200$
,, ,,	30	,,	10 ,,	$10 \times 30 = 300$
,, ,,	35	,,	8 ,,	$8 \times 35 = 280$
,, ,,	40	,,	4 ,,	$4 \times 40 = 160$
,, ,,	45	,,	twice	$2 \times 45 = 90$
	In all		38 observations	Total $1{,}140 \div 38 = 30$

[1] Take, for instance, the calorie value of the daily food intake ; and suppose that energy value is expressed in units corresponding to 100 large calories (or a " hectocalorie ") ; then the number 30 will represent an intake of 3,000 calories.

20 represents a mean of the values 17½ to 22½ ; 25, a mean of the values 22½ to 27½ ; 30, a mean of the values 27½ to 32½, etc. Further, it is assumed that these groups are small enough for the real mean of each of them to be roughly equal to the mean of its two extreme values.

II. The term *arithmetic mean* means the sum of all observations divided by their number. This can also be expressed by saying that the *weighted mean* equals

$$\frac{(2\times 15)+(4\times 20)+(8\times 25)+(10\times 30)+(8\times 35),\ \text{etc.}}{38}$$

This mean here equals *30* (value *a* in the graph).

III. What is called the *mode* is the value occurring most frequently; it corresponds to the apex of the curve. *Here the mode equals 30* (value *b* in the graph).

IV. The term *median value*, or *median*, means the value above and below which the same number of observations occur. *Here the median equals 30.*

V. *Symmetry or asymmetry of dispersion.* — Frequency curve I is symmetrical. When a curve is symmetrical, the arithmetic mean and the median coincide. So also does the mode in frequency curves of the type here considered—*i.e.*, where the values most frequently occurring fall inside the extreme values, as is usual with biological phenomena.

Frequency curve II is also symmetrical. It expresses observations of the occurrence of a phenomenon in twenty-four persons:

Value	15 occurs	4 times		$4\times 15 =$	60
,,	20 ,,	5	,,	$5\times 20 =$	100
,,	30 ,,	6	,,	$6\times 30 =$	180
,,	40 ,,	5	,,	$5\times 40 =$	200
,,	45 ,,	4	,,	$4\times 45 =$	180
		24 observations		Total	$720 \div 24 = 30$

The arithmetic mean, the mode and the median again equal *30. Here then are two series of phenomena expressed by the same mean value although their dispersion around this mean is very different. Thus the mean value alone cannot be accepted as a sufficient expression of a phenomenon.*

Actually, the frequency curve of a phenomenon rarely turns out to be symmetrical. There is nearly always some more or less marked asymmetry: take the case of curve III.

This relates to the occurrence of a phenomenon in forty-one persons :

Value	20 occurs	twice		$2 \times 20 =$ 40
,,	25 ,,	6	times	$6 \times 25 =$ 150
,,	30 ,,	10	,,	$10 \times 30 =$ 300
,,	35 ,,	8	,,	$8 \times 35 =$ 280
,,	40 ,,	6	,,	$6 \times 40 =$ 240
,,	45 ,,	5	,,	$5 \times 45 =$ 225
,,	50 ,,	4	,,	$4 \times 50 =$ 200
		41 observations		Total 1,435 $\div$ 41 = *35*

The mean value of the phenomenon equals *35*.
The mode equals *30*.
The median value is slightly less than *35*.

With an asymmetrical curve, the values of the arithmetic mean, of the mode and of the median do not coincide. The more marked the asymmetry, the more they differ. Comparison of these three values will thus give an idea of the degree of symmetry of the frequency curve. Except for this purpose, only the mean value is generally used.

Most of the phenomena which are the subject of statistical study yield an asymmetrical frequency curve. Take, for instance, the energy requirements of the adult ; the most frequently occurring value—*i.e.*, the mode—is generally less than the arithmetic mean. Thus, if the mean value is in the neighbourhood of 3,100 net calories per day, the most frequently occurring value will be slightly less than 3,000. That is because the exceptionally high values differ more from the arithmetic mean than the exceptionally low ones. This right-hand asymmetry of the curve displaces the mean to the right of the mode (see below the curve in Figure 3, page 129).

It has been explained that a phenomenon thus expressed by a given distribution curve and a given mean value reflects the characteristics of a group of persons. If the experiment is repeated several times with groups of equal numbers of persons taken at random from the aggregate of the population, it will be found that, as a general rule, the mean values of each group are not exactly the same. A fresh study can then be made, in the same way of the frequency curve, of the deviations of the several mean values from the general mean of the group means. This general mean corresponds to the theoretical mean which would have been obtained by expanding the single group under examination to include the entire population. The more observations a group comprises, the more nearly does the mean of that group approach the general mean, and the more closely does it approximate to the true facts of the position.

Whereas experience shows that the curves observed in each group (or sample) of the population are asymmetrical, the distribution curve of the means of these groups is usually symmetrical and corresponds, if the groups are large enough, to the so-called Gaussian curve.

VI. *Dispersion index* (*standard deviation*).[1] — In estimating, in each case observed, the deviation of the observed figure from the arithmetic mean of the group, we see that this deviation is sometimes positive, sometimes negative. If we find the algebraic sum of these deviations and divide it by the number of observations of the group, we obtain a figure equal to 0, which tells us nothing about distribution.

If, on the other hand, we take the arithmetic mean of the numerical values of these deviations, omitting the signs, *we obtain an average magnitude of deviation ; and this figure is of some, though perhaps not of very great, interest.*

The range of variation—i.e., the difference between the extreme values—is often used to indicate the degree of dispersion. Thus 3,000 calories may be said to correspond to a dispersion ranging between 2,000 and 6,000 calories or, in another case, between 2,500 to 4,000 calories. While it is no doubt of interest to know this range, it is far from sufficient, as it conveys no idea of the frequency distribution between the extreme values.

[1] Termed " écart quadratique moyen " or " écart normal " in French publications.

In other words, it gives no idea of the shape of the frequency curve—*i.e.*, of the manner in which the individual values are distributed around the mean ; or of whether most of the observed values lie close to the mean or not. The margin merely indicates the width of dispersion. The most satisfactory method of eliminating the sign in deviations from the mean is to square them ; this will give values of the same sign (since a square is always positive). The average of these squares is then taken and the square root of this average is calculated. The result is known as the standard deviation [1] (in French, *écart quadratique moyen*).

The standard deviation is high when the frequently observed values are widely dispersed around the mean. On the other hand, two cases having the same mean and the same range of dispersion may show, one a high and one a low standard deviation. This will depend upon whether the majority of the observations lie close to the mean or not.

The ratio of the standard deviation to the arithmetic mean, taking the latter at 100, is known as the *coefficient of variation*.

If the arithmetic mean is 30 and the *standard deviation* is 6, we say that the coefficient of variation is 20 % $(\frac{6}{30} \times 100)$. If the figures are to have any significance, therefore, it is necessary, in making comparisons, to express the arithmetic mean and the *standard deviation* in terms of a common unit.

Let us, by way of example, set out in detail the calculation of the standard deviation in curves I, II and III described above (in doing so, we shall not use the simplified methods which are described hereafter) ; the figures will be found in the table hereunder.

---

[1] The standard deviation is usually represented by the Greek letter *sigma* and deviations from the mean by x. The standard deviation is therefore represented as follows, taking n to represent the number of observations :

$$\sigma = \sqrt{\frac{\Sigma x^2}{n}}$$

$\frac{\Sigma x^2}{n}$ is known as the *variance*.

	Observed values	Deviation of these values from the mean	Square of deviation	Weighted average of the square of the deviations
Curve I :	15	15	225	2 × 225 = 450
	20	10	100	4 × 100 = 400
Mean	25	5	25	8 × 25 = 200
value = **30**	30	0	0	0
	35	5	25	8 × 25 = 200
	40	10	100	4 × 100 = 400
	45	15	225	2 × 225 = 450
				Total = 2,100 ÷ 38 = 55.26
		Standard deviation = $\sqrt{55.26}$ = **7.4**		
		Coefficient of variation = **24.7%** $\left(\frac{7.4}{30} \times 100\right)$		
Curve II :	15	15	225	4 × 225 = 900
	20	10	100	5 × 100 = 500
Mean	30	0	0	0
value = **30**	40	10	100	5 × 100 = 500
	45	15	225	4 × 225 = 900
				Total = 2,800 ÷ 24 = 116.7
		Standard deviation = $\sqrt{116.7}$ = **10.8**		
		Coefficient of variation = **36%** $\left(\frac{10.8}{30} \times 100\right)$		
Curve III :	20	15	225	2 × 225 = 450
	25	10	100	6 × 100 = 600
Mean	30	5	25	10 × 25 = 250
value = **35**	35	0	0	0
	40	5	25	6 × 25 = 150
	45	10	100	5 × 100 = 500
	50	15	225	4 × 225 = 900
				Total = 2,850 ÷ 41 = 69.51
		Standard deviation = $\sqrt{69.51}$ = **8.3**		
		Coefficient of variation = **23.7%** $\left(\frac{8.3}{35} \times 100\right)$		

It will be seen that the coefficient of variation—*i.e.*, the ratio of the standard deviation to the arithmetic mean—increases with increasing dispersion of the frequent values. We shall find later on that the number of subjects constituting a group under observation also influences these magnitudes, and the ratio just described possesses real significance only if the mean of a group is representative of the population as a whole.

Let us now consider what would be the position if we merely took the weighted average of the deviations instead of the standard deviation. The results of calculations based on weighted deviations (disregarding the signs of the deviations) are as follows :

Curve I.	*Curve II.*	*Curve III.*
2 × 15 = 30	4 × 15 = 60	2 × 15 = 30
4 × 10 = 40	5 × 10 = 50	6 × 10 = 60
8 × 5 = 40	0	10 × 5 = 50
0	5 × 10 = 50	0
8 × 5 = 40	4 × 15 = 60	6 × 5 = 30
4 × 10 = 40		5 × 10 = 50
2 × 15 = 30		4 × 15 = 60
Total = 220	Total = 220	Total = 280
÷ 38 = **5.8**	÷ 24 = **9.17**	÷ 41 = **6.8**

If we compare this table with that of the standard deviation, we shall see that the latter is higher than the weighted average of the deviations ; that is because the extreme values, though rare, play a relatively more important part in the total of the squared deviations than in the total of the unsquared deviations.

* * *

Having considered what is meant by standard deviation, let us see how this deviation is measured in practice. For this purpose, we will take a concrete example from actual practice.

3,300	4,200	3,700
3,600	4,700	3,800
3,000	3,300	4,800
2,900	2,400	3,100
3,700	3,200	2,900
3,200	3,100	4,900
3,900	3,000	3,900
3,500	2,900	3,800
3,100	2,400	3,400

A nutrition survey was made of ninety-seven adult men engaged in moderately heavy work (enquiry by A. Slosse at Brussels, 1910). The average working-day (paid work) was 11 hours (10 to 12 hours). The net calorie intake per

3,700	3,200	6,400
2,600	3,100	3,000
3,000	4,800	3,000
3,500	2,400	3,900
3,800	3,200	3,200
3,200	3,400	6,100
3,000	3,800	3,800
4,200	1,800	3,800
3,100	3,000	4,100
3,500	3,300	2,600
4,000	3,000	3,300
2,700	3,800	2,800
1,900	3,200	4,100
3,900	2,400	3,600
2,600	3,200	3,000
4,700	2,500	3,300
3,500	3,900	3,400
3,200	3,300	3,000
3,300	2,900	3,700
2,600	3,500	
3,000	3,700	
3,700	3,000	
3,300	3,000	
4,000	3,600	
3,700		104,400
4,400		122,200
3,900		106,200
122,200	106,200	332,800 ÷ 97 = 3,431

day per person will be found in the table opposite.

The mean figure for this group is 3,431 net calories ; the median is 3,300 net calories ; the most frequent figure is round about 3,000 net calories.

The range of individual deviations from the mean goes from 1,800 to 6,400 net calories, the mean of the two extremes being 4,100. Distribution is therefore asymmetrical, but the small difference between the mean, the mode and the median indicates at once that the asymmetry will not be very pronounced (see below).[1]

The first step towards simplifying the calculations is to adopt a unit which will enable the measurements to be expressed by the simplest possible numbers. If, for instance, we keep to four-figure numbers to express the daily calorie intake, the calculations involved in working out the standard deviation will be complicated. It will be far simpler in the present case to divide these figures by 100—*i.e.*, to work in hectocalories : the figure 3,300 would then become 33, for instance.

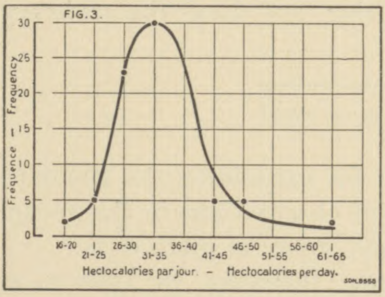
[1] The dispersion in the case under consideration is therefore fairly pronounced. The reason is that we are dealing with subjects of different heights, taken at random from families of varying composition.

We can analyse a series of observations by taking each item separately. But we can also subdivide it into small groups. Let us begin with groups. The ninety-seven subjects forming the group may be subdivided into ten classes.

1st class	16 to 20 hectocalories	Frequency	2 [1]
2nd ,,	21 to 25 ,,	,,	5
3rd ,,	26 to 30 ,,	,,	23
4th ,,	31 to 35 ,,	,,	30
5th ,,	36 to 40 ,,	,,	25
6th ,,	41 to 45 ,,	,,	5
7th ,,	46 to 50 ,,	,,	5
8th ,,	51 to 55 ,,	,,	0
9th ,,	56 to 60 ,,	,,	0
10th ,,	61 to 65 ,,	,,	2
	Total number of observations . .		97

The frequency distribution curve will be found in Figure 3. The extremes are, of course, only approximate, and the curve therefore passes between the points. If we carried this method further, we should, of course, have to assume for each subdivision that the true average was the same as the average of the extremes of each subdivision. But that is only roughly the case. It is preferable, whenever possible, therefore, to take each item of the general group separately.

FIGURE 3



Let us then consider the whole group without subdividing it.

The frequency with which each of the figures (in hectocalories) occurs is as follows :

[1] That is, a value in this subdivision occurred twice.

Hectocalories	Frequency	Hectocalories	Frequency	Hectocalories	Frequency
18	1	31	5	40	2
19	1	32	9	41	2
24	4	33	8	42	2
25	1	34	3	44	1
26	4	35	5	47	2
27	1	36	3	48	2
28	1	37	7	49	1
29	4	38	7	61	1
30	13	39	6	64	1

$$\text{Weighted average} = \frac{(1 \times 18) + (1 \times 19) + (4 \times 24) + (1 \times 25) \ldots \text{etc.}}{97} = \mathbf{34.31}$$

The next step is to ascertain how far each item deviates from the mean. For instance :

First item : the deviation = 34.31 — 18 = 16.31.

As these deviations are to be squared, the calculations would be laborious. A device is therefore employed to simplify the operations : instead of being worked out from the true mean, the deviations are calculated from an arbitrary figure, selected for the purpose of simplifying the calculations. In the present instance, for example, the figure 30 will be used (the true mean is 34.31).

Let us take x as the true deviation, and x_0 as the arbitrary deviation. The formula

$$\sigma = \sqrt{\frac{\Sigma x_0^2}{n} - (m - m_0)^2}$$

will give the necessary adjustment for calculating the standard deviation, where n is the number of observations in the group, m the mean, and m_0 as the arbitrary figure in place of m.[1]

In the example we are analysing, therefore, we take x_0 as the deviation from 30. On the other hand,

$$(m - m_0)^2 = (34.31 - 30)^2 = 4.31^2 = 18.58.$$

[1] The arbitrary figure in question can also be represented as 0. The formula then becomes

$$\sigma = \sqrt{\frac{\Sigma a^2}{n} - m^2}$$

taking m as the mean of the observations, the latter being themselves represented by a.

Below will be found the figures for x_0 for each item in the table on page 128 (tables of squares and square roots of numbers are used for this purpose) :

x_0	Corresponding frequency f	x_0^2	$f.x_0^2$
— 12	1	144	144
— 11	1	121	121
— 6	4	36	144
— 5	1	25	25
— 4	4	16	64
— 3	1	9	9
— 2	1	4	4
— 1	4	1	4
0	13	0	0
1	5	1	5
2	9	4	36
3	8	9	72
4	3	16	48
5	5	25	125
6	3	36	108
7	7	49	343
8	7	64	448
9	6	81	486
10	2	100	200
11	2	121	242
12	2	144	288
14	1	196	196
17	2	289	578
18	2	324	648
19	1	361	361
31	1	961	961
34	1	1156	1156
		Total	$6816 = \Sigma f.x_0^2$

$$\sigma = \sqrt{\frac{\Sigma x_0^2}{n} - (m - m_0)^2} = \sqrt{\frac{6816}{97} - 18.58} = \sqrt{70.27 - 18.58} = \sqrt{51.69}$$

standard deviation $= \sigma = \sqrt{51.69} =$ **7.19**

coefficient of variation $= \frac{7.19}{34.31} \times 100 =$ **20.95**%

If n is sufficiently large, the standard deviation of the group may be taken to be almost identical with the standard deviation of the whole population, of which the group is merely a sample. But if n is too small, particularly if it is less than about 100, it is better, for the purpose of obtaining a reliable estimate of the standard deviation of the whole, to take $n - 1$ instead of n in calculating the σ of the group :

$$\sigma' = \sqrt{\frac{\Sigma\, x^2}{n - 1}}$$

In other words, the number of subjects forming the denominator of the ratio under the square-root sign is decreased by one unit. A simple calculation shows that $\sigma' = \sigma \times \sqrt{\frac{n}{n-1}}$ This adjustment is only of significance if n is too small. To ascertain whether this is the case, we must work out σ and σ' ; we first find the value of σ and calculate σ' in accordance with the above equation. In the case under consideration :

$$\sigma' = \sigma \times \sqrt{\frac{97}{96}} = 7.19 \times \sqrt{1.0104} = 7.19 \times 1.005 = \mathbf{7.22}$$

Coefficient of variation = *21.04*%

It is therefore hardly necessary to make any adjustment in the present case.

* * *

VII. There is one other important question—the extent to which the mean value of a group is representative : how far it applies to the whole population to which the persons forming the group belong. If we take m as the mean of the group under consideration, and M as the mean of the whole population, to what extent can we gauge M from m ?

For this we employ the standard deviation, and calculate the standard error of the mean ("*erreur quadratique de la moyenne*" of French authors). This corresponds to the standard deviation divided by the square root of the number n of subjects. In the present case, the error e is as follows :

$$e = \frac{\sigma}{\sqrt{n}} = \frac{7.22}{\sqrt{97}} = \frac{7.22}{9.85} = \mathbf{0.733}$$

Mathematical probability shows that :

1. There are about 68 chances out of 100 that M will be within the limits of $m \pm e$.

2. There are about 95 chances out of 100 that M will be within the limits $m \pm 2e$.

3. There are about 99.7 chances out of 100 that M will be within the limits $m \pm 3e$.

In the present instance : $e = 0.733$

$2e = 1.47$

$3e = 2.2$

If, therefore, the mean observed in the group is 34.31 (3,431 calories), there are about 68 chances out of 100 that M will be between 34.31 — 0.73 and 34.31 + 0.73—*i.e.*, between 3,358 and 3,504 calories ; there are about 95 chances out of 100 that the true mean of the whole population will be between 34.31 — 1.47—*i.e.*, *32.84*—and 34.31 + 1.47—*i.e.*, *35.78* ; in other words, there are about 95 chances out of 100 that the true mean will be between 3,284 and 3,578 calories. Lastly, there are about 99.7 chances out of 100 that this mean will be between 34.31 ± 2.2—*i.e.*, between 32.11 and 36.51 (*i.e.*, between 3,211 and 3,651 calories). In other words, we may say that within less than ± 200 calories the mean of the group is representative of the total population.[1] To put it in yet another way, the group studied was sufficiently large to be representative, bearing in mind the variability of the factors concerned—*i.e.*, the variability of the individual energy requirements of the adults under consideration.

Some writers work out the *probable error* instead of the *standard error.* It corresponds to the latter multiplied by the coefficient 0.6745—*i.e.*, to about two-thirds of the standard error. In the present instance, the *probable error* is 0.733 × 0.6745, or **0.49**.

[1] It should be remembered that even in the estimate of energy requirements, there is an approximation of at least ± 5%.

There are about as many chances that the general mean M will be within the limits of $m \pm$ the probable error (34.31 ± 0.49) as that it will be outside.

There are about 95 chances out of 100 that the general mean will be within the limits of the mean of the group $\pm$ 3 times the probable error—*i.e.*, $34.31 \pm 3 \times 0.49$, or 34.31 ± 1.47 (see above).

The probable margin is therefore $m \pm$ twice the *standard error*, or, what amounts to practically the same, $m \pm$ three times the *probable error*, and in this case there are about 95 chances out of 100 that the true mean of the whole population will be within this margin.

* * *

To illustrate the importance of calculating these errors, let us consider the following possibility :

Let us assume that the survey did not cover 97 persons, as above, but that only 12 persons, taken at random from these 97 persons, were available. Let us further assume that this led to the formation of the following small group :

	1 worker at	20 hectocalories	$1 \times 20 = 20$
	2 workers at	27 ,,	$2 \times 27 = 54$
	2 workers at	30 ,,	$2 \times 30 = 60$
	2 workers at	33 ,,	$2 \times 33 = 66$
	1 worker at	35 ,,	$1 \times 35 = 35$
	2 workers at	42 ,,	$2 \times 42 = 84$
	1 worker at	48 ,,	$1 \times 48 = 48$
	1 worker at	64 ,,	$1 \times 64 = 64$
Total . .	12 workers		Total . .431
			$\div 12 = 35.91$

The weighted average corresponds to **35.91** (3,591 calories).

Let us calculate the deviations from 30 again. The standard deviation is obtained by the following calculation :

x_0^2	Corresponding frequency f	x_0^2	$f.\,x_0^2$
— 10	1	100	100
— 3	2	9	18
0	2	0	0
+ 3	2	9	18
+ 5	1	25	25
+ 12	2	144	288
+ 18	1	324	324
+ 34	1	1,156	1,156
	12		1,929 = $\Sigma f.\,x_0^2$

$$\sigma = \sqrt{\tfrac{1,929}{12} - (35.91 - 30)^2} = \sqrt{160.75 - 34.93} = \sqrt{125.82} = \mathbf{11.22}$$

$$\sigma' = 11.22 \times \sqrt{\tfrac{12}{11}} = 11.22 \times 1.09 = \mathbf{12.23}$$

$$\text{Coefficient of variation} = \frac{12.23}{35.91} \times 100 = \mathbf{34.06}\ \%$$

The standard error e = :

$$\frac{12.23}{\sqrt{12}} = \frac{12.23}{3.46} = \mathbf{3.53.}$$

$m \pm 1e = 35.91 \pm 3.53$
$m \pm 2e = 35.91 \pm 2 \times 3.53 = 35.91 \pm 7.06$
$m \pm 3e = 35.91 \pm 3 \times 3.53 = 35.91 \pm 10.59$

In other words, the mean of the group of 12 workers = 3,591 calories—*i.e.*, a figure not very different from the mean of the larger group of 97 (3,431 calories). But this figure—3,591—is hardly representative of the general mean of the population, if taken separately, as there are about 68 chances out of 100 that the general mean of the population will fall within 35.91 — 3.53 and 35.91 + 3.53—*i.e.*, between 3,238 and 3,944 calories ; there are about 95 chances out of 100 that it will be between 2,885 and 4,297 calories (35.91±7.06), and there are about 99.7 chances out of 100 that it will be between 2,532 and 4,650 calories (35.91±10.59). The range of these values is too wide for the mean of the group (3,591 calories) to be regarded as significant ; in other words, the group is too small, in view of the variability of the factors in question.[1]

In the group of 97 subjects, the mean was about 3,400 calories and the probable margin of error of this figure was about 3,300 to 3,600 calories.

In the group of 12 subjects taken at random from the *same* 97 subjects, the mean was about 3,600 and the probable margin of error extended from 2,900 to 4,300.

3,400 for the group of 97 subjects is a mean representative of the whole.

3,600 for the group of 12 subjects is not a mean representative of the whole.

In conclusion :

The object of a statistical analysis of the results of nutrition surveys is :

(1) To determine the distribution of the observed values around the mean.

The extreme limits between which the figures vary and the arithmetic mean of all the observed values do not in themselves constitute sufficient data to show the distribution. For this purpose, it is necessary to work out the standard deviation

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[1] In order not to confuse the issue, the number of chances out of 100 for $m \pm 1e$, $2e$ or $3e$ have been taken as the same as on page 133 ; in point of fact, however, they should probably be slightly different in the present unfavourable instance, because the group is too small ; the error is therefore slightly larger here than in the group of 97 subjects :

$m \pm 1e$: 66 instead of 68 chances out of 100
$m \pm 2e$: 92 instead of 95 chances out of 100
$m \pm 3e$: 98.5 instead of 99.7 chances out of 100
$m \pm 4e$: 99.7 chances out of 100

This adjustment is necessary because computation of the mathematical probability, as shown on page 133, is based on the fact that the curve of distribution of the mean of groups around the general mean is a Gaussian curve, *when the groups are sufficiently large.* When the groups are too small, on the contrary, the frequency curve of means of groups is still fairly symmetrical, but it ceases to be Gaussian, and the calculation of the mathematical probability has therefore to be adjusted. It is of little consequence in a first approximation, however, if the groups provide for at least fifteen or twenty observations.

It should be noted, however, that, even when the groups are sufficiently large, the statistical computations can only be worked out strictly when the group is really taken at random —and this is rare in nutrition surveys. Generally speaking, the computation of the statistical errors can thus only be approximate in practice,though this is sufficient for the purpose in view.

and the coefficient of variability. They are an index of distribution when the group of subjects observed is sufficiently large to be representative.

(2) To ascertain whether the group in question is sufficiently large to be representative : If it is, the mean of the group is near the true mean of the whole population, of which the group studied is merely a sample. *The standard error*, or *the probable error*, serve to show the extent to which the mean of the sample is representative of the true mean of the whole population. To calculate these errors, it is necessary to find the standard deviation. They enable us to ascertain whether the group studied was sufficiently large to give reliable results, bearing in mind the variability of the factors considered.

Only by measuring these errors, can we therefore ascertain the extension which is appropriate for nutrition surveys (see Chapter VI, page 39). In the survey taken as an example in this chapter, there was a fair measure of variability, mainly because the subjects were of different stature and were living in families of different composition. When a survey entails the classification of households in more homogeneous groups (see Chapter III, page 25), there is less variability in each group, and the groups need not be so large as heterogeneous groups. It should not be forgotten, however, that, if the households studied are to be classified in homogeneous groups, representative of each type of family, it is none the less necessary that the whole survey should cover a fairly large population, as we have already seen, since the number of groups between which a distinction should be drawn is inevitably higher if each is to be really homogeneous from every point of view.

Part II

ENQUIRIES INTO THE STATE OF NUTRITION[1]

INTRODUCTION

Whereas dietary surveys have been carried out in large numbers for some considerable time, and standardisation of the methods of investigation employed in this connection is not merely desirable but feasible, elaborate enquiries into the state of nutrition reflect a more recent development, save, perhaps, for biometric studies. It should further be noted that, originally, such enquiries were undertaken with the object, not of determining a physiological condition, but of securing anthropological data.

Investigations into the state of nutrition considered in relation to dietary problems—investigations, that is, which are concerned with questions of morbid physiology—have thus been somewhat infrequent up till now ; they are fragmentary and unrelated to each other, owing to the rapid advance of the knowledge on which they are based. The experience acquired is still too limited for standardisation of the methods of enquiry to be suggested. Such studies are, in fact, in the nature of pure research, in which the investigator's initiative cannot be hampered without detriment to the work itself and to the solution of the problems concerned. We shall see, nevertheless, that three types of enquiry were indicated for guidance by a Committee of Experts which met at Geneva in December 1936, on the proposal of the Technical Commission on Nutrition.

The present monograph will be concerned principally with the tests that can be used in such investigations. In view,

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[1] This second part is taken from an article written by Dr. Bigwood in 1937, which was published in the *Bulletin of the Health Organisation* of the League of Nations, Volume VI, Extract No. 5, 1937. The article has been revised, expanded and brought up to date for the purposes of the present publication.

however, of the great rapidity with which knowledge is accumulating in this field, this second part will assume the form rather of a bibliographical survey of these tests, together with accompanying comments, than of a description of methods of enquiry. This is why Part II contains a bibliographical index of a kind which has no counterpart in Part I.

We may begin by retracing the history of the efforts that have been made to study the state of nutrition of populations, and of the work done in this connection by the Health Organisation of the League of Nations.

The first research into the effects of under-nourishment on health took the form of physiological investigations and group surveys relating to pronounced under-nourishment and even complete fasting.

The classical work of F. G. Benedict and his school on prolonged fasting (1) and Starling's publications dealing with under-nourishment as observed in Germany between 1917 and 1919 (2) are familiar. These latter publications referred to an adult diet, the energy value of which averaged 1,700 calories and very rarely exceeded 2,000 calories ; it consisted of from 15 to 20 grammes of protein and from 30 to 40 grammes of fat, and was thus very markedly deficient from every point of view. This study may serve as an example of the type of study which was being carried out twenty years ago, or even more, and of the kind of acute nutritional deficiency which suggested itself naturally as a subject of investigation.

It is not surprising, therefore, that doctors and hygienists should have been impelled to enquire into the serious and far-reaching effects of this severe deficiency on public health.

More recently, again, the world economic depression had a serious influence on public health in many countries. During the worst years, unemployment had so greatly increased that, in many cases, Government relief had become quite inadequate. Here, again, the gravity of the situation naturally suggested an enquiry into the effects of under-nourishment on public health, especially the more far-reaching effects such as an increase in mortality or morbidity. Two papers dealing with mortality and morbidity statistics were published by the League of Nations in 1930 and 1933 (3, 4).

In its first report on the question, which appeared in September 1932, the Health Section of the League of Nations Secretariat made a detailed study of the data then available, which may be summarised as follows (5) :

During the second half of 1931 and the early part of 1932, statistics did not seem to point to any appreciable effect of the economic depression on the aggregate death rate in the United Kingdom, Czecho-Slovakia, France, Germany, Hungary, Italy, the Netherlands, Poland, or the United States of America. It was difficult, however, to know what construction to put upon this fact. It was realised that the conclusion could not be drawn that the depression had had no effect upon public health. There were too many factors capable of influencing the statistics for the latter to have any real value for the purpose in view. Doubtless, also, it was still too early to judge of the remoter effects of the depression, such as its influence on the aggregate death rate ; and, as for morbidity, it seemed difficult to obtain valid statistical data on a very large scale.

It may be pointed out, however, that there are countries in which it might be of some interest to investigate the fluctuations of the death and morbidity rates considered in relation to those of the price index and purchasing power of populations. Such studies are however, in a degree which varies according to cases, subject to errors of interpretation.

Enquiries into the nutrition of the unemployed showed that, in some countries, unemployment relief was insufficient to provide a diet yielding a normal calorie intake. In other words, the diet in those countries was quantitatively deficient. The qualitative balance of the diet was also seriously defective : the consumption of cheap foods, poor in " protective " constituents (bread, cereals, margarine), increased at the expense of the dearer foods (milk, meat, butter, eggs, vegetables and fruit) with a high content of such principles.

In other countries, however, such as Belgium, the enquiries conducted in 1932 among the insured unemployed revealed the same qualitative deficiency, although the aggregate energy intake (net total calories) was comparatively satisfactory, or, at all events, not seriously deficient. We have therefore instances in which the diet of a people is characterised by an inadequacy of protective foods without any caloric deficiency. The opposite may perhaps occur in certain hot countries, but the evidence available is not sufficiently full in this connection to warrant any definite assertion. In our countries of Western civilisation, in which the findings of past enquiries permit of a more detailed analysis of the situation, of the two deficiencies —the deficiency of protective foodstuffs and the deficiency in caloric value—the former is usually the first to arise ; the only way to provide the necessary energy *cheaply* is to sacrifice the protective components of the diet. This is illustrated particularly by the Belgian enquiries, the results of which were not mentioned in the League's 1932 report, since they were not published until later (6). They reveal the important fact that a diet can be definitely deficient without any shortage in its aggregate energy value, expressed in calories.[1] Such a state of affairs is probably much commoner than has hitherto been supposed, and this observation takes on a special significance at the present time. While we are witnessing a recovery in the general economic situation, our rulers are becoming increasingly anxious to improve the living conditions of *all* social classes, and hence the main problem of nutritional hygiene is somewhat different from what it used to be. It consists much more in assessing the consequences of a diet which is ill-balanced, though adequate from the standpoint of energy, than the effects of gross under-nourishment. Not, unhappily, that the latter is nowhere apparent ; but the detection of early and unobtrusive signs of a slight nutritional deficiency has become a burning problem in our countries of Western civilisation.[2]

We now know that, with a sufficiency of calories, the contingency of pronounced malnutrition may be ruled out ; but this does not necessarily mean that the diet is satisfactory, inasmuch as there may still be a deficiency of protective foods.

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[1] This question has already been considered in Chapter XI of Part I, which deals with the economic aspects of the questions arising out of dietary surveys.

[2] See Part I, pages 12, 80 and 81.

None the less, there is a certain relation between the calorie-producing value of a diet and the quantity of protective foodstuffs required.

But let us return to the Health Section's report of 1932. The highly unsatisfactory state of nutrition of a large part of the population of various countries at that time was soon to produce medically detectable consequences. Several instances were reported by health services as a result of fragmentary enquiries conducted mainly among children : diseases accompanying growth, delayed growth, prevalence of anæmia, scrofula, rickets, dental caries and nervous conditions leading to rapid fatigue and lack of concentration ; frequency of various affections, especially tuberculosis, etc.

While an accurate grasp of the remoter consequences of a deficient dietary was necessary, it was also clearly essential, from the standpoint of preventive medicine, to be able to detect at an early stage the first unobtrusive symptoms of malnutrition, so as to act in time.

At a first international Conference held at the end of 1932, the Health Committee of the League sought to bring about an exchange of views on the methods to be employed for this purpose, which were to be based in particular upon a clinical examination of a standard type to be determined (7). The Conference felt that all available data should be turned to account, even those which might be of but approximate value or difficult to interpret when taken singly. It therefore advocated combined medical and social investigations covering the same population groups. The social side of the investigations was to include a study of incomes, diet, cost of living, and death and morbidity rates. It was to be based upon official statistics for the country as a whole, or for certain of its administrative areas, and upon statistics drawn up from time to time as a result of local enquiries.

As for the medical work, the Conference considered that it should be confined to *simple and expeditious methods applicable to mass investigations* (groups of some tens of thousands of persons). In the first place, as a basis for the medical enquiry, it recommended that the age, sex, weight and height (sitting and standing) should be recorded, together with an index combining certain of these data—the "Pelidisi" index of von Pirquet (see page 166 below). It also thought that a general clinical impression of the state of health of the persons examined should be given in a simple standard form to be agreed upon, and for this purpose it proposed another of von Pirquet's formulæ (the "Sacratama" index, see page 177 below). The large-scale enquiries were to be limited to this, but it was recommended that they should be supplemented in respect of a smaller number of persons by physiological examinations, chief among which are :

Determination of the hæmoglobin content of the blood by an accurate process such as van Slyke's.

Determination of protein content of the blood serum and of the ratio of globulin to serum albumen in this medium.

Fatigability after moderate muscular exertion. Certain methods, such as those of Murlin or Atzler, are mentioned in Annexes 2 and 3 of the report of the Berlin Conference.

Signs of the preliminary stages of avitaminosis :

(1) Xerophthalmia—Bitot's spots, keratinisation of the corneal epithelium in vitamin-A deficiency ;

(2) Symptoms of polyneuritis and pellagra in B-group avitaminosis ;

(3) X-ray photographs of the epiphyseal junctions and determination of inorganic phosphate content of the blood in vitamin-D deficiency.

Since that date, a large number of enquiries have been undertaken in various countries ; it was thus possible to ascertain the value of the methods advocated, which, in practice, were found to be unreliable. Experience has also shown that, from a social standpoint, small detailed enquiries carried out with the utmost care yield more valuable results than large-scale enquiries, which, as they are conducted under less strict conditions, necessarily furnish less accurate data ; the advantage of the former over the latter has been clearly established, although they do not always represent the general situation. It was also found that medical surveys carried out on a very large scale, but by over-rudimentary methods, yield data which are difficult to interpret. It is often much more useful to ascertain the *precise* social conditions of a small group of individuals than to obtain a *very rough* idea of the general condition of a large number of persons. Similarly, it may be more instructive to find out the *exact* diet of one hundred persons than to obtain an imperfect and debatable idea of the average diet of one hundred thousand.

The very simple methods used, which could easily be applied to a large number of subjects, were mainly based on *somatometric*[1] measurements. It was soon seen that they might lead to the confusion of purely anthropological considerations, on which the classification of men into different types is based, with physiological considerations such as differences in physical condition due to defective nutrition. Moreover, it was necessary to distinguish between malnutrition of morbid origin and malnutrition due to a defective diet in the case of a subject who would otherwise be healthy. The use of over-simplified methods was obviously calculated to lead the hygienist astray.

Knowledge concerning the physiological examinations carried out only in the case of less extensive enquiries was, however, soon widened by experience. Certain recommendations in the 1932 report could no longer be accepted without modification. For instance, certain fatigability tests are inexpedient in the case of some subjects ; moreover, as we now see, signs which were then regarded as indicating the prodromal stages of avitaminosis are clearly signs of frank avitaminosis. It was therefore necessary to continue research with a view to detecting much earlier stages of vitamin deficiency, forms of pre-deficiency which were still " non-apparent ", and to look for " tell-tale " signs[2] of these obscure and hidden states by

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[1] This term is preferable to " biometric ", which is more commonly used but which may relate to functional measurements such as vital capacity (difference of thoracic volume as between forced expiration and inspiration). It therefore refers exclusively to morphological considerations.

[2] The expressions in inverted commas are translations of the terminology used by Mouriquand in describing these pathological states.

means of appropriate tests. These conclusions were, moreover, justified by experiments on animals.

In short, knowledge in this sphere had increased considerably since 1932, and a further meeting of experts was necessary for the re-examination of these questions.

In June 1935, there appeared an important report by E. BURNET and W. R. AYKROYD on "Nutrition and Public Health" (8), in which the problem is studied in its various and manifold aspects. The tests referred to above are only mentioned briefly. A few "*indices of nutrition*" are simply enumerated and divided into three categories :

(1) *Somatometric indices* of QUÉTELET, LIVI, PIGNET and VON PIRQUET ("Pelidisi") (see below, page 166).

(2) *Clinical indices* of DUNFERMLINE, VON PIRQUET ("Sacratama"), FRANZEN (A.C.H.) (see below, page 175).

(3) *Physiological tests*, for which the reader is referred to the 1932 report (7).

It should be pointed out, however, that, as regards vitamin-deficiency tests, reference is already made in the report to more exact methods than those described in the 1932 report (7). The authors mention the first attempts to detect obscure forms of pre-deficiency : HESS's capillary resistance tests and JEANS' and ZENTMIRE's visual test (see below, pages 190 and 194).

Concurrently with the development of the study of nutritional hygiene in relation to living conditions, and the efforts to solve the practical problem of the early detection of the first effects of defective nutrition on public health, research was being carried out in the physiological field. Its object was to define the standards of a normal diet from the quantitative and qualitative standpoint, the relative proportions of the various constituents of a normally balanced diet—in other words, the body's need for these various constituents. A first international Conference on this question was held at Rome in September 1932 (9).

The question was taken up again in 1935, when the Health Committee's Technical Commission for the Study of Nutrition was set up under the chairmanship of Sir Edward MELLANBY. This Commission met for the first time in London in November 1935 (10) and for a second time at Geneva in June 1936 (11). The object of this Commission was to establish human nutritive food requirements. In point of fact, this problem is closely bound up with the determination of the means of ascertaining whether these requirements are satisfied. Physiologists and medical men have at their disposal two methods of research for the purpose of ascertaining human food requirements — (*i*) experiments on animals and (*ii*) nutritional surveys.

Experiments on animals have made it possible to establish certain basic principles regarding the physiology of nutrition. They have taught us a great deal about the function of mechanism of nutritive exchanges, but do not enable us to determine with sufficient accuracy what constitutes a balanced diet for human beings.

Nutritional surveys have also been carried out among populations living under varying social conditions, *which are in some cases unsatisfactory*—when they have revealed the influence of various factors on the composition of the diet—*and in some cases normal*, at all events in appearance, when they cannot, even so, be blindly accepted as a necessarily correct assessment of *nutritional requirements*, for there are too many fortuitous factors which are likely to influence the diet, and, besides, it is not always easy to distinguish between the normal satisfaction of nutritional requirements and a tendency towards over-feeding.

We are therefore faced with a difficult problem, and it is not surprising to find at the head of the list of subjects recommended for further study by the Technical Commission the *assessment of the nutritional state of children*. It is growing children who have the greatest need of protective foods and in whose case even a slightly defective diet is likely to produce the most clear-cut ill effects. We are therefore confronted with the same problem as before : *how we can detect at the earliest possible stage the first signs of malnutrition attributable to even a slight defect in diet.*

Towards the end of 1936, therefore the time, seemed to be ripe for a further meeting of experts to discuss the assessment of the nutritional state of children in relation to defective diet.

Many of the countries co-operating with the Health Organisation in this field planned at that time to carry out further investigations ; in Sweden, they were to cover 50,000 children ; in Czecho-Slovakia, 10,000 ; in Austria, 20,000 ; in other countries—such as Belgium, the United Kingdom, the Netherlands, Norway, Poland and the United States of America —similar enquiries were already in progress. The discussion of the methods employed and of certain results already obtained was therefore calculated to lead to the immediate establishment of certain basic principles. A meeting was held at Geneva for this purpose on December 8th, 9th and 10th, 1936.[1]

The experts invited to attend this meeting and consulted on the methods of assessing the state of nutrition of children and young people (children of pre-school age and school age, and adolescents) decided to recommend **three types of enquiry** *applicable to different requirements.*

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[1] The group of experts, presided over by Professor H. LAUGIER, of Paris, and comprising sixteen members from eleven countries, was made up as follows :

United States of America: Dr. Martha M. ELIOT, Assistant Chief, Children's Bureau, United States Department of Labour, Washington.

Austria: Dr. Edmund NOBEL, Primärarzt am Mautner Markhofschen Kinderspitale der Stadt Wien, Universitätsprofessor für Kinderheilkunde, Vienna.

Belgium: Dr. Edouard-Jean BIGWOOD, Professor of Biochemistry, Medical Chemistry and Nutritional Hygiene at the " Université libre ", Brussels.

United Kingdom: Dr. Arthur Griffith MAITLAND-JONES, of the London Hospital, London ;
Dr. M. T. MORGAN, Medical Officer, Ministry of Health, London.

Czecho-Slovakia: Dr. Hynek J. PELC, Professor at the Charles IV Faculty of Medicine, Prague.

Denmark: Dr. Louis Sigurd FRIDERICIA, Professor of Hygiene at the University of Copenhagen.

France: Mme. C. BRUNSCHWICG, Under-Secretary of State, Ministry of National Education, Representing the Ministry of Public Health, Paris ;
Dr. Henri LAUGIER (*Chairman*), Professor at the Sorbonne and at the Ecole des Arts et Métiers, Paris ;
Dr. Pierre NOBÉCOURT, Professor at the Faculty of Medicine, Paris ;
Professor Jacques PARISOT, Director of the Institute of Hygiene, Nancy.

Netherlands: Dr. Evert GORTER, Professor at the University of Leiden ;
Professor Johannes Coenraad STRENG, Chief of the School Inspection Department, The Hague.

Norway: Dr. Carl SCHIÖTZ, Professor of Hygiene, Institute of Hygiene, Oslo.

Poland: Dr. Miecislas MICHALOWICZ, Professor of Pediatrics at the Joseph Pilsudski University, Warsaw.

Sweden: Dr. Urban HJÄRNE, *Privat-docent* in Pediatrics, Upsala.

1st Type of Enquiry :

This type of enquiry is essentially suitable for practical work, such as the determination of the state of nutrition of large numbers of children in the course of extensive demographic surveys, or the first rough classification of a very large number of subjects (mass enquiries). For this first type of enquiry, the experts recommend the preparation of record cards giving particulars of:

1. *Age ;*
2. *Sex ;*
3. *Physical appearance (slender, medium or stocky type) ;*
4. *Weight ;*
5. *Height (and possibly the sitting height).*

The experts recommend that weighing and measuring be repeated at fairly frequent intervals. In addition, each child should be subjected to a simple elementary clinical examination bearing in particular upon the colour of the skin, the firmness and elasticity of the skin, the state of the teeth, the condition of the subcutaneous fat layer, the state of the muscles and any signs of abnormal fatigue.

The object of this kind of enquiry being to discriminate between the children who seem to be normal and those whose nutrition appears to be defective, it goes without saying that children of the latter group should be subjected to a medical examination and form the subject of a medical social enquiry dealing especially with their diet.

2nd Type of Enquiry :

The second type of enquiry is intended for more thorough and more scientific, but still partial, investigations, covering less numerous groups than the previous type. The object of enquiries of this second type will be to study the significance of the data collected in the course of the first type of survey, by examining them in the light of complementary research work.

The second type of enquiry should necessarily include, in the first place, all the tests of the first type, as well as the following tests :

(a) *Enquiries into the child's food intake ;*

(b) *Enquiries into the economic and social status of the child's family ;*

(c) *Thorough medical examination.*

To these, there can be added some of the following tests, to be selected by the investigators according to the facilities at their command :

(d) *Additional somatometric data* (e.g., *the bisacromial breadth, the breadth of the pelvis, chest girth, etc.*) *;*

(e) *Special tests, in particular : measurement of hæmoglobin and protein content of blood, pre-deficiency tests, etc. ;*

(f) *Photography.*

In enquiries of this type, the experts suggest that special attention be given to the tests that may be presumed to be related to states of malnutrition, in particular tests for latent unapparent pre-deficiency.

Vitamin—A Pre-deficiency : *Slight night blindness* (*adaptation of visual acuity in semi-darkness*) *;*

Vitamin—C Pre-deficiency : *Vascular fragility ; ascorbic acid saturation tests* (*determination of the ascorbic acid content of the blood and urine*) *;*

Vitamin—D Pre-deficiency : *X-ray examination of wrist* (*in infants*) *; determination of phosphatase content of blood.*

3rd Type of Enquiry :

The object of the third type of enquiry is to study scientifically the disturbances to which all the functions of the body are subjected when the diet is quantitatively or qualitatively deficient. Such enquiries, which are of a biotypological nature, should be as extensive as possible ; they should include all the tests of type-1 enquiries, coupled with as many significant measurements as possible of all morphological characteristics and biological functions amenable to mensuration. In this way, it should be found possible to work *out individual graphs and collective graphs for under-nourished individuals and groups, affording a complete definition of the individuals and groups concerned as distinguished from normally nourished individuals and groups.*

This research work should also yield information as to which of the tests are most constantly and markedly affected by malnutrition, and could hence be recommended thereafter for use in large-scale surveys.

This kind of enquiry should include somatometric measurements and physiological measurements bearing upon the muscular system, the respiratory system, the circulatory system, the digestive system, the nervous system, the endocrine system and the urinary system, as well as blood and sensorial measurements and psychological tests.

Furthermore, **each subject should be submitted to a complete medical and psychiatric examination.**

Whatever type of enquiry is being conducted, it would be desirable in all cases that the measurements taken should be supplemented by enquiries concerning the diet of the subjects concerned. The experts point out, however, that such investigations can be of real value only if sufficiently precise and full information is given as to the conditions in which they were conducted. **For enquiries of type 2 and 3, such information regarding food intake is indispensable.**

No matter how elaborate the enquiry may be, information as to the child's progress in school work should be added.

* * *

In a word, each of these three types of enquiry was intended to be used alone, according to the size of the population under investigation. The first type was designed for mass investigations calling for simple methods, and the second and third for less extensive but more elaborate studies. Technically, such studies involve the application of a series of tests that can be combined in different ways, according to the plan of action contemplated.

Such tests can be grouped into three categories — **somatometric, clinical** or **physiological.** *A separate chapter will be devoted to each of these.*

Before proceeding to deal with them in detail, it may be well to mention that the Technical Commission on Nutrition, in the course of its session in London in November 1937 (76), recommended that enquiries into the state of nutrition combined with dietary surveys and covering the same population should henceforth be undertaken. Such investigations have this advantage, that they yield data both as to the response of the persons investigated to a sensitive test for latent pre-deficiency, and as to the quantity of protective principles supplied in their diet. Whilst it is reasonable to suppose that, in many cases, comparison of these two factors will afford the physiologist some information as to the bodily requirements of protective principles, it must nevertheless be borne in mind that the problem under consideration is complex. There is not necessarily any simple relationship between the supply of protective principles at the time of testing and the more or less satisfactory response to an appropriate test at that same time. In other words, allowance must be made for the following physiological factors, the importance of which has been demonstrated by both animal experiments and observations in human pathology.

(1) *A " Time " Factor.*

(*a*) If an animal is subjected to a deficient diet, it will be found that a period of latency precedes the time of appearance of overt signs of deficiency. The duration of this phase of latent pre-deficiency, during which the organism is living on its reserves, is inversely proportional to the seriousness of the dietary defect, and may extend over a considerable period of time. Sensitive tests capable of detecting such non-manifest conditions are the more valuable, the earlier the phase at which they give a response. In this matter of early detection, the probability is that no ideal test has yet been devised. There is hence a period of latency preceding the phase at which such tests prove effective. We must therefore bear in mind that we may find persons whose appearance and response to these tests is still normal, although their diet is not completely so.

(*b*) Intercurrent influences may, spontaneously and without any test, cause a state of latent pre-deficiency to emerge in noticeable form, thus shortening the period of latency. This is true of pregnancy and even of common infections,[1] or of the incidence of some critical phase in the development of a child, such as puberty, etc. It follows from this that the retarded consequences of some transient period of dietary deficiency have to be reckoned with, even though the food intake may have been normal between that period and the appearance of morbid signs. Thus a temporary defect in the diet of an infant may not show its effects until a very late stage of development.

(*c*) According to the degree or duration of the dietary inadequacy concerned, a condition of definite nutritional deficiency may remain for a long time *reversible* in the sense that it can be corrected by an adjustment of the food intake. When, however, a certain point is reached, the deficiency becomes *irreversible*, and dietetic treatment ceases to be effective. In such serious cases, the pathological condition persists and grows worse, in spite of the administration, in therapeutic form, of large quantities of protective principles. MOURIQUAND demonstrated this in both animals and human beings.

(2) *The Factor of the "Diversity" of Morbid Manifestations which may appear in Association with* ONE AND THE SAME *Highly Defective Diet.*

As MOURIQUAND relates in his publications (77), V. BABÈS reported on a German camp for war prisoners in the 1914-1918 war, in which Russian and Roumanian prisoners fed on a like highly deficient diet were living side by side. Whilst apparently healthy at the start, the Russian soldiers contracted scurvy, and the Roumanians pellagra. Here, therefore, were two groups

[1] Thus, in the course of an influenza epidemic, it was found that large numbers of children in certain children's hospital wards showed signs of deficiency of the scorbutic type, whilst in other wards these signs were not observed. The first group of children came from an area in which the population was in a condition of scorbutic pre-deficiency, whereas the second group came from an area in which it was not.

of men who showed signs of *different* kinds of frank deficiency, although they were both on the *same* unbalanced diet. The extensive depletion of their reserves disclosed in the one case a pre-existing latent sub-deficiency of the scorbutic type and in the other a sub-deficiency of the pellagrous type.

(3) *The Factor "Individual Variability" of Body Requirements in respect of Certain Protective Principles.*

Two cases should be distinguished :

(*a*) This variability may appear in the same person and depends on the *composition of the diet* in respect of the components other than that of which the requirements are being assessed. By way of example, reference may be made to the body requirements of vitamin B_1, which vary with the intake of carbohydrate ; so much so, indeed, that signs of beri-beri may appear in consequence of an excess of carbohydrate in a diet diet sub-deficient in vitamin B_1, and may be removed by reduction of the amount of energy-bearing materials without any concurrent increase in the vitamin intake. In such a case, the carbohydrate excess is the factor which discloses a latent vitamin B_1 pre-deficiency which might have remained latent had that excess not occurred.

(*b*) The variability of vitamin requirements—as it may show itself between various more or less susceptible persons consuming a diet containing the same quantity of energy-bearing and protective nutrients—is due to the influence of *individual endogenous* factors whose regulative action produces *differences in the absorption or utilisation of the vitamins.* These are the *deficiencies of secondary origin,* which have already been discussed in Part I, pages 13 and 82.

There may thus be said to be a whole series of reasons why the requirements of the body in vitamins may vary and may depend both upon dietary factors and upon individual physiological factors independent of age, sex bodily size or energy expenditure on work. This important fact should be borne in mind in the comparative analysis of the results of dietary surveys and of enquiries into the state of nutrition.

Chapter I

SOMATOMETRIC TESTS

The purpose of these tests is to determine the effect of diet on the rate of growth and physical condition and the form and figure of the individual during and after growth. Since the characteristics of the adult bodily form are largely a matter of race, it is the rate of growth in a group of children which calls for special attention in the construction of somatometric indices in relation to nutrition.

1. Trend of the Mean Weight and Mean Height of Groups of Children

These two magnitudes—height and weight—form the basis of all somatometric tests. No extensive enquiry is conceivable in which these two fundamental indications are not given together with *age* and *sex*. But what significance is to be attached to them in the question under consideration ?

Although a contrary opinion was originally held, little useful and precise information as to the state of nutrition of an individual can be derived from a comparison between his height and weight and the corresponding data contained in a table of statistically calculated averages. There is no objective criterion of *normality* in respect of mean values, nor is there any as regards the limits of individual fluctuations around the mean. The normal limits are estimated differently according to authors. According to some, they are plus or minus 7% ; according to others, they range from minus 10% to plus 20%. According to some observers, the width of this margin varies with the age (see below, page 163). Individuals whose deviation from the mean, in weight or height, exceeds these limits may certainly be regarded as abnormal ; in such a case, however, the anomaly is well marked and is very likely to be due to disease-engendered malnutrition producing obesity or emaciation rather than to bad feeding. If, however, the fault should lie with the diet—which may be regarded as exceptional—the case will no doubt prove to be one of very pronounced under-feeding readily discernible by a simple observation of living conditions.

Measurements of height and weight may serve for the easy detection of these somewhat exceptional cases of pronounced malnutrition, but cannot give any indication as to whether this condition is due to organic or to dietary causes. [1]

This is therefore a very rough method, and it is unlikely that it can be refined, for a scale of " normal " heights and weights established on the basis of statistical measurements is of questionable value. Anthropological differences are sufficiently marked to preclude the choice of a single scale of reference. Statistical *averages* show differences, not only between countries, but between different parts of the same country, between different races in one and the same district, and also differences in time. This has been shown by extensive somatometric investigations carried out in England by the Board of Education and the Ministry of Health. Material differences were observed according to locality between the mean height and weight of children of the same age. These may certainly be due to differences of social circumstances or food habits, but they may also be attributed to other causes. This is particularly well brought out by an examination of Netherlands statistics compiled in the schools of the city of Amsterdam (12) (13). Height and weight measurements were taken at different ages, in the non-Jewish schools (group *a*) and in the Jewish schools (group *b*). Here are a few examples taken at random from among the results obtained :

Girls 6 ½ years of age	Average height.	116.6 cm.	in group *a*.
		109.8 cm.	,, ,, *b*.
	Average weight	21.4 kg.	,, ,, *a*.
		18.2 kg.	,, ,, *b*.
Boys 10 years of age	Average height.	134.9 cm.	,, ,, *a*.
		130.4 cm.	,, ,, *b*.
	Average weight	30.3 kg.	,, ,, *a*.
		28.0 kg.	,, ,, *b*.

[1] There are examples in which extensive and prolonged under-feeding has led to a fall in weight. This was the case of the German population during the war, as has been shown by RUBNER (22).

Girls 10 ½ years of age	Average height.....	143.3 cm.	in group	*a*.
		136.5 cm.	,, ,,	*b*.
	Average weight	35.1 kg.	,, ,,	*a*.
		32.9 kg.	,, ,,	*b*.
Boys 13 years of age	Average height.....	147.3 cm.	,, ,,	*a*.
		143.4 cm.	,, ,,	*b*.
	Average weight	38.4 kg.	,, ,,	*a*.
		37.1 kg.	,, ,,	*b*.

Although the number of children examined in each of the groups *a* and *b* was not the same, the consistency with which the differences lie in one direction is striking. The divergencies thus brought to light, despite the fact that figures are taken which apply to the same town and the same date, are attributable to differences of race and perhaps also, but only in part, to differences in dietary habits.

In any case, a comparison of the height and weight measurements of a given child with the figures of a table can only be justified if this table is considered, not as a standard of normality, but simply as a datum of reference in the study of variations ; and, once this is conceded, it becomes questionable whether such a datum is really essential.

Moreover, as an indication of normal values, the same table is not valid everywhere ; indeed, it can scarcely be so even for a single locality and a single period. The mere difficulty of defining exactly what is normal—assuming that the question can arise at all—is a sufficient reason for endeavouring to avoid it.

In any case, even if a given table is adopted as an expression of the norm, it will only serve to detect malnutrition when the latter is pronounced, and will give no indication as to whether the diet was at fault.

It is quite otherwise with investigations involving the statistical recording over a given period of the average height and weight of children in one and the same locality, or comparisons between different social classes. In the Netherlands, investigations referred to above the rate of growth in 1935, for example, showed a definite improvement over that for the period 1916-1920 ; and, weight for weight and height for height, the average child of 1935 proved to be one year in advance of those of 1916-1920 (9 to 15 months ahead in respect of weight). In 1936, the situation was the same as in 1935.

Here, therefore, are data in which constitutional factors, differences of race, etc., no longer play a preponderant part. The progress recorded is due to improved feeding and better living conditions in the community.

What the normal rate of growth is and whether it is desirable to accelerate it are, of course, questions that are open to discussion. If, however, the acceleration is accompanied by an improvement in the average state of health and in school efficiency, and other indications of a similar kind, it may also be regarded as reflecting a real advance in the physiological rate of growth.

It is, of course, necessary to define clearly how the measurements were taken before interpreting their results. The subject is measured, for height, standing to attention with bare feet, and weighed completely unclothed. When this last condition is not observed, as much information as possible must be given as to the exact manner in which the weight was taken ; for example, the average weight of clothes worn at the time of weighing, etc. This is important for the comparison of weights at different seasons, since the nature of the clothing varies a great deal.

Another investigation undertaken at Oslo by the late Professor SCHIÖTZ (14) yields evidence similar to that of the Netherlands. [1] An example of his observations *on children aged* 13, showing both the progress in time and the differences inherent in social conditions, is given in Table 1.

Table 1

Boys.

	Schools of the poorer classes		Schools of the well-to-do classes	
Average for the years	Height Cm.	Weight Kg.	Height Cm.	Weight Kg.
1920	143.27	35.05	147.44	37.80
1925	145.79	36.64	150.65	39.85
1930	147.78	38.09	151.13	40.67
1935	150.46	40.43	157.08	45.03

[1] Investigations in the schools at Utrecht in the Netherlands yielded data comparable to those related here (26).

Girls.

Average for the years	Schools of the poorer classes Height Cm.	Weight Kg.	Schools of the well-to-do classes Height Cm.	Weight Kg.
1920	145.62	37.40	149.36	39.59
1925	147.91	38.36	151.08	40.81
1930	150.40	40.83	153.73	43.39
1935	153.06	43.28	157.42	44.50

Table 2

LARGE-SCALE INVESTIGATION UNDERTAKEN AT OSLO FROM 1920 TO 1925 (BY C. SCHIÖTZ). THIS INVESTIGATION SHOWS THE FIVE-YEARLY TREND IN THE MEAN WEIGHT AND HEIGHT OF SCHOOL-CHILDREN AND THE DIFFERENCES IN THIS TREND ACCORDING TO SOCIAL CONDITIONS

MEAN HEIGHTS

Elementary Schools.

Age (years [1])	Boys				Girls			
	1920	1925	1930	1935	1920	1925	1930	1935
	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.
8	121.80	125.53	125.17	127.21	120.58	124.45	124.72	126.41
9	126.05	128.57	130.59	132.11	125.30	127.82	129.71	131.33
10	130.91	132.90	135.13	136.75	130.02	132.27	134.59	136.69
11	135.02	137.83	139.81	140.91	135.05	137.21	139.49	141.48
12	139.23	141.34	142.93	145.60	140.37	142.38	144.84	147.47
13	143.27	145.79	147.78	150.46	145.62	147.91	150.40	153.06
14	148.22	150.51	153.10	155.00	150.60	151.39	154.94	157.30
15			157.90	158.75		152.39	157.27	160.31

[1] 8 years = $7^1/_2$ to $8^1/_2$, etc.

Higher-grade Schools.

Age (years)	Boys				Girls			
	1920	1925	1930	1935	1920	1925	1930	1935
	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.
11	140.34	145.46	145.27		137.98	142.12	145.07	
12	144.73	146.50	147.51		143.81	147.37	149.76	
13	147.44	150.65	151.13	157.08	139.36	151.08	153.73	157.42
14	153.46	155.86	157.39	162.66	154.91	155.93	158.52	161.17
15	159.47	162.36	163.84	166.76	157.88	158.69	160.83	162.47
16	165.73	167.57	170.17	171.33	159.87	160.66	161.62	163.17
17	170.03	170.98	172.77	174.12	160.97	161.66	163.01	164.17
18	173.55	174.65	176.07	176.59	161.04	161.43	164.69	164.58
19	174.14	175.95	176.94	177.23				164.88

MEAN WEIGHTS

Elementary Schools.

Age (years)	Boys				Girls			
	1920	1925	1930	1935	1920	1925	1930	1935
	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
8	23.85	24.61	23.33	25.66	22.58	24.30	23.03	25.24
9	25.28	26.20	27.23	28.07	24.58	25.69	26.99	28.01
10	27.58	28.49	29.87	30.80	27.02	28.09	29.79	31.05
11	29.93	31.39	32.82	33.46	29.94	30.89	32.65	34.17
12	32.44	33.64	34.75	36.77	33.28	34.17	36.22	38.16
13	35.05	36.64	38.09	40.43	37.40	38.36	40.83	43.28
14	38.54	40.01	42.64	43.60	41.81	42.43	45.50	47.26
15			45.76	46.75			47.55	51.95

Higher-grade Schools.

Age (years)	Boys				Girls			
	1920	1925	1930	1935	1920	1925	1930	1935
	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
11	32.80	35.56	38.05		31.91	36.06	37.00	
12	35.64	36.92	38.35		36.33	37.69	39.44	
13	37.80	39.85	40.67	45.03	39.59	40.81	43.39	44.50
14	42.39	43.84	45.46	50.05	44.92	45.93	48.19	50.06
15	47.25	49.60	51.09	53.93	48.15	49.83	51.51	52.44
16	53.04	54.16	57.30	58.94	51.27	51.87	53.67	54.59
17	58.06	59.23	60.65	61.95	53.59	53.78	54.75	56.32
18	62.30	63.11	64.27	65.60	52.87	54.52	56.94	57.29
19	65.50	64.38	66.36	66.40				58.74

A more detailed table of values referring to the age of children is given in Table 2. It relates to a large-scale investigation conducted at Oslo from 1920 to 1935, the details of which were communicated by Professor SCHIÖTZ.

The growth of the children of well-to-do parents is thus in advance of that of children of the poorer classes. That of all the children under observation at Oslo in 1930 was also in advance of the rate of growth for 1920.

The same conclusion emerges from the numerous extensive and detailed studies made at Vienna between 1920 and 1935 under the auspices of the American Save the Children Fund. Only a brief allusion will be made to these studies here to corroborate the facts reported above, since they have already been dealt with in a detailed article published in 1934 (15) (16). These observations showed that the mean height and weight of adults and children were, as a rule, greater in families of workers in employment than in unemployed households, and that in these two social groups the figures were higher than those observed by Nobel and von Pirquet immediately after the war (1920-1923).

It was recognised, moreover, that the cause of this fact might reside in a series of factors of some complexity.

In England, too, like observations have been made. They are set forth in a general report recently published by Sir J. B. Orr (58). It was found that the mean height and weight of children of the same age differed according to social class. Families were classed according to estimated *per caput* income (aggregate family income divided by number of persons in family).

A study of the trend of the mean *weight and* mean *height of children and adults in the same social group from year to year, or a comparison between such values obtained at the same period in different social groups, can provide interesting data on the state of nutrition. This conclusion justifies the proposal which has been made to repeat these measurements at given intervals.*

On the other hand, it is of less value from our point of view to compare these same data with those of the table of so-called normal figures, the criteria of normality being difficult to determine. [1]

We have just considered the absolute figures of height and weight in relation to age and sex. Another aspect of this question consists in analysing the *weight to height ratio,* perhaps even independently of age (W/H). This ratio, known in France as the *Bouchard index,* is held by its author to characterise the condition of stoutness or thinness of an individual ; it expresses the value of the *anthropometric segment—i.e.*, the average weight

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[1] In the United States of America, use was formerly made of Baldwin-Wood's tables, which give the mean age-weight-height ratio (61). [See also (62) and (63).]

of the individual per decimetre of height, the weight being expressed in kilogrammes and the height in decimetres. LAUGIER and LIBERSON have recently summarised what is known of this segment, which in the average normal adult man weighs 4.2 kg. The normal mean values vary, however, with the height and sex, and should be corrected by means of empirical coefficients computed on the basis of general build and muscular development. LAUGIER and LIBERSON state that the determination of the value of this segment will yield an indication as to a person's state of emaciation, but does not always warrant the conclusion that there has been under-feeding. This index probably does *not* constitute a very refined test of under-feeding. Thus, for example, stout persons may fail to grow thinner despite a strict diet, and, conversely, lean persons may fail to grow stouter despite an abundant diet. It does not appear from experience that we are entitled to regard this index as providing genuinely new information which would not be afforded by the absolute figures for weight and height. The interpretation of this index is, moreover, sometimes liable to error, since normal children who are rather small for their age may be comparatively over-weight, while normal children who are rather big for their age may, on the contrary, be, relatively speaking, under-weight.

Another way of studying the ratio between weight and height is to compare the individual's weight with the average for persons of his height, as given in a table of such values.

Certain authors have expressed the plus or minus deviation of the real mean weight from the " normal " mean weight for the height considered, the normal weight being always reduced to 100. In the Netherlands, this positive or negative number is called " Van der Heijden's number " (12). This method has also been employed in other countries. In the Netherlands, it has been declared inutilisable (12). In the United States of America, the method has been much studied (18), and also at Vienna (*loc. cit.* (15), page 489) ; and here, too, certain difficulties of interpretation are mentioned. According to the late Professor SCHIÖTZ at Oslo, the numerical standards of the American

EMERSON should not be applied too strictly, otherwise they would be misleading.[1]

The investigations made at Oslo from 1920 to 1935 showed that the weight-to-height ratio is subject, among other influences, to seasonal effects which cause fluctuations : rise in the W/H ratio towards the end of October, decline until the New Year, fresh rise at the beginning of spring and fresh decline during the spring until the beginning of summer. A study of the variations of the W/H ratio from one year to another must therefore rest on measurements made at the same time of the year. Moreover, according to SCHIÖTZ, within the limits of normality, the standard deviations from the mean weight for a given height work out at values which, expressed as a percentage of the mean, range from ± 7% to ± 12%, *according to the height considered* (24).

Generally speaking, the majority of health experts now accept the view that a simple record of the mean weight and mean height of children is all that is really necessary, and that it is better to keep to these two absolute figures in large-scale enquiries, to the exclusion of more complicated measurements. The recording of these data is only of real interest when it is periodically repeated, preferably at comparable times of the year, and when these data are compared with other observations concerning social conditions, school results, standard of living, certain general clinical indications and, lastly, certain physiological tests. Only then can they give useful information on the state of nutrition considered in relation to food habits.

Let us, however, examine briefly the series of more complicated somatometric indices which have already undergone the test of experience at the hands of health experts.

* * *

[1] According to WOOD's statistics (United States Bureau of Education), 20% of American children taken at random after the war in different social circles showed somatometric signs of malnutrition. According to that author, a child whose weight is 10% or more below "normal" in relation to his height must be considered under-nourished.

According to EMERSON, on the other hand, the limit is 7%. But the establishment of a standard mean value of normality is difficult. In 1917, the mean weight of a normal child of 14 was fixed at 80 lb. (36.24 kg.) and the mean height at 56 in. (140 cm.) in the State of Illinois (Child Labour Act of July 1917).

Later, these figures were reduced to 75 lb. (34.1 kg) and 55 in. (137.5 cm.) respectively. Once again, what is the criterion of normality ?

An excellent statement of the position with regard to these questions in 1921 was given briefly by MERRILL and VIOLLE (20).

2. Various Other Somatometric Indices

Quetelet's Index.

$$\frac{\text{weight}}{\text{height}^3} \text{ or } \frac{\text{weight}}{\text{height}^{2\frac{1}{2}}}$$

This index is not much used now.

Livi's Index (index ponderalis).

$$\frac{100 \times \sqrt[3]{W}}{H}$$

W = weight in grammes. H = height in centimetres.

This index, also, is not much used now.

* * *

Pignet's Index (coefficient de robusticité).

$$H - (W + Cg)$$

H = height in centimetres. W = weight in kilogrammes.
Cg = chest girth in centimetres.

According to Nobécourt and Vitry (19), the value of this index is doubtful. It does not deserve the description of *coefficient de robusticité* ; it only gives a qualitative indication of corpulence and numerically it varies in inverse ratio to the latter. Too large a coefficient reflects either too low a weight or too small a chest girth ; while, when the coefficient is too small, either the weight or the chest girth may be abnormally large. In any case, therefore, this index does not necessarily give any true indication of the state of nutrition alone.

* * *

Röhrer's Index.

$$\frac{W \times 100}{H^3}$$

This index has been much used in Germany since the war (American missions on infant nutrition in Germany). It has been abandoned by the majority of experts for some considerable time past, owing to the errors of interpretation which have been found to occur when too rigid a construction was placed upon it. According to Schiötz, this index may be of some value when it is used with discernment and when it is determined at regular intervals with the same child, but it gives no indication as regards the child's state of nutrition. It certainly provides no more information than that afforded by a simple study of the trend of the mean height and weight.

* * *

Manouvrier's Index.

$$\frac{H - SH}{SH}$$

H = erect height.

SH = sitting height or height of head and trunk—*i.e.*, the distance from the vertex to the seat on which the person is sitting.[1] H — SH therefore expresses the height of the lower limbs.

This ratio of Manouvrier's varies with age and sex ; it must always be compared with the figure corresponding to the person's height. According to Nobécourt, it gives no direct information on the state of nutrition, but it may reflect a pathological condition involving disturbances of nutrition ; and the measurement of the distance from finger-tips to finger-tips with laterally outstretched arms leads to considerations of the same kind (19).

In German-speaking countries, this ratio is known as the " length of leg to sitting height ratio ". These measurements are essentially characteristic of constitutional types. They can only serve as an indication of a state of nutrition when they are used for a comparison between individuals of the same

[1] *Sitzhöhe, Stammlänge.*

constitutional type, and this circumstance greatly reduces their practical value. In more than a quarter of the cases observed, this index is liable to misinterpretation (21).

* * *

Sitting-height Index.

$$\frac{SH}{H}$$

This ratio between the sitting height and the erect height is a variation of MANOUVRIER'S index. It has been used by E. NOBEL at Vienna (*Stammindex*). It calls for the same observations as MANOUVRIER'S index.

* * *

Von Pirquet's " Pelidisi " Index.[1]

$$\frac{\sqrt[3]{10\,W}}{SH}$$

W = weight in grammes. SH = seated height in centimetres.

According to VON PIRQUET, this somatometric index must be considered as expressing the state of nutrition of the subject examined, owing to the relation between the terms of the " *Pelidisi* " ratio and the absorption surface area of the intestine. This relation is based, in the main, upon two roughly established statistical findings :

(1) The length of the intestine is about ten times the sitting height, while the circumference of the intestine is about one-tenth of that height, although in reality it varies with its

[1] This index was first called "*Gelidusi*", from the first syllables of the words forming the sentence "*Ge*wicht zehnfach, *li*near durchziehen der dritten Wurzel, dividiert *du*rch *Si*tzhöhe". Subsequently, the word " *Pelidisi* " was preferred, derived from the Latin : " *P*ondus d*e*cies *li*neare *di*visio *s*edent*is* altitudo ".

contents. The intestinal surface S is therefore the square of the sitting height, and this ratio can be verified.

$$S = 10\ SH \times \frac{SH}{10} = (SH)^2 \text{-------} \quad (a)$$

(2) The cube of the sitting height in centimetres is about ten times the body weight in grammes.

$$10\ W = (SH)^3 \text{---------------} \quad (b)$$

$$\text{Or again, } SH = \sqrt[3]{10\ W} \text{----------} \quad (c)$$

If we divide equation (*b*) by equation (*a*), we get :

$$\frac{(SH)^3}{(SH)^2} = SH = \frac{10\ W}{S} \text{-----------} \quad (d)$$

from which it follows that :

$$S = \frac{10\ W}{SH} \text{-------------------} \quad (e)$$

Lastly, from equation (*c*) there may be deduced the following ratio, which gives the *Pelidisi* index :

$$\frac{\sqrt[3]{10\ W}}{SH} = 1 = \frac{100}{100} \text{-------------} \quad (f)$$

The equation (*e*) shows that this index (*f*) is theoretically a function of the intestinal absorption area.

The theoretical normal index value is thus represented by unity, but in reality the measurements yield a figure which deviates somewhat from this.[1] According to NOBEL (see page 127 of reference (7)), the real figures are as follows :

[1] For this reason, it is usual to multiply the results by 100, and the theoretical figure is thus 100 instead of 1. To illustrate this point, an example of calculations is taken from the article of MERRILL and VIOLLE (20) :

A child whose body weight is 19.3 kg. and whose sitting height is 60 cm. :

$$10\ P = 10 \times 19{,}300 \text{ grammes} = 193{,}000.$$

Pelidisi index $= \frac{\sqrt[3]{193{,}000}}{60} = \frac{57.8}{60} = 0.963 = \frac{96.3}{100}$; instead of the theoretical value $\frac{100}{100}$, the *Pelidisi index* will be given as equal to 96.3.

School-children whose index value ranges from 95 to 100 are normal and those below 95 are under-nourished, while those whose index value exceeds 100 are over-nourished.

In adolescent youths, the limit of malnutrition corresponds to an index value of 98 and in adolescent girls to an index value of 99.

This complicated index, based on unduly theoretical considerations, has not produced all that was hoped of it. As in so many other somatometric indices, the measurement is only approximate. It is not completely reliable, except in cases of marked deviation from the normal. Slight fluctuations are subject to errors of interpretation. Götzl, Kornfeld and Nobel observed this in the course of their Viennese investigations : " We have been surprised to find that the *Pelidisi* index did not show the differences in the state of nutrition as clearly as we had expected in view of our previous experience of this index " (*loc cit.* (15), page 480). An examination of these authors' tables shows that many of the values recorded are markedly divergent. In other series of figures, on the contrary, the indications given by this index appear to have been satisfactory. The fact is that the same defect reappears in all indices which involve a comparison between a value that has been found and that of a table of so-called " normal " values; it is when establishing this table that errors may occur.

According to Barden, the experiments carried out in America by means of this index show that the Pelidisi index fluctuates considerably according to age, and that the relation of the cube root of the weight to the sitting height is only approximately linear during the period of growth (*loc cit.* (8), page 39). This author gives other references to investigations showing the errors resulting from an over-strict application of these indices. Moreover, the slightest error in the measurement of the height has a considerable influence on the calculation of the final figures.

In 1923, Helmreich and Kassowitz expressed the opinion that individuals might exhibit a *Pelidisi* index far too low for their age, notwithstanding the fact that they were adequately nourished (21).

Most hygienists are at present of opinion that it is preferable not to employ this index.

* * *

Index of " Vitality " or Chest Girth-to-Height Ratio.

$$\frac{Cg}{H}$$

According to Nobécourt, the chest girth should be measured at the level of the xiphoid process, on forced inspiration and expiration, and the figure taken should be the mean between these two extremes. Sex affects the measurements of the chest girth. Nobécourt agrees that the index is unsatisfactory when it is under 50 in the adult. In children, the mean varies with age, and it is not possible to give definite maximum and minimum figures (19).

According to Schiötz, it is very difficult to obtain accurate measurements of the chest girth for comparative purposes in mass investigations, and for this reason it is preferable not to employ this criterion.

Liefman (23) prefers the ratio of the square of the chest girth to the height (" Quadratisches Brustumfangsindex ").

$$\frac{(Cg)^2}{H}$$

or else another variant, the *Brugsch index:*

$$\frac{Cg \times 100}{H}$$

This author shows how these indices are influenced principally by differences between constitutional types, which he divides into three — slender, medium or stocky (*leptosome, mesosome* and *pyknosome*) [1] — and observes that even within these three general categories the index still permits of distinguishing

[1] See page 176.

morphological sub-groups, so that it can hardly serve as a test for malnutrition unless the individuals in any one group are compared with one another.

The same conclusion is arrived at with regard to the *vitality index* $\frac{Cg}{H}$, according to Helmreich and Kassowitz (21). These authors do not consider it of any great value as a test of malnutrition. They regard it simply as an objective means of distinguishing between different constitutional types.

* * *

Flesch Index (Measurement of the Carpus, Wrist Girth).

This index gives an indication as to the general constitution of the skeleton. The normal figures for the Vienna population expressed in millimetres are, according to E. Nobel, those shown in Table 3.

Table 3

Flesch Index (Wrist Girth in Millimetre) : Normal Figures for the Viennese Population according to E. Nobel

Age (years)	Boys	Girls	Age (years)	Boys	Girls
At birth . .	76	76	8	124	124
1.	113	113	9	127	127
2.	116	116	10	130	130
3.	117	117	11	134	134
4.	118	118	12	139	139
5.	119	119	13	144	144
6.	120	120	14	148	148
7.	122	122			

It should be noted, however, that no data are given concerning physiological fluctuations. The figures recorded in Table 3 are not necessarily valid for every country, and there is nothing to show what part nutritional and constitutional factors play respectively in determining this index.

A great deal still remains to be learnt on this subject as well as on the accuracy attainable in such measurements.

* * *

Circumference of the Skull.

This index has also been recommended, for reasons similar to those which apply to the Flesch index.

According to E. Nobel, the normal figures are the averages shown in Table 4.

Table 4

Mean Values in Centimetres for the Circumference of the Skull in the Viennese Population, according to E. Nobel [1]

Age (years)	Boys	Girls
At birth	34.5	34.2
1	46.5	45.4
2	48.0	47.0
3	48.8	47.8
4	49.5	48.5
5	50.0	49.0
6	50.5	49.5
7	51.0	50.0
8	51.5	50.4
9	51.8	50.8
10	52.0	51.1
11	52.3	51.3
12	52.5	51.5
13	52.7	51.7
14	52.8	51.9
15	53.0	52.0

Most hygienists, however, consider that standardisation of the method of effecting this measurement is too intricate to undertake, and that, in practice, such a measurement is too difficult for the purposes of a large-scale survey, and might involve the investigating officers in errors.

* * *

[1] The figures in Table 4 are taken from the observations of Kornfeld (25), of Professor Nobel's service. They concern individuals whose height does not differ by more than 5% from the mean height corresponding to their age. Individual fluctuations do not exceed ± 3% to 4% and, lastly, concordance with the values observed in other countries is said to be satisfactory.

Pryor's Indices (Width to Height or Weight Ratios).

Certain authors have endeavoured to establish a relationship between height and age, on the one hand, and the bony structure, on the other—that is to say, the state of development of the skeleton. The breadth of the body has been suggested in the United States as a means of expressing the degree of skeletal development, and it has been suggested that the said breadth be measured across the pelvis. The landmark adopted by PRYOR is the iliac spine, so that the bisiliac diameter gives the breadth of the body. [1] The ratio of breadth to height, or, more accurately, the ratio of the bisiliac diameter to height, constitutes Pryor's index. Tables giving such values for all ages have been published by this author in the United States (64, 65). Take, for instance, a boy of 9 : his height is 135 cm., the bisiliac diameter 23 cm. PRYOR'S index is then 23/135 = 0.17.

In reality, this index is a numerical expression of the various constitutional types : *leptosome, mesosome* or *amplosome—i.e.*, the slender, medium or stocky types referred to elsewhere in this report (see page 176). It is thus dominated essentially by anthropological factors and, whilst it is possible that the state of nutrition may also influence this index, the extent to which it does so still remains to be determined. The author certainly found that there was a connection between the value of his index and the basal metabolism rate, inasmuch as persons of the leptosome (slender) type (low index) generally show a higher rate than amplosome (stocky) subjects (higher index). It is probable that the endocrine balance may underlie these individual biotypological differences, but it has not yet been proved that dietary inadequacies may affect PRYOR'S index. Other tables of the same author give the width-weight ratios for different heights.

* * *

Franzen's Index (A.C.H.).

In order to make certain that the purely somatometric indices have a really significant connection with the state of nutrition

[1] This measurement is considered preferable to that of the bisacromial diameter.

of the persons examined and not merely with their biotypological characteristics, FRANZEN studied, after 1929, more complex indices establishing a relationship between (1) the weight of the subject, (2) muscular development as judged from arm girth, (3) the development of the subcutaneous cellular tissue as measured at the surface of the biceps,[1] (4) the index of vitality and (5) PRYOR's index (66).

In practice, however, it was found that these indices were too intricate. In any case, they do not lend themselves to large-scale enquiries. FRANZEN and PALMER have accordingly proposed a simplified test involving the use of only three measurements : the arm girth, the depth of chest and width of pelvis. This simplified FRANZEN and PALMER index is known in the United States as the A.C.H. index, these being the initials of the three parts of the body measured[2] (67). The authors acknowledge, however, that these measurements can only be effected by specially trained observers if comparable data are to be obtained. Moreover, it still remains to be seen whether FRANZEN's elaborate or simplified (A.C.H.) indices can really be used with advantage as a means of assessing the state of nutrition of children.

* * *

McLoy's Index.

This is a variant of FRANZEN's index. It is also highly intricate and takes into account the vital capacity (respiratory volume) and basal metabolism. This index is very little used.

* * *

Tuxford's Index (78).

For the metric system : $\frac{\text{Weight}}{\text{Height}} \times [381\text{—age (in months)}] : 54.$

For English weights and measures :

$$\frac{\text{Weight (in lb.)}}{\text{Height (in in.)}} \times [379\text{—age (in months)}] : 0.3.$$

[1] These measurements are analogous to those of KORNFELD (see below, pages 178 and 179).

[2] *A*rm, *C*hest, *H*ip.

This index has been studied at length, and has been specially recommended, in England, by R. H. Jones (79).

* * *

Various Other Indices.

Yet other indices which are not mentioned here are to be found in R. H. Jones's paper, quoted above (79).

Chapter II

CLINICAL TESTS

The exclusive use of somatometric tests has been recognised to be inadequate as a means of forming a sound opinion of the state of nutrition of an individual or group of individuals. The reasons for this are given in the previous chapter. Accordingly, it has long been recommended that mass investigations should be supplemented by simple clinical examinations giving a brief indication as to the general condition of the persons considered and their clinical aspect. The Berlin Conference in 1932 emphasised the necessity for employing for the purpose a practical, simple and rapid method summing up a general clinical impression. It recommended von Pirquet's "*Sacratama*" index (see Annex 1, page 127 of that report, prepared by Nobel (7); see also below, in the present report, pages 177 and 178).

Burnet and Aykroyd called attention again to this aspect of the matter (see page 40 of their report (8)). The feeling that the general condition should be assessed in terms of a very simple standardised scheme of classification has had this consequence, that investigating physicians have been left to appraise, according to their own subjective judgment, the factors on which such a classification rests. An example is afforded by the *Dunfermline* [1] scale referred to in Burnet and Aykroyd's report, which involves a distinction into four categories:

1. General condition excellent;
2. General condition good;
3. General condition requiring supervision;
4. General condition requiring treatment.

The equivalent of this division is found in the classification now adopted in the investigations carried out by the British Board of Education and the Ministry of Health since 1935—viz.,

[1] See also (68).

division of children into four groups according to the estimate of their general condition, based on a subjective clinical opinion : [1]

Excellent—Normal—Slightly subnormal—Bad.

The estimate will depend more particularly on the child's general appearance, facies, carriage, attitude, condition of the mucosæ, muscular activity, amount of fat in the subcutaneous cell tissue, colour of the skin, brightness of the eyes, degree of alertness, etc.

In other countries, further considerations are : frequency of chills, number of days of absence from school, teacher's impression, scholastic results, etc.

Classification in four groups has also been criticised on the ground that there is no objective criterion for distinguishing between the groups. Whether to assign a child to this or to that group is too frequently a matter for hesitation. Accordingly, a scheme of classification into three groups instead of four,—viz. :

Good—Doubtful—Bad—

may appear preferable.

In addition to this clinical and empirical classification, certain hygienists, such as Schiötz, lay great stress on the necessity for a second classification, into the three human or physical types :

Tall or slender (*leptosome*) ;
Medium (*mesosome*) ;
Short or stocky (*amplosome*). [2]

Schiötz preferred the terms in parenthesis, on the grounds that they could be employed internationally.

The chief drawback of a very simple clinical classification based on ill-defined considerations is that the findings are not comparable *inter se.* Two kinds of difficulties have been observed :

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[1] There has been some discussion on the terms used to describe these four groups, although this aspect of the question is but of secondary importance, given agreement on the conventions. It may, for instance, be thought irrational not to include in the category of normal individuals children whose condition is considered excellent. These terms need only be replaced by *good* and *very good*, if this seems preferable.

[2] Rather than *pyknosome* (Schiötz).

(1) A number of investigating physicians working simultaneously among the same group of persons have not always classified the children in the same way, some being more optimistic or more pessimistic than others in their estimate.

(2) Further, such investigations are necessarily not comparable *inter se* for another reason : the general condition of a given child may appear relatively satisfactory if he is examined in a group of children whose average general condition is only fair, whereas he himself might have been classified only as fair had he been examined in a group whose average condition was good.[1]

In a word, there are no precise or objective standards of reference, and attempts to remedy this defect have not always been successful. The index described below represents an effort in this direction.

Von Pirquet's " Sacratama " Index.

The twofold purpose of this index is to standardise methods of examination and provide a systematised method of recording findings. NOBEL gave a definition of the index in 1932 (see page 127 of reference (7). It may be useful to recall it here.

The purpose of the index is to assess :

(1) The blood content of the skin ;

(2) The condition of the subcutaneous fat layer ;

(3) The tension, or, more precisely, the elasticity, of the skin ;

(4) The condition of the muscles.

These various points are appraised according to a conventional scale represented by the five vowels of the alphabet, arranged in descending order of pitch :

i = very pronounced ;
e = pronounced ;
a = normal (average) ;
o = inadequate ;
u = quite inadequate.

[1] See also the paper by R. H. JONES, already referred to (79).

The combination of these vowels with the initial letters of the following four Latin words :

(1) *sa*nguis,
(2) *cra*ssitudo,
(3) *t*urgor,
(4) *m*usculus,

yields a descriptive word, which expresses the properties in question. A normal (average) state of the skin, subcutaneous cellular tissue and muscles will be described by the word *Sacratama*. The term *Socretami*, on the other hand, will signify that the blood content of the skin is inadequate, and that the subcutaneous fat layer is fairly thick, but that the elasticity of the skin is normal and that there is great muscular development. *Socretemo* will indicate pallor, a thick fat layer, excessive skin tension and a defective condition of the muscles.

This ingenious proposal, however, does not appear to have found favour with hygienists. It has been very little used, except at Vienna, and does not seem to have been as practical as was hoped.

On the other hand, attempts have been made to express the normal condition of the skin, the subcutaneous cellular tissue and the muscular system in standardised numerical terms. This question has been dealt with statistically, chiefly at Vienna (25) and in the United States (75).

A. *Measurement of the Thickness of the Skin and of the immediately Subjacent Tissues.*

The process recommended by Kornfeld (25) is to measure with a compass, in millimetres, the thickness of a fold of skin at various points on the surface of the body ; these points are always the same, and are selected very carefully—*e.g.* :

A. The skin of the *chest*, 2 or 3 cm. below the middle of the right collar-bone.

B. The skin of the *abdomen*, 2 or 3 cm. to the right of the navel (vertical fold of skin).

C. The skin of the *back* near the median line, to the right, halfway up the vertebral border of the scapula.

D. The skin of the soft part of the *cheek* over the cheek-bone (thickness of the skin of the cheek).

The average normal figures are given in millimetres in Table 5 (according to KORNFELD).

Table 5

AVERAGE NORMAL THICKNESS OF THE SKIN AND SUBJACENT TISSUES ACCORDING TO KORNFELD, VIENNA

The thickness is measured under standardised conditions on the chest (A), abdomen (B), back (C) and face (D) (see text).

Age (years)	Boys				Girls			
	A	B	C	D	A	B	C	D
0 to 2	10	6.5 to 9	7.5	10	10	7 to 10	7.5	10
3 to 5	9.5	7.5	7	9.5	9.5	8	7	9.5
6 to 10	8.5	8	6	8	10 to 11	9 to 11	6 to 7	8.5
11 to 14	8.5	9 to 10	6.5	7	12 to 13	12 to 17	8 to 9	8

Lastly, it should be noted that the temperature of the skin has also been proposed as a means of appraising the thickness of the fat layer.

B. *Determination of the State of Development of the Muscles.*

As a means of assessing mere muscular development, as distinct from functional quality (for this, see physiological tests below), it was recommended at Vienna that the girth of the biceps and of the calf of the leg should be measured. The mean normal figures for the Vienna population are shown in millimetres in Table 6 (according to KORNFELD).

Table 6

MEAN NORMAL MUSCULAR DEVELOPMENT IN THE VIENNESE POPULATION, ACCORDING TO KORNFELD (GIRTH OF THE ARM AND LEG IN MILLIMETRES)

Age (Years)	Boys		Girls	
	Biceps	Calf of leg	Biceps	Calf of leg
At birth	95	110	95	110
1	158	190	150	190
2	163	200	155	200
3	165	210	156	205
4	166	215	157	210
5	167	220	159	215
6	168	225	162	220
7	169	230	165	230
8	171	238	170	237
9	173	245	176	245
10	177	250	182	255
11	182	260	189	265
12	187	270	196	275
13	194	278	204	285
14	202	285	212	300

The following points must, however, be considered :

(1) How far factors other than diet may influence these figures ;

(2) How accurately these dimensions can be measured ; and

(3) What is the range of physiological fluctuation above and below these average figures. It is clear also that these numerical appraisals of the average normal condition of certain tissues are not necessarily valid for other countries.

It should be noted, however, that these values have been compared with those shown in other returns. The fluctuations above and below the average figures have also been studied by KORNFELD (25) and, according to the degree of fluctuation, deviations have been classified in categories according to the conventional scale of VON PIRQUET'S *Sacratama* index.

Other Supplementary Clinical Examinations.

Summary Nose, Ear and Throat Examination.

By this is meant that a rapid examination is likely to be of use in mass investigations; there is, of course, no question of a specialist's examination, but simply a scrutiny of the pharynx, tonsils and ears.

Examination of the Teeth.

An examination of the state of the teeth is regarded as an excellent index of satisfactory or unsatisfactory nutrition. It should include an indication of the number of teeth with definite signs of disease, the number of teeth extracted and the general appearance of the teeth as a whole.

The late Professor Schiötz advocated the photographing of this general appearance as part of the records of surveys. (See Figure 1.)

Figure 1.
Photograph taken in the service of the late Professor C. Schiötz at Oslo, with the object of determining the general state of the teeth.

The Sign of the Dorsal Median Furrow (Knudsen-Schiötz).

One sign specially recommended by Schiötz in mass investigations, as constituting a true test of the state of nutrition, is the appearance of the median furrow of the back when the arms are held straight above the head. The observer should look out for two points : the appearance of the spinal column viewed from behind and the posture of the individual examined in profile. This test was proposed first by KNUDSEN in Denmark. It is claimed to be an indication of defective nutrition when the median furrow is broken or unduly sinuous, the former sign being the more important to watch for (test satisfactory in Figure 2 ; test unsatisfactory in Figure 3). According to the experience so far gained at Oslo, this is a simple and accurate test for the state of nutrition and is very little influenced by corrective gymnastics. The sign appears to depend really on the normal development of the spine and thorax under the influence of a properly balanced diet.

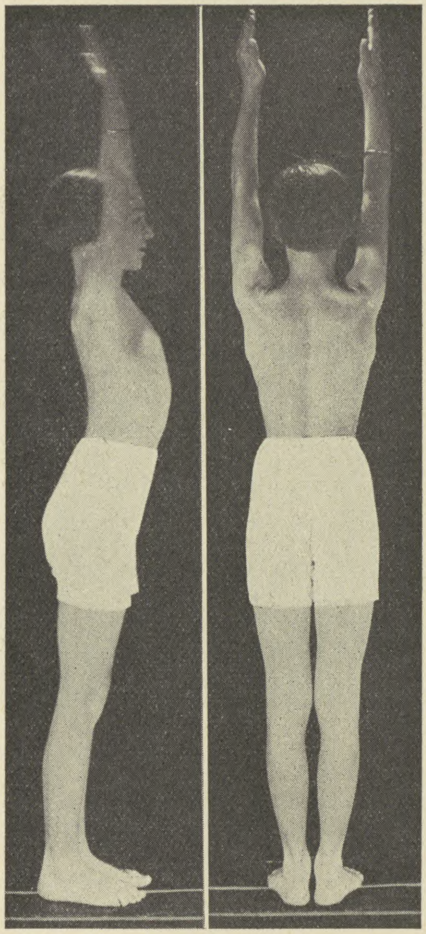

Figure 2.

Photograph taken in the service of Professor C. SCHIÖTZ at Oslo. The same subject as in Figure 1.

Appearance of median furrow. — Normal posture. Note the continuity of the furrow. The only defect is perhaps that the line is somewhat too sinuous.

Professor SCHIÖTZ laid great stress on the advantages of this test in mass investigations, its facility of application and its reliability ; he stressed the advisability of extending the *photographic method* in recording the results of investigations.

Generally speaking, no entirely satisfactory scheme has yet been devised for a simple standardisable clinical examination, to be applied on practical lines to mass investigations. The results are too vague when the method is simply defined, and there is a lack of homogeneity in the recording of results when greater elaboration is attempted. Nevertheless, it is in the direction of standardisation that perfection in the technique of examinations must be sought.

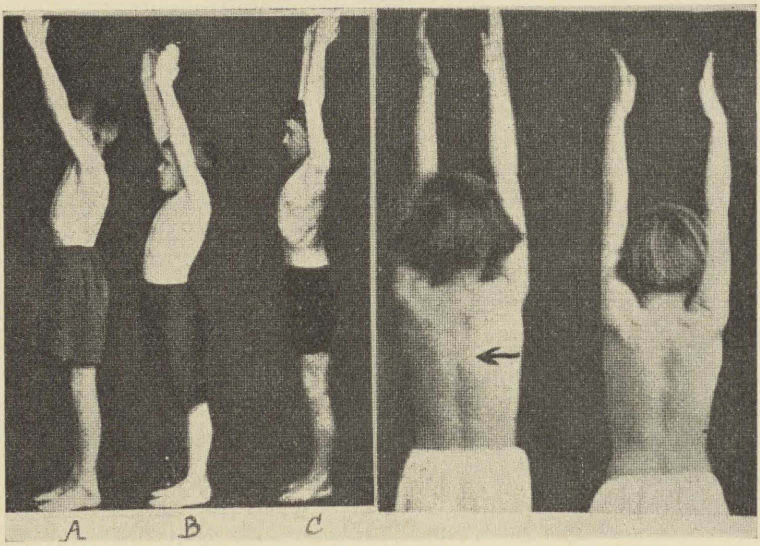

Figure 3.

Knudsen-Schiötz sign. Incorrect postures.

Appearance of the median furrow. — The arrow shows a break in the median furrow. Same observation for the child on the right, although the condition here is more satisfactory.

Posture in profile. — *A and B,* defective postures. The arms are not held vertical. The thorax does not lift sufficiently to enable the arms to assume the correct position.

C, correct posture.

Chapter III

PHYSIOLOGICAL TESTS

It is in tests of this kind that the methods of investigation studied and suggested have varied most. A distinction should, however, be drawn between *two groups of physiological tests:* (1) Specific physiological tests for malnutrition ; (2) Non-specific physiological tests for malnutrition consisting of functional tests that may, however, be indirectly affected by defective nutrition.

We will first consider the former, which, though less numerous, are undoubtedly more important, because they bear directly upon disturbances specifically attributable to the functions of certain constituents of the diet.

* * *

1. Specific Physiological Tests for Malnutrition [1]

Theoretically, in the case of most of the constituents of the diet, an inadequate intake is liable to produce specific disturbances, having regard to the part they play individually in promoting certain particular physiological functions, as distinct from any share they may have in more general joint contributions, such as the covering of energy requirements. Among specific troubles of this kind, mention may be made of deficiencies in the development and calcification of the bones, the building-up of respiratory pigments, the rate of growth of children, the co-ordination of nutritive exchanges, etc.

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[1] When correcting the proofs, the author received an American publication dealing with the same matters as the present chapter. The reader will find there a great deal of information and material of interest (119).

It is therefore clear that a deficiency of any constituent should, theoretically, be detectable by means of a suitable specific test.

At the present time, however, such specificity has been attained only in one or two tests. We must therefore learn what we can from these in looking for the early signs of slight malnutrition. And, apart from the specificity of such signs of latent deficiency, we must also consider, for practical reasons, how early they appear and how far they are reliable.

From this point of view, we shall consider the following signs of pre-deficiency : (1) Signs of latent vitamin pre-deficiency ; (2) Signs of mineral deficiency ; (3) Signs of protein deficiency.

We are thus considering, generally speaking, early indications of deficiency in " protective nutrients ". The importance of this aspect of the question at the present time has already been emphasised on several occasions. It is evidenced by the fact that an unsatisfactory standard of life leads to a deficiency of protective foods in the diet before any deficiency in the aggregate calorie intake occurs.

The conception of latent vitamin pre-deficiency or unapparent hypo-vitaminosis, as compared with frank, well-marked vitamin deficiency, is a fairly new one. According to this conception, the development of deficiency diseases may be divided into two successive stages : (1) Prodromal period of occult or unapparent hypovitaminosis ; (2) Period characterised by more pronounced, clinically apparent, deficiency disease.

Whilst frank vitamin deficiency is not common except in certain countries in which there is pronounced malnutrition and a decided lack of balance in the diet, there is a growing amount of evidence to suggest that, in countries in which these diseases are rarely found, if ever, a slight lack of balance in the diet may nevertheless bring about a state of insidious unapparent pre-deficiency, though this does *not* commonly lead to sickness, since the diet is usually not sufficiently unbalanced for that.

The reality of the fact that latent pre-deficiency may remain hidden for a long time was verified by experiments on animals, and a striking example will be found in the papers of MOURIQUAND and his school (27 to 30). Animals suffering from vitamin-A pre-deficiency are found to be in an unapparent pathological condition, traceable by an appropriate test long before the ocular effects of definite vitamin deficiency (xerophthalmia and keratomalacia) begin to appear. The first signs of eye trouble are preceded by weakened resistance of the cornea to certain pathogenic agents. This can be shown by producing very slight irritation by brief exposure of the cornea to ultraviolet rays. The micro-lesion is then watched through the biomicroscope. In the ordinary way, it should heal within three or four days. Animals suffering from unapparent pre-deficiency take longer to recover, and in some cases this slight irritation leads to serious complications, suppurating ulcers followed by typical xerosis lesions. Tests of this kind cannot, of course, be used in human pathology, but they serve to demonstrate the existence of latent pre-deficiency conditions in animals.

We may therefore assume that other tests could be used in practice to disclose similar conditions in man.

Studies of this kind are not very advanced at present, but if we continue on these lines we may hope to establish objective tests of a normally balanced diet.

Up to the present, we have not sufficient experience to permit of the early diagnosis of latent vitamin pre-deficiency, except in the case of partial deficiency of three vitamins : A, D and C.[1] We will take these three cases in turn.

Vitamin-A Deficiency.

The MOURIQUAND test on animals bears upon the early stages of morphological impairment leading to xerophthalmia and keratomalacia and thus seems to be concerned with the part played by vitamin A in increasing the resistance of mucous

[1] Work is only now beginning on methods which may serve as early tests of vitamin-B1 pre-deficiency. These comprise determinations of the vitamin content of the urine (118), and tolerance tests shown by the organism after intake of certain products of the intermediate carbohydrate metabolism (lactates, pyruvates) (117).

membranes and teguments to the attacks of microbes (vitamin A is sometimes described as " anti-infectious " for this very reason). The test applicable in human pathology, on the other hand, is concerned with another aspect of the physiology of vitamin A, especially the part played by this vitamin in the production of *visual purple*. Proportionately speaking, the retina is the organ which is richest in vitamin A (31), and a dietary deficiency in vitamin A has a considerable effect on its concentration in the retina.

The presence of a fairly large supply of vitamin A seems to play a decisive part in the mechanism of the reversible conversion of the visual purple into its leuco-derivative. This pigment is bleached under the influence of light and its regeneration in the dark would seem to depend upon the concentration of vitamin A in the retina.

Now the accumulation of the pigment within the rods makes the eye sensitive to weak rays of light—that is to say, increases visual acuity in semi-darkness—while its disappearance enables the eye to adapt itself to a strong light.

As one outstanding characteristic of vitamin-A deficiency is the exhaustion of the retina's reserve of vitamin A, this should retard the regeneration in the dark of visual purple, and should therefore cause some delay in the function of dark adaptation .[1] Hemeralopia ,[2] or tropical night-blindness—one of the forms of frankly apparent vitamin-A deficiency—is to be explained by this mechanism, which has been verified by FRIDERICIA and HOLM (32) on animals fed on a diet deficient in vitamin A.

Whereas xerophthalmia and night-blindness are forms of distinct avitaminosis,[3] it has been suggested that a slight weakening of the adaptability of visual acuity, so faint that the

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[1] " Dysadaptation " is the term used by EDMUND to describe this slowing-down of the adaptation of visual acuity to variations in the intensity of the light.

[2] *Hemeralopia* or *crepuscular amblyopia* is defective sight in semi-darkness, the sight being satisfactory in daylight ; *nyctalopia* is defective sight in the daylight (dazzle), the sight being satisfactory at night.

[3] Examples are to be found in Europe of such frank avitaminosis occurring either in a relatively large number of persons or in isolated cases—viz., in Denmark in 1917 (BLEGVAD, 33) ; in Vienna in 1919 (34) ; in the North of England in 1930 (35), etc.

Figure 4.

FRANDSEN'S charts. The figures placed below the letters indicate the logarithmic scale of the coefficients of extinction.

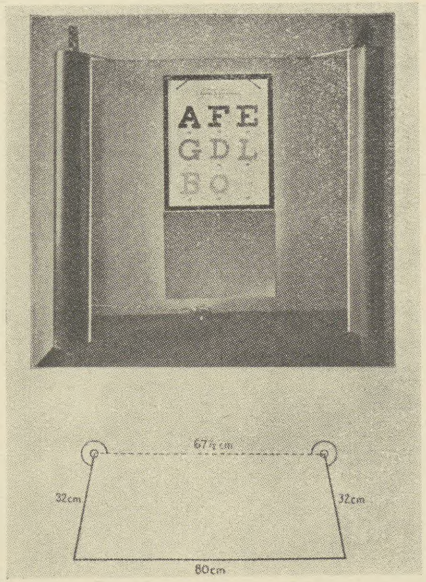

Figure 5.

Method of lighting the charts for examinations.

person is not even conscious of it, might, if it could be detected early and by objective means, afford an early specific test of a very slight hidden form of latent night-blindness and so serve to indicate a state of early vitamin pre-deficiency, in so far as such " dysadaptation " may not be attributable to other known local causes, discernible by ophthalmological examination.

The test consists, then, in ascertaining quantitatively the minimum intensity of light in which visual acuity can be determined by some particular ophthalmological test, first, when the eye has been moderately dazzled beforehand by a given source of light, and, secondly, after a certain time has been allowed to elapse for dark adaptation ; in other words, the test consists in ascertaining the rapidity with which the eye adapts itself to a change in the conditions of light in which visual acuity is measured.

Four methods have been suggested for this purpose :

(a) *Edmund's Method.*

The principle and application of this method have been described by the author in various memoranda (36, 37) ; his experience as a whole in the matter will be found in the monograph published by him in collaboration with Clemmesen (37). Variations on the same method have been used by Frandsen (38). The main principle may be briefly stated as follows :

A graded range of grey tones of given degrees of darkness can be made up in various ways. One is illustrated in figures 4 and 5. It consists of letters on a white background. The gradual toning-down is determined photometrically in accordance with a scale indicating progressive extinction from left to right, corresponding to the following coefficients :

$$\frac{1}{10^{0.25}} \quad \frac{1}{10^{0.50}} \quad \frac{1}{10^{0.75}} \quad \frac{1}{10^{1}} \quad \frac{1}{10^{1.25}} \quad \frac{1}{10^{1.50}} \quad \frac{1}{10^{1.75}} \quad \frac{1}{10^{2}}$$

The corresponding logarithmic scale of this series extends as follows in relation to 0.00 (absolute black) (Figure 4) :

0.25	0.50	0.75	1	1.25	1.50	1.75	2

These coefficients are indicated in Figure 4.

The plates can thus be exactly calibrated photometrically, if it is desired to render the results of various investigations comparable. But, for the purposes of one given investigation, charts reproduced with rough accuracy can be used, provided subjects enjoying normal adaptation have first been tested with them. The only limitation is that the numerical results obtained cannot necessarily be compared quantitatively with those obtained with the use of photometrically standardised charts.

The charts are read by the subject under observation, who wears a series of smoked glasses of varying opacity (TSCHERNING's photometric scale ; series in increasing order of opacity) (39).[1] Visual acuity is determined by the number of letters read on the charts in varying intensities of light, regulated by the Tscherning glasses worn. The distance from observer to chart, the size of the letters and the brightness of the illuminant are fixed and are kept constant. Series of letters on a number of different charts are used, so as to obviate errors due to memorisation by the subject.

Another means of eliminating this source of error has been resorted to by FRANDSEN ; he uses a single, movable letter (E, for instance), which is successively placed in different positions. EDMUND's method has also been used by CLEMENTS in Australian enquiries (81).

(b) *Birch and Hirschfeld's Photometer Method.*

Figure 6 illustrates the principle on which this method, borrowed from the work of JEANS and ZENTMIRE (40), is based. A source of light (**A**) of given intensity emits a ray traversing

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These glasses should be worn in addition to those which the subject may normally wear, since the subject's refraction must be corrected in advance where necessary.

an iris diaphragm having an adjustable aperture (**B**) provided with a conventionally numbered scale, and a disc (**E**) with five holes placed like the pips on a "5" playing-card. A GOLDBERG smoked screen (**C**) [1] is placed across the light beam in such a way that its position, which is also plotted on a conventional

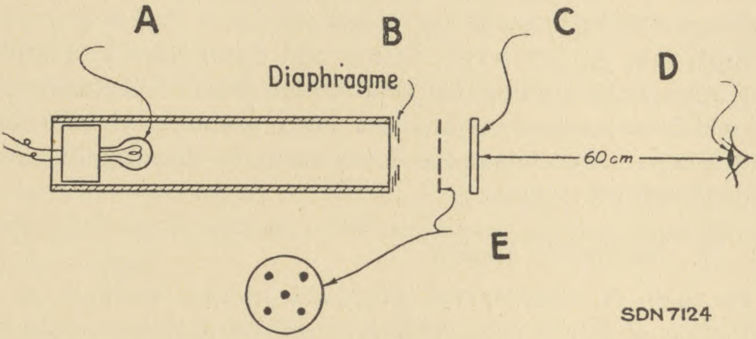

Figure 6.

BIRCH-HIRSCHFELD photometer or adaptometer.

scale, regulates the degree of extinction.[2] The observer is placed with his eyes 60 centimetres from the apparatus. Two factors control the degree of extinction : the position of the Goldberg screen and the aperture of the iris diaphragm ; through the action of the Goldberg screen, the five luminous points produced by the disc have different degrees of brightness, while the diaphragm enables the luminosity of the whole image to be changed.

Measurement takes place in the dark, and consists in ascertaining the diaphragm aperture at which not less than three luminous points are visible to the observer.[3] His sight must, of course, be corrected in advance, if necessary by suitable glasses.[4]

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[1] This screen consists of a wedge-shaped rectangular piece of smoked glass, the opacity of which increases progressively in the direction of its longest side.

[2] The screen moves in a direction perpendicular to the path of the beam.

[3] The position of the Goldberg screen is first suitably adjusted.

[4] JEANS has recently recommended a new design for his apparatus (69).

Visual acuity is measured first after the subject has been somewhat dazzled for a while by means of a lamp. The measurement is then taken again after several minutes spent in complete darkness. The rapidity with which adaptation takes place is thus judged by the difference in the threshold of intensity of the light. The power of adaptation is impaired by vitamin-A deficiency.

Bigwood, Jacquemyns, Danis and Sano have also utilised an apparatus similar to this (Birch-Hirschfeld-Zeiss) (82), of which a further variant has been proposed by Rudolph and Hecht. The latter has been used by Booher, Callison and Hewston (83).

(c) *A. Chevallier's Method.*

In 1938, A. Chevallier proposed another method for the detection of latent hemeralopia, based on a principle different from that of previous tests (84). He does not measure visual acuity or its speed of adaptation to darkness. He determines the threshold intensity of light which is perceptible by the person under test as dim light and not as a defined image. His measurement is thus concerned with peripheral vision alone. He rejects any test of acuity, because this involves macular vision, whereas he argues that the distribution of visual purple extends more especially over the remainder of the retina and that there is less in the fovea. Against this argument, it might be urged that, when a person is trying, in the dark, to detect the moment at which he begins to perceive a gradually appearing image, the whole of the retina is brought into play in this effort of detection. Moreover, macular vision also undergoes dark adaptation and the fovea is also said to contain a photosensitive pigment chemically similar to visual purple (Z. Hecht). On the other hand, Chevallier does not measure the speed of regeneration of the visual purple in darkness ; he determines a threshold intensity value which, according to him, is related to the maximum quantity of visual purple that can be formed in a given retina. He claims that this maximum rises with an increasing supply of vitamin to the retina. It should, however, be noted that Fridericia and Holm (32) have found in animals that, when the eye is completely adapted to darkness, the content of visual purple, which is then at its highest, appears to be the same in animals suffering from frank vitamin-A deficiency and in normal controls. According to this evidence, therefore, the factor to be taken into account is the rate of regeneration of the visual purple rather than the maximum quantity of purple which the eye is capable of regenerating when given time to do so.

However this may be, CHEVALLIER believes that his method provides him with a reliable technique for the detection of latent hemeralopia. The half-hour in complete darkness which his method requires is, however, a difficulty in the way of its practical use in surveys. His apparatus, on the other hand, is fairly simple.

(d) *Method of Friderichsen and Edmund.*

These authors have attempted to determine the threshold of luminous intensity in infants adapted to complete darkness, by observing the reflex action of the face and eyes caused by the perception of light radiation.

* * *

FRANDSEN (38), in March 1933, found impaired power of adaptation in sixty-five school-children in apparent good health ; forty-six showed latent hemeralopia in varying degrees. Four months later, during the summer, their condition had spontaneously improved.

The same author also examined twenty-six children in a boarding-school, where the fare could be exactly controlled. The diet was deficient in vitamins. Twenty-one of these children showed signs of latent hemeralopia, together with a tendency to calcium and phosphate deficiency in the blood. After one month's treatment with cod-liver oil and calcium phosphate, the hemeralopia signs disappeared entirely or in part.

Finally, from among seventy-two children examined in private practice for eye troubles (conjunctivitis, photophobia, cephalea, etc.), the great majority (seventy patients) showed signs of latent hemeralopia, which yielded to treatment with fat-soluble vitamins.

Edmund has also shown by his method that 50% of pregnant women admitted to a Copenhagen municipal hospital showed signs of dysadaptation (37).

Toverud used the same method in testing children at Oslo for dysadaptation (108).

Jeans and Zentmire have investigated the incidence of vitamin-A pre-deficiency among school-children in Iowa City (United States) and the surrounding countryside, using the Birch-Hirschfeld apparatus (40 and 41).

Their enquiry, undertaken during 1934, covered 213 children aged from 6 to 15 attending the out-patient department of Iowa City Hospital. Normal reactions to the test were obtained in 168 cases. The remaining forty-five subjects showed signs of latent hemeralopia ; half of them were admitted to hospital, and their eyesight was tested regularly during treatment with cod-liver oil. The tests showed that sight became normal after a period varying from four days to six weeks.

The same method was subsequently used by the same authors on 404 school-children taken from : (1) a village of 2,000 inhabitants ; (2) the countryside surrounding this village in a ten-mile radius ; (3) Iowa City (150,000 inhabitants). All the subjects therefore came from the State of Iowa. The town children were divided into three categories according to their social status, as indicated by average income. Clear evidence of latent hemeralopia was found in 26% of country children, 53% of village children, 56% of town children in the higher social category, 63% in the middle category and 79% in the lower category. The investigators found no correlation between the incidence of latent pre-deficiency and sex or age ; but they were struck by these high percentages, and continued observation on the subjects during treatment with cod-liver oil or carotene. Of ninety-nine children either definitely deficient or subnormal (border-line cases), seventy-five were cured in three to six weeks, nine improved substantially in health although treatment was not sufficiently prolonged, twelve were lost sight of (refusal to submit to treatment, intercurrent ailments, etc.), and only three did not react to treatment even though prolonged for a further three to six weeks. The authors consider that this test can be relied upon to indicate vitamin-A pre-deficiency in 95% of cases.

Having improved their technique, these authors (69) arrived somewhat later at very slightly modified percentages, which did not, however, affect the order of relative incidence of the latent pre-deficiency which was disclosed by this means in the American population group studied.

Bigwood and Danis (82) conducted similar observations in the Brussels population, both among adults and also, and especially, among children (130 subjects examined). They found defective adaptation in about 40% of cases examined, whilst in about 20% it was doubtful and, in the remaining 40%, good. They also found that, save in a few exceptional cases, the findings remained reasonably constant when the examination was repeated after a few days' interval. The reliability of the test has, however, been questioned by certain authors (Palmer and Blumberg (107) and Snelling (104)). Nevertheless, most workers regard this method as generally reliable and specific, at least within certain fairly satisfactory limits.

At the same time, the distinction between good and bad adaptation cannot be said to be easy. The methods adopted to draw the line of demarcation vary according to the author concerned, so that the technique is not yet standardisable. Difficulties of interpretation subsist in border-line cases. Really good adaptation can be distinguished without hesitation from marked dysadaptation, but the border-line cases are many.

One difficult technical point still in need of elucidation is the degree of adaptation of the eye to light, which may affect the rapidity of the subsequent adaptation of the visual acuity to darkness (105, 106, 111).

Observers are generally agreed on the following principle as a criterion of normal or defective adaptation. Any adaptation test finding that can be definitely improved by the addition to the diet for a few days of a substantial supplement of vitamin A in the form of some concentrate (10,000 international units and over *per diem*) shows that there is dysadaptation (pre-deficiency). Adaptation is normal when no such improvement is observed. It is therefore assumed that the normal condition is one of maximum adaptation. It may, however, be asked whether such a view is not arbitrary. Is not such a criterion of normality too stringent ? The most recent research work has accordingly been designed to ascertain whether the individual response to the test can be influenced by modifications of the diet other than the addition of a vitamin concentrate in high doses. In the course of an enquiry conducted in a Danish prison, FRIDERICIA found that a supplementary milk ration bringing the intake of vitamin A and pro-vitamin A up to 1,500 international units or more per day for an adult man eliminated the seasonal fluctuations observed without this supplement (80). BOOHER, CALLISON and HEWSTON (83), in tests on four normal adults of 55 to 70 kg. body-weight, found that a daily supply of 2,000 to 3,000 international units was necessary to maintain good adaptation of visual acuity to darkness. BIGWOOD and his collaborators (82) made similar observations in thirty-five Brussels families of all income classes. Their observations yielded evidence of fairly marked individual differences. When the daily intake exceeds an average of 3,500 international units per head in the family (irrespective of age or sex), adaptation is good ; when it falls below 1,000 units, it is bad ; between these limits, individual cases can be found in which adaptation is satisfactorily maintained on a low intake of vitamin A, and others in which adaptation is less good, though the supply of vitamin is more abundant.[1] Speaking generally, any substantial change in the quantity of vitamin A and pro-vitamin A provided in the diet has a distinct effect on the dysadaptation test ; there are, nevertheless, factors which modify the vitamin requirements of the body fairly considerably. The reason for these individual fluctuations is probably to be sought in differences in digestive utilisation, in the efficiency of the conversion of carotinoids into

[1] These values have been derived from the tables of SHERMAN, FABER and NORGAARD. If, however, they are computed from the tables of FIXSEN and ROSCOE, they must be reduced by an amount which is fairly small on the average, and which will be given in a comprehensive paper to be published later. (See Part I, pages 60 to 62.)

active vitamin A, in the balance of the diet, in the utilisation in the tissues, and, finally, in build and height, age and sex. This shows the importance of working, primarily, on average results observed for whole groups.

In conclusion, reference may be made to the observations of Staz in South Africa (109), of Maitra and Harris in England, (110 and 115), of Schuck and Miller (112), of Corlette *et soc.* (113) and of Juhasz Schäffer (114), in regard to the incidence of dysadaptation in both children and adults, or in pregnant women.

Though no attempt can be made to draw conclusions from these —so far insufficiently numerous—observations, it can already be seen that (1) *the test for latent hemeralopia is applicable to investigations in the field of social medicine,* (2) *it will yield useful information, although the exact technique has not yet been worked out in its final form, and* (3) *latent vitamin-A pre-deficiency can, even at this stage, be asserted to be frequent in many parts of our countries of Western civilisation, although its incidence cannot yet be reliably assessed in numerical terms.*

* * *

Wessely's Method.

This method rests upon a principle entirely different from that of the three tests already described. Whereas the latter disclose latent forms of hemeralopia—that is to say, functional disturbances whose pronounced form in human beings is night-blindness—Wessely's method should probably be regarded as a test for a latent trophic defect, the pronounced form of which is keratomalacia. The method consists in examining the reflective power of the cornea. In vitamin-A pre-deficiency, the optical properties of the cornea are impaired, so that it reflects but imperfectly an incident ray of light emitted by a standardised source. The test amounts, in fact, to a comparison of the brightness of the cornea under examination with that of a normal cornea. Wessely described his method in 1927 (55) (85). It was not used, however, until much later as a test for pre-deficiency. In this connection, reference may be made to the investigation which HEIJERMANS and ZEEMAN carried out in the Amsterdam schools during 1937 and 1938, using both the WESSELY method and the measurement of latent hemeralopia. By the latter method, these authors detected a condition of latent vitamin-A pre-deficiency in about 20% of the school-children examined. As for WESSELY'S method, it proved rather unsatisfactory, the results of successive examinations of the same children showing very considerable discrepancies.

Method of determining the Vitamin-A Content of the Blood.

This method was used by Dr. MENKEN at the Health Laboratory of the University of Utrecht. The question is not examined in detail here, since information upon it has already been published in the *Health Bulletin* (42).

Vitamin-A pre-deficiency, according to this method, is probably accompanied by a lowering of the proportion of this vitamin in the blood.

All observers do not agree that the fluctuations of the vitamin-A content of the blood really reflect the variations of the intake in the food, though CHEVALLIER takes the view that determinations are useful in this connection. This difference of opinion is due to the fact that the methods applied in making the determinations do not give comparable results and are not all equally specific in regard to the substance measured.

* * *

Vitamin-D Deficiency.

(Pre-rachitic condition.)

Signs of a pre-rachitic condition in infants can be discerned by *X-ray examination of the wrist*, but this method does not appear to give as early an indication as a determination of the phosphatase content of the blood.

Determination of the Phosphatase Content of the Blood.

A latent pre-rachitic state can, according to certain authorities, be detected by measuring the phosphatase content of the blood serum. It is known that the blood content of this enzyme is increased in patients suffering from various bone, and even other, diseases. The increase is therefore not a specific symptom of the single complaint of rickets. If, however, it can be shown to occur regularly in children who are in the pre-rachitic phase but are otherwise clinically normal, such a sign may be of practical importance as an indication of vitamin-D pre-deficiency.

As the test has to be used on children, it is essential that it should be applied to the capillary blood. LUNDSTEEN and VERMEHREN have, with this object, worked out a micro-method of determination of phosphatase in the plasma, which requires 50 cubic millimetres of capillary blood for each double test (43). Using this method, VERMEHREN obtained the following preliminary results, the normal phosphatase content of the blood varying considerably according to age :

Age (years)	Units [1]
New-born infants	80-100
0-1 (artificial feeding)	100-250
1-2	120-250
3-6	65-190
6-10	65-135
10-12	40-125
20-30 (adults)	20-55

In rachitic children (well-characterised rickets) between 6 months and 2 years of age : *300 to 700 units.*

This excess of phosphatase in the blood is known to be the symptom which is the last to yield to treatment. Moreover, this same symptom also appears *before* the clinical, radiographic and other biochemical signs in the blood (calcium and phosphorus content). It is therefore clearly an early sign of a latent pre-rachitic condition.

[1] The unit is taken as the amount of phosphatase which can release 1 mgrm. of phosphorus from its organic compounds in twenty-four hours at 37° C.

Lastly, seasonal fluctuations are also observed in the blood phosphatase content of children of normal appearance ; this rate falls from spring to autumn and rises in the winter.

These observations of VERMEHREN are still of a preliminary nature, but they already show that this test for latent vitamin-D pre-deficiency promises to yield valuable results. They were described by Professor FRIDERICIA at the meeting of the Committee of Experts held at Geneva from December 8th to 12th, 1936.

* * *

Vitamin-C Deficiency.

(Sub-clinical, pre-scorbutic condition.)

The Normal Vitamin Content of the Organs.

The animal species studied up till now may be divided into two categories : those which are liable to scorbutic deficiency and those which are not. The latter form the majority. They synthesise vitamin C *in vivo*, and are thus not dependent upon their diet for their ascorbic acid requirements. The vitamin content of their organs is, and remains fairly constantly, at the maximum level ; it is unaffected by fluctuations of the food intake. It is characteristic for each organ, irrespective, so far as this category is concerned, of the species considered ; hence the idea that it is representative of the normal physiological condition (state of saturation).

Among species liable to vitamin-C deficiency (man, monkeys and guinea-pigs), it is probable that synthesis *in vivo* is practically *nil* ; these species have to look to their food for the necessary supplies of ascorbic acid. The vitamin content of their organs is variable and affected by the diet ; it is very often below the physiological saturation level as defined by the values observed in synthesising animals. Adult man requires, on the average, at least 50 mgrm.) 1,000 international units) of ascorbic acid to reach this " ceiling ". The fact that guinea-pigs reach this maximum degree of saturation of themselves when allowed to feed unrestrained on what they choose suggests that this " ceiling " really reflects the normal condition. It has not, however, been proved unequivocally that physiological values may not differ somewhat from it. The determination of the ascorbic-acid content of the tissues is obviously impracticable in nutritional surveys. The only test which would be in some measure equivalent is ROTTER'S test (87), which consists in injecting 1 c.c. of 0.0025N (N/400) dichlorphenol-indophenol under the skin. If the coloration of the reagent disappears in less than 5 minutes, the organs are saturated. If the time required is between 5 and 10 minutes, the person examined is still normal. Deficiency is present if the decolorisation takes more than 10 minutes.

* * *

The Vitamin-C Content of the Blood.

All methods do not give the same result. According to EMMERIE, the normal serum contains an average per litre of 5 mgrm. of ascorbic acid in its reduced form alone ($C_6H_8O_6$) (determination by dichlorphenol-indophenol—*i.e.*, TILLMANS'S reagent). WOLFF, BANNING and VAN EECKELEN measure both the vitamin in its reduced form and its reversible oxidation derivative, dehydroascorbic acid ($C_6H_6O_6$). (They also use TILLMANS'S reagent for titration.) Tested in this way, the content may vary from 0 to 18 mgrm. per litre, the mean lying somewhere between 10 and 12 mgrm. (42). CHEVALLIER assays spectrophotometrically and finds an average of 20 mgrm.

Another method is that of TRIER, who determines only the reduced form by the process of photochemical reduction with methylene blue (a process worked out for his tests by LUND and LIECK (47)). TRIER'S values fluctuate between 2 and 6 mgrm. per litre in normal or *non*-febrile sick persons. The author observed seasonal variations as follows (according to 500 analyses performed at the Copenhagen Municipal Hospital—communicated by FRIDERICIA (95)) :

	Milligrammes per litre (mean values)
January to April	2.5 to 3.5
May and June	2.0 to 2.5
July and August	5.0 to 5.5
September and October	4.0 to 5.0
November and December	2.5 to 3.5

In case of definite deficiency, 0 to 2 mgrm. per litre. The absolute value of these determinations can obviously not be judged, but their relative value is of significance in enquiries in which one and the same method is used. Thus we have seen that, according to Wolff, Banning and van Eeckelen (42), for instance, the blood content can vary between 0 and 18 mgrm. per litre. When, on the showing of the urine test, the organism is saturated with the vitamin, the concentration in the blood varies between 14 and 18 mgrm. and some passes into the urine. This state of affairs is regarded as normal and as corresponding to the utilisation of 50 mgrm. of ascorbic acid in a subject weighing 70 kg. (0.7 mgrm. per kg.).

When the organism is in a state of definite pre-deficiency, it utilises only 0.1 mgrm. per kg. (7 mgrm. in a subject weighing 70 kg.) and the proportion in the blood is reduced to 0 to 4 mgrm. per litre. A concentration of from 4 to 12 mgrm. might be still sufficient, but would not indicate a really satisfactory condition, for which the minimum is about 12 mgrm. per litre.

According to these same authors, the inhabitants of the Netherlands who consume a sufficient quantity of potatoes—and this may be roughly estimated by the number of hot meals eaten per week (from five to seven)—have a satisfactory blood-content of vitamin C. They consider the determination of this content a more reliable test than the measurement of vascular fragility ; the drawback to it is that blood samples must be taken, which always complicates social enquiries.

* * *

The Vitamin-C Content of the Urine and the Urine Saturation Test.

In the urine even more than in the blood, chemical tests have the disadvantage that they are not strictly specific for ascorbic acid. In spite of all precautions, what is really tested is a mixture of reducing substances among which ascorbic acid is preponderant. An increase in the degree of specificity for the vitamin alone is obtained by acidifying the urine immediately after discharge (preferably with metaphosphoric acid) [1] and by proceeding very quickly to cold colorimetric titration. Under these conditions of test, the output of reducing substances expressed in terms of ascorbic acid varies in man between 5 and 100 mgrm. per day (average 30 mgrm.). It is certain that these empirical values do not relate exclusively to the ascorbic acid, for methods of biological assay demonstrate that the urine exerts no antiscorbutic activity unless the diet is fairly rich in ascorbic acid. It should, however, be borne in mind that the toxicity of the urine hampers these biological assays.

However that may be, according to Harris and Ray, such empirical data obtained by Tillmans's reagent determinations should be interpreted as follows : The normal adult eliminates, on the average, every day more than 15 mgrm. of reducing substances expressed in terms of ascorbic acid (average concentration in several samples of urine fractionated : over 10 mgrm.).

An adult in a state of pre-deficiency eliminates on the average every day less than 10 mgrm. (average concentration in several samples of urine fractionated : below 7 mgrm).

In view of the uncertainty attaching to the interpretation of ascorbic-acid measurements in the urine, *the so-called saturation tests are to be preferred.* They consist in determining the quantity of ascorbic acid which must be ingested, in order to produce an abrupt increase of the quantity of reducing substances eliminated in the urine.

According to Wolff, Banning and van Eekelen (42), the test is carried out as follows : The subject is required to ingest 250 mgrm. of ascorbic acid per day. The analysis of the urine is repeated daily. If the reducing power of the urine measured by Tillmans's process increases on the first day, this means that the organism is saturated with ascorbic acid—the most satisfactory condition. Normally, however, this increase may not occur for from one to four or even five days. If it is delayed still longer, pre-deficiency exists.

[1] Six parts of acetic acid and two parts of metaphosphoric acid or 100 parts of urine.

Variations of this technique have been proposed by HARRIS and RAY (48) and JEZLER and NIEDERBERGER (49).

The saturation test is undoubtedly valuable, but many factors of error are liable to operate unless it is carried out under strict experimental conditions, which make the test impracticable for the purposes of social enquiries.[1]

The following are some of the difficulties : the instability of ascorbic acid in the urine, even when the latter is acidified ; the extreme variability in the speed with which this acid is destroyed in the urine, which makes it necessary to examine the urine without delay ; the presence of other substances also possessing reducing properties ; the possible variability in the threshold of elimination of ascorbic acid by the kidneys, so that, with the same degree of saturation with ascorbic acid and the same excess of this acid in the organism (ingestion of the same quantity of ascorbic acid), different subjects may nevertheless eliminate varying quantities of this substance (L. S. FRIDERICIA) ; not only are there other substances in the urine which, like ascorbic acid, are capable of reducing the oxidation-reduction indicator employed by TILLMANS'S, but the reducing power of the vitamin itself is influenced by widely different factors : pH, partial pressure of oxygen, total salts in the urine (chlorides and phosphates, etc.), the concentrations of urea, uric acid, creatine and creatinine, etc.

The urine saturation test has been applied in a variety of ways. The reader will find numerous indications on the subject in the report made by GIROUD and LEBLOND in 1938 to the twenty-fifth French Congress of Medicine (88). Many scientific workers use the daily dose of 300 mgrm. advocated by DEMOLE. Some measure the ascorbic-acid content in a twenty-four-hour sample of urine, others determine the variations of concentration in samples of freshly discharged urine. A distinction is also made between *slow methods* and *rapid methods*, as exemplified below :

Example of a slow method. — The person concerned ingests 300 mgrm. of ascorbic acid every morning at 8 o'clock. The urine

[1] See also JOHNSON, S. W., and ZILVA, S. S., regarding certain difficulties in the interpretation of saturation tests (70, 71).

passed during a period of from eight to twelve hours following each ingestion is then collected. When 40% of the 300 mgrm. is eliminated within this period of eight to twelve hours, the person under examination is saturated. Alternatively, if saturation point is reached only after the third or fourth day, the person concerned was in a state of pre-deficiency. Certain authors merely record the time at which the concentration begins to rise noticeably.

Example of a rapid method. — FINKLE injects 1 gramme of ascorbic acid intravenously and collects the urine passed during the six hours following the injection. The person is saturated if he has eliminated from 30% to 50% of the dose injected. HARRIS and RAY collect the urine passed between 7 and 10 a.m.; they are of opinion that the "ascorbic acid" eliminated during that period is roughly equivalent to an eighth of the twenty-four-hour output. At 10 o'clock, the person is given 700 mgrm. of ascorbic acid. In the course of the afternoon, a normal person should have eliminated at least 30% of this dose. L. J. HARRIS and A. ABRASY have proposed another simplified method of the same kind (116).

These rapid methods are obviously the rougher and the more unreliable. They are advocated merely because they are more handy in practice than the slow methods.

It would seem that saturation can be obtained more easily with food rich in vitamin C than with ascorbic acid taken separately (88, 91). These facts show the great need for caution in placing a physiological construction upon saturation tests. These tests must be regarded as unquestionably useful in practice but as affording, so far, only very empirical indications.

* * *

Vascular Resistance.

The tests mentioned above for the detection of vitamin-C pre-deficiency represent that part of our present knowledge which is physiologically most satisfactory. From the practical standpoint of nutrition surveys, however, they have very considerable drawbacks, in that they require the taking of blood samples or samples of urine, or subcutaneous injections. Now these are procedures which the population groups under enquiry are usually somewhat unwilling to accept. Moreover, when the enquiry extends over a somewhat numerous group of persons, they involve a great deal of work. This is why great hopes were entertained of the capillary resistance test, which has no such disadvantages and is much more simple to perform. Unfortunately, the findings of different scientific workers are not concordant, and opinions still differ as to the practical value of this method. Generally speaking, the principal advocate of this method is Göthlin, in Sweden. We shall, accordingly, first state his view, and then pass on to the objections urged by his opponents.

We may begin by an indication of the various techniques used.

The wall of the small blood-vessels (arterioles, capillaries and venules) is normally capable of a high degree of mechanical resistance. It can be considerably distended without rupturing. On the other hand, in certain pathological states (hæmorrhagic and scorbutic syndromes), it becomes comparatively fragile, and slight distension then causes breaks accompanied by punctate perivascular hæmorrhagic extravasations (petechiæ).

Vitamin C increases this mechanical resistance of the vascular walls ; its absence from the organism occasions the fragility in question. It should be remembered, however, that this is not the only principle which affects the capillarie.

If there is a marked deficiency (pronounced scurvy), the hæmorrhagic extravasations occur spontaneously. When the deficiency is less marked (latent pre-deficiency), moderate distension is necessary before the fragility becomes apparent.

The low resistance of the vessels was first observed by the thong or garrot test (Rumpel Leede test) : passive distension by venous stasis obtained with a garrot, the constriction of which is sufficient to stop the venous circulation but insufficient to prevent the arterial circulation. This test did not, however, lend itself to mensuration. Hess's technique was an improvement on this method, inasmuch as the distension was obtained by means of a pneumatic sleeve connected with a pressure-gauge. Compression of the arm was maintained at 100 mm. of mercury for three minutes ; if not less than ten petechial spots were then observed on the part of the arm in which stasis was produced, the test showed abnormal fragility.

A variant of this technique, G. F. Göthlin's method, consisted of three successive constrictions, of increasing severity : a first quarter of an hour at 35 mm. Hg, a second quarter of an hour at 50 mm. and a third at 65 mm. At the end of each stage, the number of petechiæ was counted. A minimum of eight petechiæ observed at the end of the first of the three tests revealed abnormal vascular fragility.

These improvements were considered inadequate by some experimenters. Hecht introduced for the first time in 1907 another method of distension by suction with a small cupping-glass connected with a pressure-gauge (44). This innovation is a real improvement from the standpoint of measurement. Nevertheless, Hecht's process was not followed up until much later by Da Silva Mello, Cutter and Marquardt, Wiemer, Dalldorf, Adant and other investigators. A diagram of the method is given in Figure 7, which I have taken from M. Adant's publications (45).

A specific degree of depression is produced for thirty seconds by the cupping-glass, which is pressed on the wet skin at the bend of the elbow. The skin is drawn into the cup and thereafter, the surface is examined with a magnifying-glass through a glass slide which is pressed down upon the portion of skin to be examined ; by this means, the number of punctate petechiæ formed under the cupping-glass can easily be counted. The petechiæ are counted several times in adjacent areas after the application of varying degrees of depression. The maximum depression which can be used without producing petechiæ and the minimum depression which causes them to appear are ascertained. These two data usually coincide to within 10 or 15 mm. of mercury, and this shows the sensitiveness of the test.

Various factors influencing the experiment have been studied : differences in the sensitiveness of the skin according to the area, constancy of the results obtained with the same subject provided the measurements are made at the same time of the year, as there are seasonal variations in capillary resistance connected with the changes in the quality of protective foods at different times. The influence of various pathological conditions was also studied.

The resistance of the vessels is normal if, without the production of petechiæ, they can stand suction for thirty seconds at a barometric depression varying from 175 to 350 mm. (in exceptional cases, 400) of mercury, according to the subject and the time of year.

This method is simple, rapid, painless and accurate.

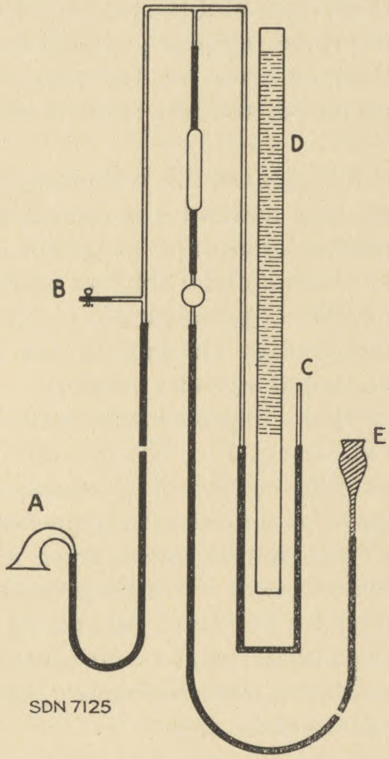

Figure 7.

Apparatus for the Measurement of Vascular Fragility.

(A) Cupping-glass 12 mm. internal diameter (flat edge 2 mm. thick).
(B) Spring clip obturating the lateral tube.
(C) Mercury pressure-gauge.
(D) Graduated scale.
(E) Mercury bulb.

* * *

Göthlin is of opinion that the measurement of capillary resistance offers a means of detecting latent vitamin-C pre-deficiency. In his latest papers (89, 90), he measures what he calls the " petechial index " (this numerical index is twice the number of petechiæ observed in the crook of the elbow after a quarter of an hour's stasis at 35 mm. mercury pressure, plus once the number of extra petechiæ which develop in the course of a second quarter of an hour's stasis at 50 mm. of mercury pressure). This index is said to show seasonal variations which are related to differences in the vitamin-C content of the diet.

In view of the fact that, according to the author, a connection between this index and vitamin-C pre-deficiency may be postulated only in the absence of certain chronic diseases and the influence of certain therapeutic agents (vascular poisons), GÖTHLIN now proposes the following test : *Measurement of the petechial index at the crook of the elbow. Repetition of the test on the other elbow after administration of a daily dose of* 300 *mgrm. of ascorbic acid for six days. If under such conditions, the index falls by about* 30% *of its initial value, and if the said initial value was abnormally high, the person under test was in a state of vitamin-C pre-deficiency.* GÖTHLIN estimates that, towards the end of the winter, the percentage of cases of pre-deficiency among the school-children in certain parts of Sweden is 22 %.

From the experiments he carried out with his capillary resistance tests in order to determine the vitamin-C requirements of an adult man, GÖTHLIN has arrived at the following figures :

	Milligrammes per day
Adult of 50 kg. body weight . . .	20 to 24
,, 60 ,, ,, ,,	23 to 29
,, **70** ,, ,, ,,	**27** to **34** (average about **30**)
,, 80 ,, ,, ,,	31 to 38
,, 90 ,, ,, ,,	35 to 43

It would therefore appear that requirements depend upon body weight and that the average figure is about 30 mgrm.

It has been seen that estimates of the requirements of the adult human organism in respect of vitamin C have varied, up till now, according to the criterion used for the assessment :

Mean daily dose exerting an anti-scorbutic action, just a few milligrammes.

Mean daily dose ensuring normal capillary resistance, 30 mgrm.

Mean daily dose ensuring urinary saturation, 50 mgrm.

Mean daily dose ensuring saturation of the organs, at least 50 mgrm.

Let us now turn to the considerations which do not militate in favour of the capillary test.

DEGELLER is unable to establish any relation between capillary resistance and the vitamin-C concentration in the blood (92). According to ADANT (Brussels), the intravenous injection of a single heavy dose of 100 mgrm. of ascorbic acid regularly raises capillary resistance in man for several hours following the injection (45, 46). This, however, is also true if the capillary resistance was already high before the test, and it is equally true of persons who are saturated on the showing of the urine test. The ingestion of a single dose of 300 mgrm., on the other hand, does not produce this immediate effect, even in persons shown by the urine test *not* to be saturated (93, 94). It should, however, be noted that these tests differ from those of GÖTHLIN in respect both of the technique of measurement and of the fact that the Scandinavian author studies the effect of small *doses repeated for a considerable period of time.* ADANT also failed to observe any improvement of the capillary resistance in the course of a urine saturation test involving the daily ingestion of 300 mgrm. of ascorbic acid for a week.

Finally, BIGWOOD, DANIS, JACQUEMYNS, SANO and ADANT, in the course of an investigation the results of which are not yet published (82), were unable to establish any regular correlation between the magnitude of the vitamin-C intake in the food and the capillary resistance of the children and families studied in the course of a dietary survey.[1]

To sum up, it is difficult to draw any consistent all-round conclusion from the experience thus far obtained with the capillary test. Some authors deem it of value, others not, in the detection of a vitamin-C pre-deficiency.

* * *

[1] There would no doubt be some advantage in resuming these investigations, using GÖTHLIN's technique, which is perhaps superior.

Tests for Pre-deficiencies of Inorganic Chemical Elements.

Our present knowledge of these signs is still very imperfect. They are also related, to some extent, to vitamin deficiency.

Calcium and Phosphorus Deficiency.

This may be due to insufficient intake of these elements when the diet is deficient in protective foodstuffs, a shortage of milk and cheese being the principal cause of calcium deficiency.

But conditions of vitamin pre-deficiency also have a marked effect on calcium assimilation, and the acid-base balance of the diet, too, has an influence. The quantity of calcium ingested is thus only one of the elements in the complicated problem with which we are confronted when we come to consider the many factors affecting the calcium and phosphorus balance.

As already noted, a deficiency in the calcium and phosphate content of the blood has been observed, together with latent hemeralopia in conditions of pre-deficiency brought about by a lack of fat-soluble vitamins (page 193).[1] Such a deficiency of phosphates and calcium may also be found in rachitic subjects ; but, as we have seen, excess of phosphatase in the blood is an earlier biochemical sign and probably the only sign capable of revealing a pre-rachitic condition (page 199).

Iron Deficiency.

Anæmia from lack of iron in infants is a typical example, when a mixed diet is started too late.

But anæmia is also connected with vitamin deficiency, and the determination of the hæmoglobin in the blood has therefore been recommended as a test in various investigations into nutrition and under-nutrition. This test is obviously only valid when the anæmia is not attributable to a morbid cause. Accurate methods of hæmoglobin determination arere quired, in order that the hæmoglobin content may be objectively

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[1] In a normal individual undergoing a complete water fast, the calcium content of the blood does not appear to be modified even in a fast for two or three weeks (54), but in cases of prolonged and serious malnutrition, there is a slight tendency towards a lack of calcium in the blood (50).

assessed. VAN SLYKE'S method was recommended at the Conference of 1932 (7).

In England, the use of DARE'S hæmoglobinometer has been recommended, the blood being taken from the lobe of the ear. According to MACKAY (56) in London and DAVIDSON (57) at Aberdeen, about half of the women who come to the hospital out-patient department are suffering from a form of anæmia which can be cured by iron treatment. These authors think it possible that this common form of anæmia may have its origin in a defective diet, and it is proposed that studies should be carried out in England with a view to the statistical comparison of nutrition in groups differing from one another in respect of the mean hæmoglobin content of the blood.[1]

Tests for Protein Pre-deficiency.

The quantitative determination of the total nitrogen content of a twenty-four-hour sample of urine was recommended by the International Conference in 1932 (7). While this test undoubtedly gives an accurate indication of the total nitrogen intake in the diet, it is open to one serious objection : it necessitates the obtaining of a true sample of the urine passed in twenty-four hours. The test is admittedly difficult to carry out in practice with the necessary care, and is not very suitable for purposes of social investigations.

Protein Content of the Blood Serum.

The normal human blood serum contains the following quantities of total proteins :

7 to 8 grammes % (sometimes 9 grammes) in the adult ;
6 to 7 grammes % in the infant.

The normal ratio of serum albumin and serum globulin (A/G ratio) is 1.7 to 1.9.

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[1] See also JEFFREY RAMSAY, v. T. THIERENS and H. E. MAGEE (96) and H. E. MAGEE (98).

Cachectic œdema and starvation œdema are accompanied by hypo-albuminosis of the serum ; the total protein content often drops to a figure ranging, according to JANSEN (50), from 4.6 to 5.9 grammes %.

At the same time, the A/G ratio tends to fall. It was reasonable, then, to suppose that similar but less accentuated blood-serum modifications might be observable at a fairly early stage in persons living on a diet unbalanced in respect of nitrogen intake. This is why the use of these criteria was recommended at the Conference in 1932 (7).

Various micro-analytical methods, perfected and now accepted as classic, can be recommended : there is, for example, the PARNAS and WAGNER (microkjeldahl) process or FOLIN'S colorimetric test, for both of which one-tenth of a cubic centimetre of blood serum is sufficient. The accuracy and reliability of these methods are well established ; they are described in different classical treatises. An optical process, based on the measurement of the refraction index of protein media, has also been known for some time.

A method more recently recommended is that of the determination of protein nitrogen, based on the principle of TER MEULEN'S method (51), while, lastly, and more recently still, E. GORTER, of Leyden, has proposed a physical method employing a one-in-ten blood-serum dilution spread in a monomolecular film on $\frac{N}{10}$ hydrochloric acid (measurement of the spreading power of protein media on the surface of liquids (52)).

It still has to be determined, however, whether these blood analyses are really capable of revealing at an early stage a specific state of protein pre-deficiency in persons whose diet has a comparatively satisfactory aggregate energy value. Only if this is so can the method be of any practical value in detecting a deficiency of protective food in respect of protein. If, on the other hand, the dietary deficiency must be pronounced to the point of affecting the total calorie intake before it can influence the protein concentration of the blood serum, the method will lose much of its value, owing to the lack of sensitiveness of the test.

Further research will be necessary to settle this question. It is conceivable that protein deficiency may be indirectly determinable through its effect upon basal metabolism (see below).

2. Non-specific Physiological Tests

Whereas the specific physiological tests which we have just been studying are designed to reveal latent states of pre-deficiency attributable to an ill-balanced diet deficient in protective foodstuffs—and we have seen that, in the present state of our knowledge, these methods cannot be regarded as being all of equal value—it now remains to review rapidly, or simply to enumerate, the physiological tests—non-specific in the sense just defined—which are concerned with physiological functions liable to be affected by under-nutrition, though they are not to be regarded yet as early tests for malnutrition.

These tests extend, generally, to all physiological measurements of the muscular, respiratory, circulatory, digestive, endocrine, nervous and urinary systems, and to hæmatological, sensory and psychotechnical measures.

A few tests only will be briefly described here by way of example, as they cannot all be mentioned.

Measurement of the Basal Metabolism.

It has long been known that basal metabolism tends in the long run to slacken slightly in persons who have been suffering for some time from pronounced under-nutrition (1, 2). It remains to be determined whether this test can be used to detect conditions of moderate malnutrition at a fairly early stage. This appears unlikely *a priori*, but the possibility cannot be entirely dismissed. Again, the lower limit for a basal-metabolism value that is still normal is not sharply defined, and questionable limiting values must be viewed with caution. Certain signs of a downward tendency of basal metabolism also occur, especially when the protein intake is deficient, even when the total energy value of the diet may be high (Deuel (53)). Thus the fall of the basal-metabolism value is an index of protein deficiency rather than evidence of a shortage of total calories, but the lack of protein must be pronounced before it affects basal metabolism.

A slight reduction of about 10% of the basal-metabolism figure was observed in a few individuals during the war of 1914-1918—that is to say, during a period of pronounced and protracted under-nutrition (for references, see LAUGIER and LIBERSON (17)).

CHEVALLIER has shown that vitamin A exerts upon the rate of basal metabolism an action antagonistic to that of thyroxin (97). But the variations of basal metabolism which may be produced by vitamin-A deficiency fall within the limits of normal physiological fluctuations. For the practical purposes of enquiries, it is hence difficult to detect any abnormality of the basal metabolism rate which is inherent in vitamin-A pre-deficiency.

Similarly, B-group deficiencies are known to depress the basal-metabolism rate. But here, again, it would appear that the stage of frank deficiency must be reached before any distinct difference in the rate of basal metabolism can be discerned.

Blood Tests.

There is a definite tendency towards a *fall in the sugar content of the blood* during the first week of a complete water fast, after the second or third day. In the course of a prolonged fast, the blood sugar tends to resume its normal level. On the other hand, the level does not appear to be appreciably modified when the diet is unsatisfactory, especially since there is never any dearth of carbohydrates in ill-balanced qualitatively defective diets. Carbohydrate deficiency is found only in very pronounced cases of general under-nutrition.

Many other blood measurements have been effected in cases of under-nutrition : counts of blood cells, red corpuscles and leucocytes, differential counts ; coagulation time ; measurement of the alkaline reserve, of the specific gravity ; uric-acid and cholesterol content, etc.

It has not been proved that these measures can be taken as a sensitive index of defective nutrition. They have generally been carried out only during complete fasting or in persons suffering from very marked under-nutrition. A fairly complete bibliography on the question is given by LAUGIER and LIBERSON in a memorandum which has already been published in the *Bulletin of the Health Organisation* (17).

The same applies to several analyses of urine : the total nitrogen content, creatinuria and the urea-nitrogen ratio (urea N/total N) fall in persons who are fasting. The ammonia coefficient (ammonia N/total N) and acetonuria increase during complete fasting (the well-known phenomenon of starvation acidosis) ; the ratio of carbon to nitrogen also increases. But here, again, only very pronounced under-nutrition and starvation have been studied on these lines (17). There is nothing to suggest that these signs are capable of revealing a lack of balance in a diet of fairly adequate total energy value.

Cardiac and Vascular Tests.

MURLIN'S test was mentioned at the 1932 Conference (7). The pulse is taken in the resting position, before and at certain fixed intervals after a measured amount of work, such as stepping up on to a chair and down again five times in fifteen seconds (heart fatigability test) (see also 99).

The product of the heart differential pressure (difference between systolic and diastolic) and of the pulse rate gives a value which is said to run parallel with the oxygen absorption and may thus be taken roughly as an index of variation of the blood volume flow per minute. The characteristics of the pulse and arterial pressure during fasting have been studied (see 17).

Fatigability of Subject under Observation in the Course of Muscular Exertion.

A note by Professor ATZLER appeared as an annex to the report of the 1932 Conference (7) with reference to the various tests : dynamometrical measurement of the force exerted by the dorsal muscles during the transition from the bending to the erect position ; dynamometrical measurement of the force exerted by the hand ;[1] ergographic tests applied to flexion and extension movements of the forearm. Measurements of muscular chronaxie have even been suggested.

In England, movement co-ordination tests have been proposed —according to Horsley's method, for instance. Dynamometrical tests are also used there, and the results obtained in all these various ways are correlated with the somatometric data and with the classification of children into four groups according to general clinical appearance (see page 176).

In Belgium, M. Delaet has examined another test of the normal capacity of adult man and of his endurance in the course of muscular exertion. This test consists in determining the ratio of respiratory capacity in cubic centimetres to the pulse rate per minute. The test is based upon the fact that lung capacity may offset cardiac excitability during severe exertion, whereas, on the other hand, slowness of the pulse can, within physiological limits, make up for a smaller respiratory volume.[2] This test is applied to normal persons to determine fitness for heavy muscular work. A ratio under 35 indicates the subject is not fit to undertake fairly tiring work and should avoid any exertion other than moderate gymnastic training. A ratio between 35 and 45 is found in subjects who are still in comparatively poor condition from this point of view. A ratio between 45 and 55 represents a fair average figure, and persons yielding a value over 55 are fit for heavy muscular work.

It does not seem that the influence of diet on the response to this test has been studied. It is not impossible that dietetic, as distinct from pathological causes may eventually be found to have some bearing upon this matter.

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[1] Dynamometers of Collin ; Hahn, Ullman (mercury) ; Hahn (traction), etc.

[2] Let us take, for instance, a case of low vital capacity in an adult man—viz., 3,000 c.c. If the subject tends to show pronounced cardiac excitability (pulse rate 90), which is unfavourable to his capacity for muscular exertion, his cardio-respiratory quotient will be comparatively poor $\frac{3,000}{90} = 33.3$. If, however, he shows bradycardia within physiological limits (pulse rate 60), he may be capable of considerable muscular exertion, notwith-standing his low vital capacity ; his cardio-respiratory ratio will be $\frac{3,000}{60} = 50$, which is satisfactory.

The test is difficult, owing to the frequency of emotional tachycardia at the time of examination.

Various Other Tests.

We have just referred briefly to a few examples of non-specific physiological tests that have already been tried on fasting or gravely under-nourished persons. All the differential *biometric* determinations could be used without exception in this connection : measurement of the thoracic capacity (spirometrics), various sensory tests, tests of skin sensitiveness (æthesiometrics, baræsthesiometrics, thermal sensitiveness, etc.), mental and psychomotor tests, etc.

These cannot be discussed here in detail. In any case, there are many scientific papers which deal with biometrics in its most general aspect. The purpose of this report is merely to show the service that has been done by those among these tests that have been profitably studied in connection with problems of nutrition.

Chapter IV

SOME EXAMPLES OF VARIOUS TYPES OF ENQUIRIES IN A NUMBER OF COUNTRIES

The 1932 Conference (7) advocated, for the purpose of enquiries designed to characterise the state of nutrition of whole populations, simple methods suitable for extensive surveys ; for practical reasons of organisation and because of the limited facilities available, investigations have frequently been limited to a few easily applied tests. Now past experience shows that this is not always a very profitable line to take ; it is desirable, on the contrary, to combine as many tests as possible in the course of the enquiries.

Taken individually, tests frequently yield divergent results that are difficult to interpret. The following is an example :

A summary clinical examination applied as the sole means of classifying subjects into three or four categories according to their general condition (page 176) has frequently led to the recording of favourable findings in respect of three-quarters of the population or more. This, according to M. T. MORGAN, has been the case in certain enquiries in England. Now, from a recent report by Sir J. B. ORR, it would seem that, in that same country, the diet is not likely to be completely satisfactory except in income groups at or above a level which is attained only by 50% of the population (58).

If we approach the matter from another angle, that of a purely physiological investigation, based upon the detection of signs of latent vitamin deficiency—a method of enquiry of which our knowledge is still inadequate—the proportion of subjects yielding favourable findings is still smaller (see above, pages 193 *et seq.*). Such fragmentary enquiries thus lead to contradictory conclusions that are difficult to interpret individually.

If we are to improve our knowledge of the state of nutrition of populations as related to diet, the enquiries to be conducted in the future must clearly be directed towards the obtaining of further evidence concerning the significance of the tests themselves—that is to say, the acquisition of more accurate knowledge as to their value, and thereafter the collection of objective data as to the requirements of the body in respect of protective foods and the variability of such needs in relation to climatic conditions.

It is in consideration of both these aims, which must be simultaneously pursued, that a distinction must be made, for practical and material reasons, between various types of enquiry.

First Type of Enquiry [1]

Simple Methods intended for Mass Enquiries.

This, as a matter of fact, is the type of enquiry already advocated in 1932 (7). It is essentially suitable for practical work, such as the rough determination of the general condition of large numbers of children in the course of demographic surveys, or the first summary classification of a very large number of subjects (from several thousand to several hundred thousand).

For this purpose, it has been recommended that record cards be prepared giving particulars of :

(1) Age ;

(2) Sex ;

(3) Physical appearance (slender, medium or stocky type) ;

(4) Weight ;

(5) Height (possibly also the sitting height, so that research workers who believe in certain somatometric tests employing this value may be able to use it).

If the first classification just mentioned consists in comparing the individually observed heights and weights with the figures in the table of " normal " values, the classification will be very

[1] See three types of enquiry already mentioned in the Introduction to Part II, pages 149 to 151.

rough. It will merely enable those subjects to be picked out whose condition is markedly anomalous, and, being so, is more likely than not to be attributable to some morbid cause rather than to defective diet pure and simple. Moreover, subjects coinciding with the norm cannot be regarded as necessarily in a state of satisfactory nutrition. This is why it is recommended that, in enquiries of this kind, the measurements should be repeated at intervals of a few years, so that the trend of weight and height in one and the same population may be determined without recourse to a table of so-called normal values.

If the latter method be adopted, this first type of enquiry thus reduces itself to judging the rate of growth, and this is the only way in which it may be usefully turned to account for the appraisal of the state of nutrition of children. It is common knowledge that growth is closely related to the composition of the diet in respect of protective foods. Now, the resultant of the phenomenon of growth—that is to say, the stature and weight of the adult subject—is governed in the main by hereditary factors ; but, as Sir John B. Orr points out, " the extent to which a child will attain the limit set by heredity is affected by diet " (58).

So far as the normal rate of growth in children is concerned, opinions might vary as to how this should be defined ; therefore, even in simple enquiries of the first type, the somatometric measurements whereby this rate is determined should be supplemented by a summary clinical examination (page 175) and by other objective data, such as the frequency of absences from school and the standard of school work. Any variation in the rate of growth which is accompanied by an improvement in the standard of work and a reduction in the absences from school may be rightly regarded as reflecting an improvement in the nutrition of the normal child.

Second Type of Enquiry

This second type of enquiry is much more elaborate than the first. For material reasons, it can be applied only to smaller groups (a few hundreds). It is definitely experimental in character and calls for the services of physiologists and of doctors trained in this line of research. For these reasons, there can be no question of proposing a rigid study programme based upon a planned scheme of organisation. It will necessarily depend on possibilities and upon the exact object in view. All that can be suggested is that such enquiries should in any case comprise :

(1) The simple tests of enquiries of the first type ;

(2) Exact particulars on diet.

Since no specification of such a type of enquiry can be given, it will doubtless be preferable to describe briefly a few examples of studies taken either from among those made in the past and already reported upon, or from among those now proceeding, even though they may not strictly follow the recommendations set forth above. Needless to say, the list of examples given below does not claim to be exhaustive. Its only purpose is to afford illustrations of the kind of work that has already been attempted or is now in progress.

I. *In England.*

Corry Mann showed in 1926 that the rate of growth of children under observation in an industrial school improved when the diet was supplemented by an additional milk ration. Where, for instance, the mean height increment among boys was 1.84 ins. a year in a control group not receiving supplementary milk, the corresponding figure was 2.63 ins. in the group receiving such milk.[1] (Reference given by Sir J. B. Orr (58).) In 1927, in seven Scottish towns, 1,500 children from elementary schools received a supplementary milk ration at school, during a period of observation of seven months. The growth recorded was 20% higher than that of children not receiving this supplementary ration. In addition, there was an improvement in the average state of health of the children (60).

[1] 4.67 cm. and 6.68 cm. respectively.

Other similar tests covering 20,000 children gave comparable results (see 58). By way of comparison, we may also mention that, among under-nourished children of the elementary schools at Tokio, the mere provision of a supplementary daily ration of 200 c.c. of milk over a period of six months considerably improved the rate of gain (plus 86% for weight and plus 16% for height) (Tsurumi). Similar results were achieved by experiments in New Zealand (see 58).

The above are enquiries involving a comparison between somatometric data and certain nutritional factors essentially connected with the protective foods.

The Ministry of Health has also had another enquiry carried out by the Milk Nutrition Committee (Milk Act, 1934) (100). It took place at Luton, Wolverhampton and Burton-on-Trent, in Renfrewshire and at Huddersfield, and covers 8,000 children from 5 to 14 years divided haphazardly into four groups:

(1) The control group receives a supplementary biscuit ration ;

(2) The second group receives 200 grammes of pasteurised milk ;

(3) The third group receives 2 × 200 grammes of pasteurised milk ;

(4) The fourth group receives a supplement of 2 × 200 grammes of raw milk.

These supplementary rations are distributed free ; the enquiry comprises a clinical examination, somatometric and physiological tests.

With regard to iron deficiency, experiments similar to those set forth on page 212 afford further examples of the same type of work.

Altogether, the enquiries involving the determination of hæmoglobin in the blood have already covered more than 2,000 persons in various urban centres (Warrington, Manchester, Huddersfield, Oldham).

Enquiries comprising, among other things, a dynamometric test have already been carried out upon some 5,000 persons

(Warrington, Manchester, Leeds, Huddersfield, Glossop, Barnsley and Walthamstow) ; voluntary movement co-ordination or balancing tests (modified ROMBERG sign) have been performed on nearly 3,000 subjects (same urban centres). In a substantial proportion of the persons examined, these various tests are accompanied by a clinical test.

Blood analyses have been taken in the case of some 500 expectant or nursing mothers at Leeds, Warrington, Barnsley and Blackburn. In the last-named locality, the analysis has been supplemented in some thirty subjects by the measurement of the calcium, phosphate and phosphatase content of the blood. Finally, it should be said that many enquiries into diet and family food expenditure have been conducted at various times in England. According to several English authorities, an acceleration of growth consequent upon a change of diet should always be regarded as reflecting an improved state of nutrition. This view is, however, not generally shared, and many physiologists and doctors on the Continent are not convinced that it is always desirable to aim at attaining the maximum rate of development in children.

This is why it was suggested that other data should be collected at the same time as particulars of the rate of growth, such as the standard of school work, in order that the exact significance of the change of rate of growth might be better judged. Here, again, exact and specific data are still lacking, and we must wait until these have been obtained through experimental work before we can discriminate objectively between normal, subnormal or deficient states of nutrition.

At the Aberdeen Imperial Institute of Animal Nutrition, research on specific pre-deficiency tests is to be undertaken with a view to developing our knowledge of the subject.

II. *In Belgium.*

The fairly numerous enquiries conducted in that country both before the war and latterly have brought evidence of the fact that the average energy value of diets is satisfactory, and this is true even in cases in which social conditions are not very favourable—*e.g.*, among the insured unemployed. It should be said, however, that this class of unemployed is not the one which is living under the worst conditions. Among the insured unemployed of Brussels, in 1932, the mean energy intake of adults of both sexes was equivalent to about 2,500 nett calories per diem. Assuming 2,800 calories to be a fair moderate figure (the mean of 3,000 for the man and 2,600 for the woman), the average deficit was only about 10%. On the other hand, the diet of a substantial proportion of the Belgian population is very definitely deficient in protective foods.

Taking, by way of example, the general average of milk and butter consumption in the country as a whole, we find that it represents only about a third of the amount that would be desirable (101). This is why social medical enquiries are undertaken at Brussels with a view to detecting latent states of pre-deficiency.

Up to the present, more than a hundred school-children of Greater Brussels have been subjected to tests for impaired power of adaptation of visual acuity and for vascular fragility. This enquiry is associated with a careful study of the children's diet, their circumstances, and their condition from the medical standpoint.[1] From a comparison of these various kinds of data relating to one and the same population, conclusions can be drawn on two points :

(1) The significance of the pre-deficiency tests concerned ;
(2) The state of nutrition of the population.

So far as the former point is concerned, there is no doubt much to be learnt before we can interpret the results yielded by these methods ; this type of investigation is thus still in the experimental stage. The children under enquiry are examined, so far as possible, twice a year : once at the end of winter, and again at the end of summer.

In this way, it is possible to determine what differences in respect of vitamin intake are attributable to the unfavourable time of the year in the one case and to the favourable period in the other.

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[1] The results of this enquiry have not yet been published *in full*. For preliminary references, see (82) and (93).

It is absolutely essential that the investigations concerning specific physiological tests should be supplemented by dietary surveys, for, even if it should be shown that an abnormal response to these physiological tests can be corrected after treatment with a comparatively high dose of vitamins administered in the form of concentrates, this does not prove that the abnormal response was due to a lack of vitamins in the diet ; the state of pre-deficiency may be attributable to an endogenous pathological cause, such as excessive vitamin destruction in the organism, and not necessarily to an exogenous cause (deficiency in the diet [1]). There still remains for us to verify whether or not there is any *regular* parallelism between fluctuations in the vitamin intake and the results of specific physiological tests.

III. *In Denmark.*

So far as earlier work on vitamin-A pre-deficiency tests is concerned, Edmund and Moeller, as well as Frandsen, have already been mentioned (pages 193 et *seq.*). Reference should also be made to the work of Friderichsen and Edmund in the same field (72).

Other similar investigations are now proceeding. They were begun in 1936 ; they are being carried out in the Faroe Islands by a group of doctors, ophthalmologists, dentists and nutrition experts ; they are planned to continue for two years.

Similar work is being done among other groups of the population (unemployed, rural districts, etc.).

IV. *In the United States.*

A large number of enquiries of various kinds have been proceeding for some considerable time in the United States. The Children's Bureau at the Department of Labour at Washington is now preparing a detailed report on the question,

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[1] The distinction between endogenous and exogenous deficiencies has been discussed on several occasions in this monograph (see pages 13, 81, 82, 154).

with the assistance of the Institute of Human Relations and the Pediatrical Service of the Faculty of Medicine of Yale University.

The enquiry comprises :

(1) Complete clinical examinations of the children under enquiry, on the lines of a standardised plan of examination laid down in advance ;

(2) Various somatometric indices of malnutrition, indices of Franzen (A.C.H.), Pryor and Baldwin-Wood (height, weight, age, sex) (pages 172 to 174) ;

(3) A social enquiry ;

(4) A dietary enquiry ;

(5) The child's medical history and especially the frequency of absences from school.

The enquiry covers some 750 children examined in 1934 and 1935.

A preliminary investigation was carried out on a group of 200 children with a view to determining the reliability of the methods adopted in noting the results of the clinical examination.

We have already seen above that the difficulty of medical enquiries resides in the method of recording the clinical impression of the examining physicians (see page 177).

In order to test the value of the method employed, the 200 children were examined at frequent intervals by three separate doctors, all of whom carried out the instructions given. In addition, a hæmoglobin determination was made in 150 out of 200 children by the Haden-Hausser method. The purpose of the enquiry was to ascertain whether the classification of children yielded by a single medical examination tallies with that which is obtained by somatometric tests, and whether the results of such examinations can be brought into relation with the dietary and social enquiries.

Somatometric tests determining the rate of growth have also been in use for ten years in the investigations undertaken by the health services of the City of Hagerstown (State of Maryland) : annual weighing of school-children, measurement of height and other somatometric tests (Franzen and Pryor).

Finally, there are yet other enquiries proceeding in the United States : dietary surveys in the rural areas and physiological pre-deficiency tests with regard to vitamin A (ocular test of dysadaptation), vitamin C (capillary fragility), vitamin D (X-ray examination of the bony structure and chemical tests) etc.

V. *In France.*

Professor PARISOT (Nancy) arranged for a dietary survey and a budget investigation to be carried out on 10,000 families in the department of Meurthe-et-Moselle by the Office d'Hygiène sociale and the Social Medical Service ; a staff of seventy nurses is in charge of the work.

An extensive national enquiry is also proceeding under the direction of Mme. L. RANDOIN, Directress of the Institut d'Hygiène alimentaire, Paris.

VI. *In the Netherlands.*

Certain results of somatometric investigations conducted in the schools of various towns have already been described in the present report (page 156). At Amsterdam, an enquiry was undertaken among school-children who were subjected to physiological tests for vitamin-A pre-deficiency (dysadaptation of visual acuity and WESSELY's method (page 198).

Finally, material concerning dietary survey findings considered in relation to blood tests has already been published in the *Bulletin of the Health Organisation* (42).

VII. *In Norway.*

Professor SCHIÖTZ's somatometric investigations were both numerous and extensive. They have been referred to in the present report (pages 158 *et seq.*).

A detailed enquiry is proceeding with regard to the state of nutrition of persons living in somewhat different social conditions (favourable and unfavourable financial circumstances). It extends to about 300 families in and around Oslo and to two fishing districts in the north of Norway. The dietary survey is repeated twice or three times in the course of the year, so that seasonal fluctuations may be followed, and, on each occasion, covers a period of four weeks. The state of health of the children is also examined three times in the course of the year, and the enquiry includes an investigation of the previously recorded medical history, a clinical examination of the heart and lungs, the measurement of height and weight, a record of the clinical impression, an examination of the teeth by a dentist, the determination of hæmoglobin of the blood (Zeiss-Ikon hæmometer), the capillary fragility test, FRANDSEN'S test of dysadaptation of visual acuity and VON PIRQUET'S skin test.

One of the purposes of the enquiry is to determine the value of the three specific physiological tests. X-ray examinations of the bones are carried out upon all subjects whose response to the capillary fragility test is unfavourable.

A systematic study of the effect produced upon the rate of growth by improving the protective food component of the diet among the poorer classes was carried out at the time when certain schools introduced the "Oslo breakfast", whilst other schools continued the older practice of giving a hot lunch. The quality of this hot meal was inferior to that of the "Oslo breakfast", which consists of protective foods (milk, Kneipp rusks and Kneipp bread, cheese, butter, orange, apple or raw carrot).

Experience has shown that, over periods of observation of six months, the rate of growth increased in the proportions of 48% among boys and 140% among girls receiving the "Oslo breakfast", as compared with that observed in children receiving the lunch, which is less satisfactory in point of physiological quality (73 and 74).

VIII. *In Sweden.*

The many dietary surveys and investigations into the state of nutrition of children in Sweden show that in that country the diet is frequently deficient both qualitatively and quantitatively, and more especially in regard to the vitamin-C intake. The Swedish Parliament has a proposal before it which, if adopted, will enable the " standard Oslo breakfast ", with its rich supply of protective foods, to be provided for some 50,000 children. It is thought that this meal will enable ascertained deficiencies to be corrected and that arrangements will be made for the children receiving it to be examined with regard to their state of nutrition both before and after this experiment. The enquiry would last a year.

Third Type of Enquiry

The purpose of the third type of enquiry advocated is somewhat different from that of the first two types.

To begin with, it calls for an even more elaborate plan of studies than enquiries of the second type, since its object is to study the disturbances occurring in *all* the functions of the body when the diet is quantitatively or qualitatively deficient, even if there is no apparent reason, either immediate or remote, to suppose that these functions may be more or less markedly affected by a state of malnutrition.

Such enquiries are thus biotypological in character, which means to say that they are essentially intended for the purpose of working out individual graphs characterising under-nourished persons or groups, and thereby ultimately distinguishing between types of persons displaying different individual reactions—that are characteristic for each group—to one and the same state of malnutrition.

The aim of these enquiries is thus somewhat different from the essential object in view here. It is not merely to define suitable methods for the detection of states of malnutrition, but to go a step farther and to investigate whether different persons are likely to react in a different way to some particular effect of malnutrition, owing to the fact that they belong to different categories of human types.

The objective of such an enquiry is thus not merely a matter of social medicine but the securing of results of purely scientific interest.

Such enquiries are therefore particularly extensive by reason both of the variety of tests involved—since these concern the functions of all organs of the body—and of the necessity, for statistical reasons, of extending these enquiries to a *very* large number of persons *all* living under *similar* social conditions in general, and nutritional conditions in particular.

This is inescapable, since, where fine shades of distinction have to be made, it is essential to make certain that the differences determined by mean statistical values correspond to real significant differences and not to meaningless fluctuations within physiological limits. The conditions for such a type of enquiry are hence complicated, for, in the first place, numerous tests have to be applied to large numbers of persons, and, in the second place, the physiological and social conditions of all the subjects under examination must be identical, so that they may be comparable.

The various tests which have been contemplated in this type of enquiry have been discussed in an article by LAUGIER and LIBERSON (17), published in the *Bulletin of the Health Organisation.*

An enquiry of this kind has been carried out in Paris, under the direction of Professor H. LAUGIER (102).

General Conclusions

Methods of assessing the state of nutrition are never simple when the object in view is a specific characterisation of this state in so far as it is clearly related to defective diet.

The comparatively simple, purely somatometric, methods that can be used in large-scale enquiries give an indication of the all-round physical condition of the subject, and the findings do not relate exclusively to the state of nutrition. Anthropological factors connected with differences of stature have an important influence upon the recorded numerical values. The only conditions in which these figures may be of some value in assessing the state of nutrition have been defined.

The more complex methods, in which it is sought to combine simple somatometric tests with either clinical or physiological tests, are not at present suitable for use in large-scale enquiries ; at the same time, they enable the problem to be studied more closely in less extensive surveys.

More detailed investigations bearing on a comparatively small number of persons may be expected to yield new knowledge concerning states of malnutrition. At present they are still in the experimental stage, but will help both to assess the intrinsic value of the methods at present contemplated and to gain a clearer idea of the requirements of the human organism in respect of protective foods. They will in future afford a means of procuring essential additional information in the field of nutritional hygiene, without which the highly valuable experimental work on animals would not enable us to reach a satisfactory solution of the problems of human morbid physiology that arise for consideration.

With these considerations in view, it will therefore be necessary to combine, wherever possible, dietary surveys and enquiries into the state of nutrition, covering the same population groups.

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TERMINOLOGICAL INDEX

(Covering both parts of the Guide)

Annexes

RECORD FORMS OR BOOKS FOR DIETARY SURVEYS

TABLES SHOWING THE VARIATION OF WEIGHT AND HEIGHT IN RELATION TO AGE AND SEX

Annex 1

AMERICAN DIETARY SURVEYS (Weekly).
(*Weighing method.*)

RECORD OF HOUSEWIVES' FOOD STOCKS (INVENTORY MADE AT BEGINNING AND END OF THE DIETARY SURVEYS)

Form B.H.E. 106 of the United States Department of Agriculture (Bureau of Home Economics, U.S.A.)

Agent .... Food Record No. ....

Information requested is confidential and giving it is voluntary. It will be seen only by sworn employees of the Federal Government.

RECORD OF FOOD CONSUMPTION FOR ONE WEEK

Inventory of food on hand.

Kind of food (specify)	Date of beginning record... After..... meal			Date of closing record... After..... meal			Difference	
	Quantity		Price	Quantity		Price	Quantity	Value
	Weight lb. oz.	Measure (give unit)	(give unit)	Weight lb. oz.	Measure (give unit)	(give unit)	Weight lb. oz.	
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								
16.								
17.								
18.								
19.								
20.								
21.								
22.								
23.								
24.								
25.								
26.								
27.								
28.								
29.								
30.								
31.								
Total . .	x x	xx	xxxx	xx	xx	xxxx	xx	

Annex 2

AMERICAN DIETARY SURVEYS (Weekly).
(*Weighing method.*)

FORM FOR EACH DAY OF THE WEEK

Form D.

Information requested is confidential, and giving it is voluntary. It will be seen only by sworn employees of the Federal Government.

RECORD OF FOOD CONSUMPTION FOR ONE WEEK

Daily record of food brought into the house and of all food waste.

Agent .... Food record No. ....
Date .... Day of week ....

Food received				All food waste		
Kind of food (specify)	Weight lb. oz.	Unit price	Expenditure	Edible waste	Inedible waste	
				Weight lb. oz.	Kind	Weight lb. oz.
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						

(1) Did any member of the family eat meals at restaurants or with friends ? Yes ? No ?

(2) If yes, what share of his day's food did these meals represent ? A half, a third, all ?

(3) Did any friends share the family's food ? Yes ? No ? If so, how many ?

What share of his day's food did each receive ? A half, a third, all ?

Annex 3

AMERICAN DIETARY SURVEYS (Weekly).
(*Weighing method.*)

ANOTHER DAILY FORM REGARDING THE FOODSTUFFS USED BY THE HOUSEWIFE

(Form B.H.E. 107 of the United States Department of Agriculture, Bureau of Home Economics, U.S.A.)

Agent .... Food record No. ....

Information requested is confidential, and giving it is voluntary. It will be seen only by sworn employees of the Federal Government.

RECORD OF FOOD CONSUMPTION FOR ONE WEEK

Daily record of food brought into the house.

Date .... Day of week ....

Kind of food (specify)	Weight lb. oz.	Measure (give unit)	Price (give unit)	Value
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				

MEALS BOUGHT AND EATEN AWAY FROM HOME

Item	Number	Price	Expenditure
1. Lunches at work			
2. Lunches at school			
Other meals, not vacation :			
3. Breakfast			
4. Noon meal			
5. Evening meal			
6. Meals on vacation			
7. Board at school			
8. Candy, ice-cream, drinks, etc.			

Annex 4

AMERICAN DIETARY SURVEYS.

(*Form E.* — Family composition and occupations.)

(*Form F.* — Menu served at each family meal for each day of the week (questionnaire method).

Form E. — FAMILY COMPOSITION AND OCCUPATIONS

Family member : Name	Age	Sex	Height	Weight	Describe occupation during the eight to ten most active hours of each day						
					Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											

Form F. — MENU SERVED AT EACH MEAL

Meal times	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Hours served......							
,, ,, ...							
,, ,, ...							
,, ,, ...							

Special notes should be made on the following points :

Baby-feeding :

Do the children take cod-liver oil or other remedies ?
Do the children receive extra food at school ? If so, what ?
Do the children eat anything between meals ?
Does the family consume much or little " warmed-up " food ?
How many hot meals a week ?

Th
is vol
agenc

ode No.
ood record No.
revious food records : Nos.
xpenditure schedule No.
own or village
Agen ounty State
Date . D. or M. C. D.

spoken	In family circle	By homemaker's parents	By husband's parents
Memb buting ea rela .... ecify)			

TYPE OF STORE FROM WHICH FOOD WAS PURCHASED DURING WEEK

		Group	Grocery			Other Store (specify)			Milk dealer or dairy (delivery)	Other (specify)
			Chain store	Independent		Chain store	Independent			
				Cash and carry	Service		Cash and carry	Service		
1.	I									
2.	\									
3.										
4.										
5.										
6.										
7.		....							x x	
8.		....							x x	
9.		....								
		ds.............							x x	
10.		getables							x x	

D NUMBER OF HOURS WORKED

			Thursday		Friday		Saturday	
		Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours
1.	I							
2.	\							
Othi								
3.								
4.								
5.								
6.								
7.								
8.								
9.	S							
10.	E							
11.	E							
12.	T	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
13.	C	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
14.	C	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x

[1] W

P. T. O.

CONFIDENTIAL

The information requested in this schedule is strictly confidential. Giving it is voluntary. It will not be seen by any except sworn agents of the co-operating agencies and will not be available for taxation purposes.

Agent
Dates covered by food record to , 1936

UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF HOME ECONOMICS' IN CO-OPERATION WITH NATIONAL RESOURCES COMMITTEE, WORKS PROGRESS ADMINISTRATION, AND DEPARTMENT OF LABOR, WASHINGTON

STUDY OF CONSUMER PURCHASES

A Federal Works Project

WEEKLY FOOD RECORD—TOWN OR VILLAGE

Code No.
Food record No.
Previous food records : Nos.
Expenditure schedule No.
Town or village
County State
E. D. or M. C. D.

EARNINGS OF MEMBERS OF ECONOMIC FAMILY, QUARTER ENDING............

Members contributing to family earnings—relationship	Kind of work (such as machinist, bookkeeper, merchant, author)	Nature of industry (such as cotton-mill, bank, shoe store, independent)	Time employed	Rate of pay	Total earnings from employment or business
1. Husband					$
2. Wife....					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.				TOTAL........	$

FAMILY INCOME, QUARTER ENDING............

1. Family earnings from employment or business	$
2. Income from boarders and/or lodgers (gross)	
3. Income from work in home not entered as earnings........................	
4. Interest and dividends from bonds, stocks, bank accounts, trust funds, etc.	
5. Profits not included above, less expenses	
6. Rents from property, less expense.....	
7. Pensions, annuities, benefits...........	
8. Gifts in cash for current use from persons not members of economic family....	
9. Other money income	
10. TOTAL (1-9)	$
11. Losses from business not deducted above	
12. Difference	$

Languages spoken	In family circle	By homemaker's parents	By husband's parents
1. English............			
2. Others (specify)			

TYPE OF STORE FROM WHICH FOOD WAS PURCHASED DURING WEEK

FOOD GROUP	GROCERY			OTHER STORE (SPECIFY)			Milk dealer or dairy (delivery)	Other (specify)
	Chain store	Independent		Chain store	Independent			
		Cash and carry	Service		Cash and carry	Service		
1. Meat....................							x x	
2. Groceries................							x x	
3. Milk.....................								
4. Baked goods.............							x x	
5. Fruits, vegetables							x x	

RECORD OF PERSONS FED FROM FAMILY FOOD SUPPLY DURING WEEK ENDING..........

PERSONS	Sex	Age	Height [1]	Weight [1]	NUMBER OF MEALS FURNISHED			PRINCIPAL OCCUPATION FOR EACH DAY, AND NUMBER OF HOURS WORKED													
								SUNDAY		MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY	
					Breakfast	Noon meal	Evening meal	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours
1. Husband.	M																				
2. Wife.	F																				
OTHER MEMBERS OF ECONOMIC FAMILY (Give relationship)																					
3.																					
4.																					
5.																					
6.																					
7.																					
8.																					
OTHERS																					
9. Sons or daughters boarding at home																					
10. Paid help.																					
11. Boarder																					
12. Tourists and transients . .			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
13. Guest			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
14. Guest			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x

[1] Without shoes.

P. T. O.

CONFIDENTIAL

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UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF HOME ECONOMICS, IN CO-OPERATION WITH NATIONAL RESOURCES COMMITTEE, WORKS PROGRESS ADMINISTRATION, DEPARTMENT OF LABOR, WASHINGTON

STUDY OF CONSUMER PURCHASES

A Federal Works Project

FOOD RECORD—FARM

Code No. | Food record No.
Previous food records : Nos.
Expenditure schedule No.
County | State
Clr | M. C. D.
Period covered by food record | to , 1936
Agent

SUPPLEMENTARY DATA : SCHEDULE YEAR BEGINNING .... AND ENDING ....

Numbers in ( ) refer to items on Family Schedule (F), Expenditure Schedule (E), or Summary of Receipts and Disbursements (S).

1. Income (S-13).............................. $
2. Money value of goods received without direct money payment (S-18) ....
3. Total (1 plus 2)...................... $
4. Money value of food home-produced or received as gift or pay (E VIII 24).................
5. Expenditure for food during schedule year (S-30) ....
6. Total person-meals in household during schedule year. (Compute from F II, as directed in instructions for use of food record).........

MENUS SERVED ON THIRD DAY OF WEEK'S FOOD RECORD

Breakfast	Noon Meal	Evening Meal

Languages spoken	In family circle	By homemaker's parents	By husband's parents
1. English			
2. Others			

TYPE OF STORE FROM WHICH FOOD WAS PURCHASED DURING WEEK

Food Group	Grocery			Other Store (specify)			Milk dealer or dairy (delivery)	Other (specify)
	Chain store	Independent		Chain store	Independent			
		Cash and carry	Service		Cash and carry	Service		
1. Meat....................							x x	
2. Groceries................							x x	
3. Milk.....................								
4. Baked goods.............							x x	
5. Fruits, vegetables							x x	

RECORD OF PERSONS FED FROM FAMILY FOOD SUPPLY DURING WEEK ENDING............

PERSONS	Sex	Age	Height[1]	Weight[1]	Number of Meals furnished			Principal occupation for each day, and number of hours worked													
								Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
					Breakfast	Noon meal	Evening meal	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours
1. Husband.........																					
2. Wife..........																					
Other Members of Economic Family (Give relationship)																					
3.																					
4.																					
5.																					
6.																					
7.																					
8.																					
Others																					
9. Sons or daughters boarding at home																					
10.																					
11. Paid help........																					
12. Boarder																					
13. Tourists and transients . .			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
14. Guest			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
15. Guest			x x x x	x x				x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x

[1] Without shoes.

ICS,
:ESS

Code No. — Food record No.
Previous food records : Nos.
Expenditure schedule No.
County — State
Clr — M. C. D.
Period covered by
food record — to — , 1936
Agent

Languages spoken	In family circle	By homemaker's parents	By husband's parents
English			
Others			

TYPE OF STORE FROM WHICH FOOD WAS PURCHASED DURING WEEK

Food Group	Grocery			Other Store (specify)			Milk dealer or dairy (delivery)	Other (specify)
	Chain store	Independent		Chain store	Independent			
		Cash and carry	Service		Cash and carry	Service		
Meat							x x	
Groceries							x x	
Milk								
Baked goods							x x	
Fruits, vegetables							x x	

. . . . .

ACH DAY, AND NUMBER OF HOURS WORKED

Wednesday		Thursday		Friday		Saturday	
l of work	Hours	Kind of work	Hours	Kind of work	Hours	Kind of work	Hours
x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x
x x x x	x x	x x x x x x	x x	x x x x x x	x x	x x x x x x	x x

Annex 7 (a)

ENGLISH WEEKLY SURVEY BOOKS

(Some typical pages.)

Study began : Date— After *
Study ended : Date— After

MEMBERS OF HOUSEHOLD

Reference No.	Age	Sex	Occupation	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

If Unemployed, how long ?
Total period of Unemployment during past 3 years.
* State Meal.

RECORD OF MEALS EATEN

If there are no absences, indicate this by X. If anyone is absent, indicate it by writing, under the proper meal, the reference number (see Page 1) of the absentee.

B—breakfast ; D—dinner ; T—tea ; S—supper.

	Absent				Visitors			
Date	B.	D.	T.	S.	Sex	Meal	Age	Remarks

REFUSE

Waste and Refuse collected: Bread, Potato-parings, etc.	Weight

FOOD SUPPLY

On Hand before study
Obtained during study
On Hand at end of study

Date	Kind	Weight	Cost	
			Total	Per Unit

Annex 7 (b)

WEEKLY BUDGET

INCOME	Father £ s. d.	Other Members £ s. d.	TOTAL £ s. d.
Wages			
Unemployment Benefit			
Public Assistance			
Pension			
Health Insurance			
Money from any other source			
TOTAL INCOME			

EXPENSES	£ s. d.	£ s. d.
1.—Food		
2.—Rent		
3.—Fuel and Light		
4.—Clothing		
5.—All other items, *e.g.*—		
Insurances		
Clubs		
Travelling		
Tobacco		
Amusements		
Newspapers		
....		
....		
....		
TOTAL EXPENDITURE		

COOKING AND PREPARATION OF FOOD

1. Is a mixed diet aimed at?

2. Is a dinner cooked daily?

3. What methods of cooking are adopted?

4. Times of meals?

GENERAL HEALTH OF FAMILY

No. of Pregnancies: —

Place in Family	Age [1]	Sex	Weight in lbs. [2]	Height in inches	Condition [3] and Defects, Illnesses (within past year), Rickets, Adenoids Teeth, etc.	Dead: Age	Dead: Cause	Still-births	Miscarriages [4]	Remarks: Care of Children, etc.
Father										
Mother										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

[1] Years and months.

[2] Children under 1 year to be weighed without clothing. Children 1-5 years, if weighed without clothing, state weight of clothes. Children over 5 to be weighed without boots and in ordinary indoor clothing.

[3] Good or bad.

[4] State Month of.

HOUSING

General Character of Neighbourhood—

Approaches—

Type of House (tenement, flat, self-contained, etc.)—

Rent (Weekly)—

Through Ventilation—

No. of Rooms—

No. of Members—

How much of House used by Family—

Cleanliness—

Ventilation—

Sanitary Arrangements—

Annex 8

FRENCH FAMILY DIETARY SURVEYS

(L. Randoin: *Bull. soc. scientif. d'hyg. aliment.*, 1937, V.25, Nos. 5 & 6.)

Form 1. — GENERAL INFORMATION CONCERNING THE FAMILY

No. of Survey : 1234.

Form No. 1 : GENERAL INFORMATION

Place [1] : Troyes, 3 rue de la Fontaine. (1 well-aired room looking out on courtyard ; 1 dressing-room).

Survey from June 1st to June 6th (inclusive).

Total family income per year : Wages : about 16,000 francs. Some private income.

Rent per year : 2,800 francs (including heating).

Light, coal and gas : 700 to 800 francs for electricity (lighting, cooking and wireless).

Christian name	Relationship	Age	Height	Weight	Origin, illnesses and state of health of members of the family [2]	Trade or occupation
Cécile . . .		52	1 m. 66	53 kg.	Born at Troyes. Appendicitis (operation at age of 25), with a period of enteritis and enterocolitis ; liver adhesions removed at the same time. Whooping - cough at the age of 33. Pleurisy and two pulmonary congestions. Mastoid operation. Inflation of the gall bladder, followed by bronchitis. Double cataract in 1936. Neither albumen nor sugar present. No constipation at present.	Welfare worker.

[1] The investigator will specify here the type of dwelling, whether the family lives in the open air, and other general health conditions.

[2] Country or town dweller ? From what region ? Place of birth ? *Do the members of the family complain of fatigue, ill-health, etc. ?*

The last question is of vital importance.

Annex 9

FRENCH FAMILY DIETARY SURVEYS (L. Randoin : *Bull. soc. scientif. d'hyg. aliment.*, 1937, V. 25, Nos. 5 & 6.)

Form 2. — INFORMATION CONCERNING THE PHYSICAL ACTIVITY OF EACH MEMBER OF THE FAMILY

No. of Survey : 1234.

Form No. 2 : SPECIAL INFORMATION : PHYSICAL ACTIVITY

Christian name	Relationship, preferably to head of family	Seated	Standing	Moving about	Heavy or light work ?	Method of travelling to work	Athletic exercise (including walking)
Cécile . . .		5 h.	½ h.	8 h.	Heavy	Omnibus	Swimming Gymnastics

Annex 10

FRENCH FAMILY DIETARY SURVEYS (L. Randoin : *Bull. soc. scientif. d'hyg. aliment.*, 1937, V. 25, Nos. 5 & 6.)

Form 3. — INFORMATION CONCERNING THE PHYSICAL ACTIVITY OF EACH MEMBER OF THE FAMILY

No. of Survey : 1234.

Form No. 3 : SPECIAL INFORMATION : PHYSICAL ACTIVITY

Christian name	Relationship, preferably to head of family	Rising-time and bed-time	(a)	(b)	(c)	(d)	(e)
Cécile		Irregular, varying according to work. Rises between 6.30 and 9 a.m. during the week and at midday on Sunday ; goes to bed about 11 p.m.		The first month of each quarter	One month in July at Nice. In bed between 10 p.m. and 7.30 a.m. Spends 3 hours on the beach and bathing in the morning. In the afternoon, goes for ride or reads, knits, and then bathes	Reading and wireless (music and the theatre). Goes to the theatre twice a month	

(*a*) Period of inactivity.
(*b*) Period of intense work.
(*c*) Length of holidays and place in the case of adults ; manner in which time is spent (approximately).
(*d*) Intellectual activities, apart from occupational work.
(*e*) Length of holidays and place in the case of children ; manner in which time is spent (approximately).

Annex 11

FRENCH FAMILY DIETARY SURVEYS

(L. Randoin : *Bull. soc. scientif. d'hyg. aliment.*, 1937. V. 25, Nos. 5 and 6.)

Form 4. — ORIGIN OF FOODSTUFFS : CATERERS

No. of Survey : 1234.

General remarks (in particular, concerning pastries for children).

	Kind [1]	Home produce	Wholesale market	Retail market	Retailer	Co-operative
1. Meat, fish	Beef				Local butcher	
2. Dairy produce, eggs					Dairy	
3. Oils, nutritive fats					Grocer	
4. Bread, flour, alimentary pastes					Bakery, Grocer	
5. Roots	Carrots, potatoes	The garden provides some vegetables		Local market		
6. Dried legumes						
7. Green vegetables, fresh and preserved		The garden		Market		
8. Fresh, dried and preserved fruits		Some fruit-trees		Market		
9. Groceries					Retailer	
10. Other foodstuffs						
11. Beverages						

[1] Should it be necessary to distinguish between several foodstuffs belonging to one group—*e.g.*, butcher's meat, poultry, pork butcher's produce—the exact names should be given in this column. For any further indication, see No. 1 in the notice.

N.B. — The above particulars are given only as *examples*. Investigators may always adapt them to each particular case.

An

FRENCH FAMILY DIETARY SURVEYS (Weekly) (Weighing Method)

DAILY CONS

(L. Randoin : *Bull. soc. sc*

No. of Survey : 1234.

Date : Monday, June 1st.

Remarks : (1) Soup weighed 0.627 kg. after strai

Foodstuff 1	Kind 2	Price per unit (kg. or litre), except where otherwise stated 3	Gross weight when received in the kitchen before cleaning 4	Non-edible portion foodstuff (specif bones, fat, gristle i the case of meat) 5
		Francs	Kg.	Kg.
Beef	Sirloin	30.00	0.217	
Butter	Table	24.00	0.013	
Oil	Arachis (peanut)	7.00	0.012	
Oil	Arachis (peanut)	7.00	0.015	
Bread	Fresh	2.40	0.215	
Carrots. . . .	New	3.00	0.125	0.025
Potatoes . . .	Old	0.85	0.310	0.080
Potatoes . . .	New, from the garden		0.115	0.012
Artichokes . .	Picked the same day		0.194	0.132 (cooke
White cherries	Picked the day before in the orchard		0.127	0.026
Sugar	Cane	4.75	0.009	
Vinegar . . .	Of wine	4.25	0.013	
Salt	Table	2.15	0.006	
Tea	Brand X			

(2) (*a*) In general, the foodstuff should be described exactly. In the case of a cheese or other product little known outside certain regions, it should be described in every possible detail (soft, cooked or uncooked, etc.) ; in the case of a raw product—*e.g.*, a special flour—the manufacturer's name should be stated and the *label showing the ingredients* sent. In the case of *preserves*, the brand and weight should be stated ; *if possible*, state the weight of foodstuff (peas, meat, etc.) and of broth.

(*b*) *In column* 4 state the weight in kilogrammes of the foodstuff before it is cleaned, meat with bones, etc.

(*c*) *In column* 5 mention all waste from cleaning—*i.e., all that is not eaten*—whether the cleaning is done in the kitchen, or when the food is eaten, as in the case of the bones of chops and rabbits, eggshells (boiled eggs, etc.), cheese rinds, the skin of fruits, etc.

(*d*) *Column* 6 shows the difference between the weights given in columns 4 and 5 ; this difference represents the weight of the foodstuff :

cooked

CARD

g. aliment., 1937, T/25 Nos. 5 and 6.)

First example of daily card.

One person only.

e end of the day, 0.425 kg. remained.

ight of edible w portion of foodstuff	Have the foodstuffs been cleaned ? Soaked ? For how long ? Method and time of cooking. State whether the water in which the vegetables were cooked was consumed—*e.g.*, as soup. State the weight of the cooked food in the case of scraps	Edible portion of food thrown away or left over		*(These 3 columns are not to be filled in by the investigator)*		
6	7	8		8(*a*)	9	10
Kg.		kg.				
0.217	20 minutes in the oven.	0.135				
0.013	With tea.					
0.012	Used up in frying.					
0.015	Artichoke.					
0.215						
0.100	Cooked in soup (45 minutes).		1			
0.230	Then strained.		1			
0.103	Fried for 20 minutes in oil.					
	Boiled for 20 minutes, water thrown away ; weight when cooked 0.215 kg.					
0.101	Washed in cold water.					
0.009	With tea.					
0.013	Artichoke.					
0.006						
	Taken in the morning (with bread and butter).					

eaten raw : fruits, salad, cheese ;

or bought ready cooked : ham.

(3) *Column 7* gives all the necessary details concerning the method and time of cooking—*i.e.* : (*a*) Is the meat roasted, boiled or fried, etc. ? (*b*) Are vegetables, salads, fruits, etc., soaked in water before being cooked ? Time of cooking ? (*c*) *What is done with the water used for cooking ?* This is of the *utmost importance*, as the greater part of the sugar and mineral elements are dissolved in the water used for boiling vegetables. State when such water *is thrown away* and when it is *consumed*—*e.g.*, in soup.

(4) Investigators will experience the following difficulties when filling in columns 8(*a*), 9 and 10 :

The cooked foodstuff has changed in weight, particularly if prepared in soup (additional water) ;

The cooked foodstuff is served up at table mixed with other foodstuffs (butter in the mashed potatoes, etc.).

First case: When the dish consists of one foodstuff only: State in column 7 the weight of the food when cooked and in column 8 the weight of the remainder. Here the work of the investigator finishes.

FRENCH FAMILY DIETARY SURVEYS (Weekly) (Weighing Method)

DAILY CON

(L. Randoin : *Bull. soc. scient. d*

No. of Survey 1234.
Date : Tuesday, June 2nd.

Remarks :

(2) Noodles were boiled in a large
(3) 197 grammes of soup were left
(4) Cornflour was eaten for break

Foodstuff 1	Kind 2	Price per unit (kg. or litre), except where otherwise stated 3	Gross weight when received in the kitchen before cleaning 4	Non-edible portion foodstuff (specif bones, fat, gristle the case of mea 5
		Francs	Kg.	
Beef	Sirloin (left over from previous day)	30.00	0.135 (cooked)	
Milk		1.50	0.157	
Butter	For the table	24.00	0.010	
Eggs (1 yolk) .	Fresh	0.65	0.060	0.005
Oil	Arachis (peanut)	7.00	0.035	
Bread	Fresh	2.40	0.192	
Noodles . . .	(Brand)		0.065	
Carrots. . . .	New	3.00		
Potatoes . . .	Old	0.85		
Cherries . . .	Picked the same day in orchard		0.145	0.032
Sugar	Cane	4.75	0.008	
Salt	Fine	2.15	0.005	
Cornflour. . .	(See attached label)		0.009	

2nd case : Where there are several foodstuffs in one dish, note in the space following information concerning the first food contained in the dish.

(*a*) All the weights of the foodstuffs, in their raw and cleaned state, of which the dish is composed (column 6) ;

(*b*) The total weight of the dish when *cooked* (column 7) ;

(*c*) The weight of the amount left over (column 8)

(*d*) Use a special number to indicate the dish ; write this number in the small column reserved for this purpose between column 8 and column 8(*a*) in the appropriate spaces opposite *each* of the ingredients of which a dish is composed.

The work of the investigator ends here.

3rd case : When it is impossible to know the weight of the dish when cooked : Fill in the consumption card as above, stating the weight of all the foodstuffs when raw and cleaned (column 6) which make up the dish, together with water if any ; in column 8, state the weight of the amount left over.

CARD

nt., 1937, T/25, Nos. 5 and 6).

Second example of daily card.
One person only.

f water ; the water was thrown away.
e end of the day.
ut bread and butter.

ght of edible when raw	Has the food been cleaned ? soaked ? For how long ? Method and time of cooking. State whether the water in which the vegetables have been boiled is consumed—*e.g.*, as soup. State weight of cooked food when some is left over	Edible portion of food thrown away or left over		*(These 3 columns to be left blank by the investigator)*		
6	7	8		8(*a*)	9	10
Kg.		Kg.				
0.135 (cooked)	With mayonnaise		1			
0.157	Cornflour		4			
0.010	Noodles					
0.023	Mayonnaise	0.032 White thrown away	1			
0.035	Mayonnaise		1			
0.192						
0.065	20 minutes in water. Weight when boiled : 215 gr.	0.125 kept	2			
	(Soup left over from previous day)		3 3			
0.113	Washed in cold water					
0.008	Cornflour					
0.005						
0.009	Boiled 12 minutes in milk		4			

4th case: When the weight of the cooked food is known, and special additional indications of value are available—*e.g.*, when it is known that only one part of one of the foodstuffs is consumed, whereas the other is consumed in its entirety, etc.

5th case: The " remains " are either eaten the next day, given to someone or thrown away. When they are eaten the next day, the consumption card must be filled in as was done for the dish itself—*i.e.* :

(*a*) Recopy the list of ingredients ;

(*b*) Write down a special number in the small column between columns 8 and 8(*a*), and copy it in the same column and in the spaces corresponding to each of the ingredients composing the " remains " ;

(*c*) note in the space corresponding to the *1st ingredient:*
the list of ingredients composing the " remains " ;
the total weight of the " remains " served up (column 6) ;
description " remains from " (date, name of dish), column 7 ;
what cannot be eaten (column 8).

6th case: Always state *the number of persons at each meal* (and their ages).

CZECHO-SLOVAK FOOD SURVEYS (Families and individuals).
Weighing Method—Annual Survey

(H. Pelc : *Trav. Inst. Hyg. p*

Meal	Food consumed	Ingredients	Total quantity of food prepared		A		
			Volume	Weight	Time of meal	Consumed	Left over
1	2	3	4	5	6	7	8
			Litres	Kg.		Kg.	Kg.
Breakfast	Unboiled milk						
	Boiled potatoes	1kg. 700 potatoes, 900 gr. butter, salt, caraway seeds		1.440	8 a.m.	0.310	0.0
	Milk					3 dcl.	
Snack	Milk		1.5				
	Bread				10 p.m.	0.080	
	Small extras						
Midday meal	Waffles with compote and curds	730 gr. flour, 1 egg, salt, 200 gr. compote, 30 gr. sugar, 550 gr. curds, 120 gr. butter		1.940	12 noon	0.330	0.1
Tea	Waffles left over from midday meal				3 p.m.	0.130	
	Bread					0.080	
	Milk						
Evening meal	Potatoes	2 kg. potatoes . .		1.650	7 p.m.	0.400	0.0
	Cabbage soup . .	50 gr. butter, spices, salt . .	1.5			4 dcl.	
	Unboiled milk						

17.III.1932.
Signature of Investigator

tchéco-sl., oct. 1934 nº 4.)

AMOUNT CONSUMED BY EACH MEMBER OF THE FAMILY

	B		C			D			E		
Time of meal	Con-sumed	Left over	Time of meal	Con-sumed	Left over	Time of meal	Con-sumed	Left over	Time of meal	Con-sumed	Left sumed
	10	11	12	13	14	15	16	17	18	19	20
	Kg.	Kg.		Kg.	Kg.		Kg.	Kg.		Kg.	Kg.
8 a.m.	0.530 3 dcl.	0.040	8 a.m.	0.340 4 dcl.		7 a.m. 8 a.m.	4 dcl. 0.180 1 dcl.	0.070	7 a.m. 8 a.m.	3 dcl. 0.080 1 dcl.	0.040
10 a.m.	0.100					10 a.m.	4 dcl. 0.030		10 a.m.	0.030	
noon	0.740		12 noon	0.360		12 noon	0.300	0.120	12 noon	0.180	0.080
3 p.m.	0.100					3 p.m	0.120 3 dcl.		3 p.m	0.080 4 dcl.	
7 p.m.	0.520 3 dcl.	0.200	7 p.m.	0.450 4 dcl.		7 p.m	0.180 3 dcl. 3 dcl.		7 p.m	0.180 1 dcl. 3 dcl.	0.060

Annex 15

BELGIAN MONTHLY DIETARY SURVEYS (FAMILY)

(Housewife's special account-book method.)

DAILY LIST

(Professor G. Jacquemyns, Head of the Investigation service of the Solvay Sociological Institute, Free University of Brussels.)

DAILY LIST

Purchases of foodstuffs.

Quantity	Designation of foodstuffs	Price

Home produce such as vegetables, eggs, milk, etc.

Gifts

Annex 16

BELGIAN MONTHLY DIETARY SURVEYS (FAMILY)

(Housewife's special account-book method.)

CARD FOR AN AGGREGATE MONTHLY FAMILY SURVEY

(E. J. Bigwood and G. Roost: "L'alimentation rationnelle et les besoins énergétiques d'une population ouvrière", publication of the Solvay Sociological Institute, Free University of Brussels, 1934).

	Grammes
Wheat bread	89,000
Wheat flour	1,000
Gingerbread (pain d'épices)	1,750
Speculaas (gingerbread men)	750
Macaroni	250
Vermicelli	250
Rice	875
Milk flour	1,000
Potatoes	81,000
Potato flour	125
Carrots	3,000
Dried haricot beans	500
Lump sugar	2,000
Candy sugar	500
Brown sugar	750
Cherry jam	500
Plum jam	500
Farm butter	750
Dairy butter	2,250
Lard	8,500
Bacon	4,000
Arachis oil . . . . 0.5 litre	
Whole milk . . . 59 ½ litres	
Sour milk . . . . . 5 litres	
Cream cheese	200
Edam cheese	100
Dutch cheese	875
Beefsteak	1,500
Fresh beef :	
Minced meat	3,500
Stewed meat	2,000
Grilled meat	5,000

	Grammes
Bones	1,250
Veal liver	250
Pork :	
Chops	3,000
Sausages	1,000
Ham	200
Knuckle of ham	725
Boudin blanc	2,000
Fresh eggs (32)	1,600
Plaice	2,000
Cured herrings (15)	1,500
Fresh herrings	15,000
Mussels	2,000
Green leaf vegetables :	
Brussels sprouts	1,000
Red cabbage	3,000
Leeks	2,000
Celery	500
Endives	7,000
Onions	1,000
Tomatoes (preserved)	100
Bananas	2,000
Lemons (8, weighing 75 gr. each)	600
Pepper	15
Salt	2,000
Nutmeg . . . . . 2 nuts	
Mustard	100
Chicory	3,500
Vinegar . . . . . 2 litres	
Coffee	2,500

Annex 17

DANISH DIETARY SURVEYS
(Type of Return Form.)

DAILY LIST
PURCHASES OF FOODSTUFFS

Date	Designation of foodstuffs			Designation of foodstuffs			Designation of foodstuffs			
	Kg.	Crowns	Ore	Kg.	Crowns	Ore	Kg.	Crowns	Ore	

Association of Danish Domestic Economy Societies

TABLES SHOWING THE VARIATION OF WEIGHT AND HEIGHT IN RELATION TO AGE AND SEX

Annex 18 (a)

SPECIMEN OF BIOMETRIC TABLE FOR CHILDREN IN THE UNITED STATES

WEIGHT-HEIGHT-AGE TABLE FOR BOYS FROM BIRTH TO SCHOOL AGE [1]

Weight is stated to the nearest pound ; height to the nearest inch ; age to the nearest month.

Up to and including 34 inches the *weights are net*. Above this the following amounts have been added for clothing (shoes, coats, and sweaters are not included) :

35 to 39 in. 1¼ pounds;
40 to 44 in. 1½ pounds;
45 to 49 in. 1¾ pounds.

Height (inches)	Average Weight for Height (pounds)	1 Mo.	3 Mos.	6 Mos.	9 Mos.	12 Mos.	18 Mos.	24 Mos.	30 Mos.	36 Mos.	48 Mos.	60 Mos.	72 Mos.
20	8	8											
21	9½	9	10										
22	10½	10	11										
23	12	11	12	13									
24	13½	12	13	14									
25	15	13	14	15	16								
26	16½		15	17	17	18							
27	18		16	18	18	19							
28	19½			19	19	20	20						
29	20½			20	21	21	21						
30	22			22	22	22	22	22					
31	23				23	23	23	23	24				
32	24½				24	24	24	25	25				
33	26					26	26	26	26	26			
34	27						27	27	27	27			
35	29½						29	29	29	29	29		
36	31							30	31	31	31		
37	32							32	32	32	32	32	
38	33½								33	33	33	34	
39	35								35	35	35	35	
40	36½									36	36	36	36
41	38										38	38	38
42	39½										39	39	39
43	41½										41	41	41
44	43½											43	43
45	45½											45	45
46	48												48
47	50												50
48	52½												52
49	55												55

[1] Tables prepared by Robt. M. Woodbury, Ph.D. Reprinted by permission of American Child Health Association.

Annex 18 (a) (continued)

WEIGHT-HEIGHT-AGE TABLE FOR GIRLS FROM BIRTH TO SCHOOL AGE [1]

Weight is stated to the nearest pound ; height to the nearest inch ; age to the nearest month.

Up to and including 34 inches the *weights are net*. Above this the following amounts have been added for clothing (shoes and sweaters are not included) :

35 to 39 in. 1 pound ;
40 to 44 in. 1 ½ pounds ;
45 to 49 in. 1 ¼ pounds.

Height (inches)	Average Weight for Height (pounds)	1 Mo.	3 Mos.	6 Mos.	9 Mos.	12 Mos.	18 Mos.	24 Mos.	30 Mos.	36 Mos.	48 Mos.	60 Mos.	72 Mos.
20	8	8											
21	9	9	10										
22	10 ½	10	11										
23	12	11	12	13									
24	13 ½	12	13	14	14								
25	15	13	14	15	15								
26	16 ½		15	16	17	17							
27	17 ½		16	17	18	18							
28	19			19	19	19	19						
29	20			19	20	20	20						
30	21 ½			21	21	21	21	21					
31	22 ½				22	22	23	23	23				
32	24					23	24	24	24	25			
33	25						25	25	25	26			
34	26 ½						26	26	26	27			
35	29						29	29	29	29	29		
36	30							30	30	30	30	31	
37	31 ½							31	31	31	31	32	
38	32 ½								33	33	33	33	
39	34								34	34	34	34	34
40	35 ½									35	36	36	36
41	37 ½										37	37	37
42	39										39	39	39
43	41										40	41	41
44	42 ½											42	42
45	45												45
46	47 ½												47
47	50												50
48	52 ½												52

[1] Tables prepared by Robt. M. Woodbury, Ph.D. Reprinted by permission of American Child Health Association.

WEIGHT-HEIGHT-AGE TAB

Height (in.)	Av. Wt. for Ht. (lb.)	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years	11 Years	12 Yea
38	34	34	34*						
39	35	35	35						
40	36	36	36*						
41	38	38	38	38*					
42	39	39	39	39*	39*				
43	41	41	41	41*	41*				
44	44	44	44	44	44*				
45	46	46	46	46	46*	46*			
46	48	47*	48	48	48	48*			
47	50	49*	50	50	50	50*	50*		
48	53		52	53	53	53	53*		
49	55		55	55	55	55	55	55*	
50	58		57*	58	58	58	58	58*	58
51	61			61	61	61	61	61	61
52	64			63	64	64	64	64	64
53	68			66*	67	67	67	67	68
54	71				70	70	70	70	71
55	74				72*	72	73	73	74
56	78				75*	76	77	77	77
57	82					79*	80	81	81
58	85					83*	84	84	85
59	89						87	88	89
60	94						91*	92	92
61	99							95	96
62	104							100*	101
63	111							105*	106
64	117								109
65	123								114
66	129								
67	133								
68	139								
69	144								
70	147								
71	152								
72	157								
73	163								
74	169								

Age		6 Years	7 Years	8 Years	9 Years	10 Years	11 Years	12 Ye
Average height (inches)	Short	43	45	47	49	51	53	54
	Medium	46	48	50	52	54	56	58
	Tall	49	51	53	55	57	59	61
Av. annual gain (lb.)	Short	3	4	5	5	5	4	8
	Medium	4	5	6	6	6	7	9
	Tall	5	7	7	7	7	8	12

* In order to extend the range of these tables so as to include weights of children who are taller or shorter than th inch in height and age of the children observed in this study.

[1] Tables prepared by Bird T. Baldwin, Ph.D., and Thomas D. Wood, M.D.

8 (b).

OR BOYS OF SCHOOL AGE [1]

13 Years	14 Years	15 Years	16 Years	17 Years	18 Years	19 Years	Av. Wt. for Ht. (lb.)	Height (in.)
							34	38
							35	39
							36	40
							38	41
							39	42
							41	43
							44	44
							46	45
							48	46
							50	47
							53	48
							55	49
							58	50
							61	51
64*							64	52
68*							68	53
71	72*						71	54
74	74*						74	55
78	78	80*					78	56
82	83	83*					82	57
85	86	87					85	58
89	90	90	90				89	59
93	94	95	96				94	60
97	99	100	103	106*			99	61
102	103	104	107	111	116*		104	62
107	108	110	113	118	123	127*	111	63
111	113	115	117	121	126	130*	117	64
117	118	120	122	127	131	134	123	65
119	122	125	128	132	136	139	129	66
124*	128	130	134	136	139	142	133	67
	134	134	137	141	143	147	139	68
	137	139	143	146	149	152	144	69
	143	144	145	148	151	155	147	70
	148*	150	151	152	154	159	152	71
		153	155	156	158	163	157	72
		157*	160	162	164	167	163	73
		160*	164	168	170	171	169	74

13 Years	14 Years	15 Years	16 Years	17 Years	18 Years	19 Years	Age	
56	58	60	62	64	65	65	Short	Average height (inches)
60	63	65	67	68	69	69	Medium	
64	67	70	72	72	73	73	Tall	
9	11	14	13	7	3		Short	Av. annual gain (lb.)
11	15	11	8	4	3		Medium	
16	11	9	7	3	4		Tall	

hese groups, there have been added as starred figures estimated weights. All the other weights represent averages for each

Annex 18 (b)

WEIGHT-HEIGHT-AGE TABLE

Height (in.)	Av. Wt. for Ht. (lb.)	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years	11 Years
38	33	33	33					
39	34	34	34					
40	36	36	36	36*				
41	37	37	37	37*				
42	39	39	39	39*				
43	41	41	41	41	41*			
44	42	42	42	42	42*			
45	45	45	45	45	45	45*		
46	47	47*	47	47	48	48*		
47	50	49*	50	50	50	50	50*	
48	52		52	52	52	52	53*	53*
49	55		54	54	55	55	56	56*
50	58		56*	56	57	58	59	61
51	61			59	60	61	61	63
52	64			63*	64	64	64	65
53	68			66*	67	67	68	68
54	71				69	70	70	71
55	75				72*	74	74	74
56	79					76	78	78
57	84					80*	82	82
58	89						84	86
59	95						87	90
60	101						91*	95
61	108							99
62	114							104*
63	118							
64	121							
65	125							
66	129							
67	133							
68	138							
69	142							
70	144							
71	145							

Age		6 Years	7 Years	8 Years	9 Years	10 Years	11 Years
Average height (inches)	Short	43	45	47	49	50	52
	Medium	45	47	50	52	54	56
	Tall	47	50	53	55	57	59
Av. annual gain (lb.)	Short	4	4	4	5	6	6
	Medium	5	5	6	7	8	10
	Tall	6	8	8	9	11	13

* In order to extend the range of these tables so as to include weights of children who are taller or shorter than those in inch in height and age of the children observed in this study.

[1] Tables prepared by Bird T. Baldwin, Ph.D., and Thomas D. Wood, M.D.

(continued)

FOR GIRLS OF SCHOOL AGE[1]

12 Years	13 Years	14 Years	15 Years	16 Years	17 Years	18 Years	Av. Wt. for Ht. (lb.)	Height (in.)
							33	38
							34	39
							36	40
							37	41
							39	42
							41	43
							42	44
							45	45
							47	46
							50	47
							52	48
							55	49
62*							58	50
65							61	51
67							64	52
69	71*						68	53
71	73*						71	54
75	77	78*					75	55
79	81	83*					79	56
82	84	88	92*				84	57
86	88	93	96*	101*			89	58
90	92	96	100	103*	104*		95	59
95	97	101	105	108	109	111*	101	60
100	101	105	108	112	113	116	108	61
105	106	109	113	115	117	118	114	62
110	110	112	116	117	119	120	118	63
114*	115	117	119	120	122	123	121	64
118*	120	121	122	123	125	126	125	65
	124	124	125	128	129	130	129	66
	128*	130	131	133	133	135	133	67
	131*	133	135	136	138	138	138	68
		135*	137*	138*	140*	142*	142	69
		136*	138*	140*	142*	144*	144	70
		138*	140*	142*	144*	145*	145	71

12 Years	13 Years	14 Years	15 Years	16 Years	17 Years	18 Years	Age	
54	57	59	60	61	61	61	. . Short	Average height (inches)
58	60	62	63	64	64	64	. Medium	
62	64	66	66	67	67	67	. . . Tall	
10	13	10	7	2	1		. . Short	Av. annual gain (lb.)
13	10	6	4	3	1		. Medium	
9	8	4	4	1	1		. . . Tall	

these groups, there have been added as starred figures estimated weights. All the other weights represent averages for each

Annex 18 (c)

TABLE OF WEIGHT AND HEIGHT FOR MEN AT DIFFERENT AGES [1]

In ascertaining height, measure in shoes ; stand erect, and press measuring rod down against scalp. Weigh yourself in indoor clothing and shoes. Subtract for height of heel if measured in shoes.

Height	Age 19 years	20	21-22	23-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59
5 ft.	111	112	114	118	122	126	128	131	133	134	135
5 ft. 1 in.	116	117	118	121	124	128	130	133	135	136	137
5 ft. 2 in.	122	123	124	125	126	130	132	135	137	138	139
5 ft. 3 in.	127	128	128	129	131	133	135	138	140	141	142
5 ft. 4 in.	130	131	132	134	135	136	138	141	143	144	145
5 ft. 5 in.	134	135	136	137	138	140	142	145	147	148	149
5 ft. 6 in.	139	140	141	142	143	144	146	149	151	152	153
5 ft. 7 in.	142	143	144	145	146	148	150	153	155	156	158
5 ft. 8 in.	147	148	149	150	151	152	155	158	160	161	163
5 ft. 9 in.	152	153	154	155	156	158	160	163	165	166	168
5 ft. 10 in.	155	156	157	158	159	162	165	168	170	171	173
5 ft. 11 in.	159	160	161	162	164	166	170	174	176	177	178
6 ft.	163	164	165	166	168	172	176	180	182	183	184
6 ft. 1 in.	167	168	169	171	173	178	182	186	188	190	191
6 ft. 2 in.	171	172	174	176	179	184	189	193	195	197	198
6 ft. 3 in.	175	175	178	181	184	190	195	200	202	204	205
6 ft. 4 in.	178	180	183	186	189	196	201	206	209	211	212
6 ft. 5 in.	183	185	188	191	194	201	207	212	215	217	219

[1] From *Personal Health Standard and Scale*, by Thomas D. Wood, M.D., Bureau of Publications, Teachers College, Columbia University.

Annex 18 (c) (continued)

TABLE OF WEIGHT AND HEIGHT FOR WOMEN AT DIFFERENT AGES [1]

In ascertaining height, measure in shoes ; stand erect, and press measuring rod down against scalp. Weigh yourself in indoor clothing and shoes. Subtract for height of heel, if measured in shoes.

Height	Age 19 years	20	21-22	23-24	25-29	30-34	35-39	40-44	45-49	50-54
4 ft. 10 in.	104	106	108	110	113	116	119	123	126	129
4 ft. 11 in.	106	107	109	112	115	118	121	125	128	131
5 ft.	112	112	113	115	117	120	123	127	130	133
5 ft. 1 in.	116	116	116	118	119	122	125	129	132	135
5 ft. 2 in.	118	118	119	120	121	124	127	132	135	138
5 ft. 3 in.	120	121	122	123	124	127	130	135	138	141
5 ft. 4 in.	123	124	125	126	128	131	134	138	141	144
5 ft. 5 in.	126	127	128	129	131	134	138	142	145	148
5 ft. 6 in.	130	131	132	133	135	138	142	146	149	152
5 ft. 7 in.	135	135	135	137	139	142	146	150	153	156
5 ft. 8 in.	138	138	139	141	143	146	150	154	157	161
5 ft. 9 in.	142	142	142	145	147	150	154	158	161	165
5 ft. 10 in.	144	144	145	148	151	154	157	161	164	169
5 ft. 11 in.	146	147	149	151	154	157	160	164	168	173
6 ft.	150	152	154	156	158	161	163	167	171	176

[1] From *Personal Health Standard and Scale*, by Thomas D. Wood, M.D., Bureau of Publications, Teachers College, Columbia University.

Annex 19

SPECIMEN OF BIOMETRIC TABLE FOR CHILDREN IN BELGIUM

TENTATIVE DETERMINATION OF MEAN WEIGHT VARIATIONS IN RELATION TO AGE AND AN INCREASING SERIES OF HEIGHT MEASUREMENT

GIRLS

Increasing heights in cm.	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years	Increasing heights in cm.	11 Years	12 Years	13 Years	14 Years	15 Years	16 Years	17 Years	18 Years
90	13.9	14.3							122	24.9							
92	14.5	14.8							124	25.1							
94	15.1	15.4							126	26.3							
96	15.6	15.8							128	26.4	28.3						
98	15.9	16.0	16.3	16.8					130	27.4	28.8						
100		16.4	16.5	17.4					132	28.3	29.6						
102		16.6	17.1	17.5	18.0				134	29.1	30.3						
104		17.0	17.4	17.9	18.4				136	29.6	30.9	33.0					
106			18.2	18.4	18.7	19.1			138	30.5	32.3	34.1					
108		18.2	18.4	18.7	19.2	19.6			140	31.2	32.7	34.9	36.8				
110			19.4	19.7	20.05	20.6			142	32.0	34.2	35.1	39.5				
112			19.6	19.9	20.11	21.1			144	32.7	35.6	36.7	40.5				
114			19.8	20.1	20.5	21.3			146	33.4	35.9	37.2	41.1	44.7			
116			20.0	20.7	21.2	21.5	22.0		148		36.4	39.4	41.5	45.1			
118				21.3	21.8	22.05	22.2		150		36.8	39.7	42.8	45.8	46.6	47.7	
120					22.6	22.9	23.0	23.4	152		39.2	40.3	43.7	45.9	49.0	50.4	
122					22.9	23.2	23.6	24.1	154			41.2	44.6	47.4	49.3	51.1	
124					23.3	23.7	23.9	24.5	156			41.6	44.8	48.7	49.6	51.6	
126					23.7	24.9	25.2	25.3	158			42.7	46.2	49.0	50.9	54.0	55.6
128					24.5	25.1	25.6	26.3	160				46.8	51.2	51.5	54.7	55.8
130						25.3	26.5	27.2	162				48.2	51.4	51.7	55.5	56.0
132						25.6	26.8	27.5	164				48.8	52.8	54.0	56.5	
134						25.8	27.5	28.3	166				49.3	53.0	54.8	58.3	60.4
136							27.7	28.6	168				51.0	58.3	56.1	58.6	60.6
138							28.0	29.3	170						58.3	60.5	63.0
140								30.3									

Annex 19 (continued)

SPECIMEN OF BIOMETRIC TABLE FOR CHILDREN IN BELGIUM

TENTATIVE DETERMINATION OF MEAN WEIGHT VARIATIONS IN RELATION TO AGE AND AN INCREASING SERIES OF HEIGHT MEASUREMENT

Boys

Increasing heights in cm.	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years
92	14.7	15.1						
94	15.2	15.5						
96	15.5	15.8						
98	15.7	16.04	17.4					
100	15.7	16.9	17.5	17.7				
102		17.2	17.7	18.1				
104		17.6	17.8	18.6	19.6			
106		17.8	18.4	18.7	19.7			
108		18.3	18.6	19.0	19.8			
110			19.3	19.6	20.1	20.3		
112			19.6	20.0	20.5	21.0		
114			20.0	20.8	21.1	21.6	21.8	
116				21.2	21.4	21.9	22.4	
118				22.1	22.2	22.7	22.8	
120				22.2	22.8	23.0	23.3	23.5
122				22.3	23.2	23.7	24.0	24.3
124					23.6	24.4	25.0	25.3
126					23.7	24.9	25.7	25.9
128						25.2	25.9	26.5
130						25.9	27.3	28.1
132						26.1	27.6	28.3
134							27.8	29.1
136							28.6	30.0
138								30.3

Increasing heights in cm.	11 Years	12 Years	13 Years	14 Years	15 Years	16 Years	17 Years	18 Years
126	26.3							
128	26.8	28.3						
130	28.2	29.1						
132	28.7	30.1	31.1	31.2				
134	29.6	30.7	31.4					
136	30.2	31.3	31.8	32.9				
138	30.5	32.0	33.1	35.0				
140	31.7	32.6	33.6	35.2				
142	31.8	34.0	34.3	37.2				
144	33.4	34.9	35.6	37.5				
146	33.8	35.2	36.6	38.4				
148		35.8	37.4	39.2	41.3			
150		36.8	38.6	40.1	43.0			
152		37.0	39.0	42.3	44.9			
154			39.8	43.0	45.5	47.6		
156		39.1	40.7	44.8	47.2	49.6		
158				45.2	47.8	50.4	51.5	
160				45.5	49.3	51.7	53.2	55.0
162				46.1	50.8	52.6	54.8	56.0
164					51.8	53.4	57.0	58.9
166					52.5	55.6	57.4	61.4
168					53.2	57.1	57.7	
170					57.5	58.1	58.9	
172						59.3	60.2	
174							62.5	

Annex 20

NETHERLANDS BIOMETRIC TABLES
(Dr. STRENG.)

THE HAGUE, 1934

BOYS

Age	Weight Kg.	Height cm.	Age	Weight Kg.	Height cm.
6 yrs			*10 yrs*	29.6	135.8
1 m.			1 m.	8	136.2
2			2	30.0	6
3			3	3	137.0
4	20.7	116.2	4	5	4
5	9	8	5	7	8
6	21.1	117.2	6	9	138.1
7	3	8	7	31.1	5
8	5	118.3	8	3	9
9	7	7	9	6	139.2
10	9	119.1	10	8	6
11	22.1	5	11	32.0	140.0
7 yrs	2	120.0	*11 yrs*	32.2	140.4
1 m.	4	5	1 m.	4	8
2	6	121.0	2	6	141.2
3	8	4	3	8	5
4	9	8	4	33.0	9
5	23.1	122.2	5	2	142.2
6	2	6	6	4	5
7	4	123.0	7	6	8
8	6	5	8	8	143.0
9	8	124.0	9	34.0	2
10	9	4	10	1	5
11	24.1	8	11	3	9
8 yrs	3	125.2	*12 yrs*	6	144.2
1 m.	6	7	1 m.	8	5
2	9	126.3	2	35.0	8
3	25.1	9	3	3	145.1
4	3	127.4	4	6	5
5	6	9	5	8	146.0
6	8	128.4	6	36.1	4
7	26.0	9	7	4	8
8	2	129.3	8	7	147.2
9	4	7	9	37.0	6
10	6	130.1	10	3	148.1
11	8	5	11	6	5
9 yrs	27.0	131.0	*13 yrs*	9	149.0
1 m.	2	4	1 m.	38.2	4
2	5	9	2	5	9
3	8	132.4	3	8	150.3
4	28.0	8	4	39.1	7
5	2	133.2	5	3	151.0
6	4	6	6	6	3
7	6	134.0	7	8	7
8	8	4	8	40.1	152.0
9	29.0	7	9	3	
10	2	135.0	10		
11	4	4	11		

Note communicated to the Health Section on June 28th, 1938 (C.H./Com.Exp.Alim./45).

Annex 20 (continued)

Height and Weight of Boys		7½ years cm.	kg.	9½ years cm.	kg.	11½ years cm.	kg.	13½ years cm.	kg.
Utrecht, Board School	1905	113	20.7	123	25	132.5	29.2		
	1916	114	21.4	124	26	134	30.7		
	1935	119	23.4	131	28.5	138.5	33.3		
Utrecht, middle-class school-children	1905	121.8	24	132	29	141	34		
	1916	125	24.8	134	30	143.5	35.2		
	1935	125	25.3	136	31.5	145.1	37		
Utrecht, poorest school-children	1920	114	21.5	123.5	26	132.5	30.3		
	1935	118	22.7	129	27.5	137.2	32.5		
Amsterdam . .	1916	115	22	126.5	27.2	139	32.1		
,,	1917	117.5	22.5	128.5	26.3	137	31.9		
,,	1918	115	22	128.5	26	135.5	31		
,,	1935	122	23.9	132.5	29.5	141.7	34.8		
,,	1936	121.3	23.7	132.1	28	142.3	35.1		
,,	1937	122	24	132.4	29	141.7	34.7		
Oslo, elementary schools	1920	125.80	23.85	128.48	26.43	137.12	31.18	145.79	36.79
	1925	125.53	24.61	130.73	27.34	139.58	32.51	148.15	38.32
	1930	125.17	23.33	132.86	28.55	141.37	33.78	150.44	40.36
	1935	127.21	25.66	134.43	29.43	143.25	35.11	152.73	42.01
Oslo, secondary schools	1920					142.53	34.22	150.45	40.09
	1925					146.01	36.24	153.25	41.84
	1930					146.39	38.20	154.26	43.06
	1935							159.87	47.54
Banska Bystrice . .		116.3	21.4	125.7	25.4	131.9	29.1		
Prague		120.51	22.70	130.15	27.70	140.51	34.22		
Kralupy n. Vlt . . .		119	22.28	129	27.12	137.5	32.05		
Berehovo.		116.78	21.22	124.57	24.31	131.97	28.53		
Mukacevu		115.82	20.41	124.03	23.98	132.22	28.25		
Sub-Carpathian Russia		116.48	20.86	124.36	24.16	132.08	28.37		
Bratislava (poor) . .		117.10	20.85	125.07	24.64	132.89	28.50		
Banovce, Trencin and Trnava		117.8	22.30	124.3	26.59	135.3	32.30		
Radnice (city) . . .		115.42	20.91	125.03	25.52	133.45	29.31		
Radnice (surroundings)		120.39	23.49	128.86	28.42	137.29	32.73		

Annex 20 (continued)

Boys — Mean Weights for Various Heights

Height cm.	Whole group Number	Kg.	7-8 years Number	Kg.	9-10 years Number	Kg.	11-12 years Number	Kg.	13-14 years Number	Kg.
103	3	21	1	15.4						
104	4	17.1			1	32.3				
105	4	18.1								
106	8	17	1	16.5						
107	5	17.1								
108	18	18.8	3	18						
109	14	18.1	2	18						
110	36	19	11	20.1						
111	45	18.8	16	18.8						
112	75	19.1	19	19.5						
113	71	19.6	20	20.7						
114	78	20.2	28	20.2						
115	89	20.5	32	20.1	1	18				
116	96	20.9	29	20.9	2	22.9	1	23.2		
117	135	21	52	21	3	20.8				
118	140	21.3	63	21.1	2	23.7	1	20.9		
119	144	21.6	59	21.7	4	22.5			1	20.8
120	171	22.2	79	22	10	22.1				
121	160	22.5	72	22.5	10	22.4	1	23.9		
122	191	23.4	90	23.4	10	23.9	1	30		
123	203	23.5	76	23.5	23	23.8				
124	195	23.8	69	23.4	24	25.4	3	24.7		
125	221	24.3	85	24.2	30	24.1	4	25.3		
126	216	24.6	70	24.6	46	24.3	1	27.2	1	23.6
127	232	25	61	24.5	40	25.4	8	27.6		
128	213	25.7	51	24.9	52	26	7	25.6		
129	217	26.3	43	25.9	64	26.5	16	27.8		
130	200	26.6	32	26.2	58	26.7	12	27.7		
131	242	27.5	31	26.4	67	27.3	13	28.9		
132	236	27.7	20	26.9	73	27.2	22	28.4		
133	252	28.3	22	28.7	82	27.6	26	28.4		
134	260	28.9	15	28.9	69	28.6	36	28.8	2	33.2
135	256	29.3	6	30.4	70	29.2	42	29.6	3	32.5
136	258	29.5	4	28.9	69	29.4	52	29.3	2	29.4
137	248	30.3	2	31	80	30.3	58	30.6	4	32
138	265	30.6	4	25.7	74	30.1	54	31.1	5	30.7
139	238	31.2	1	28.5	52	31.1	62	31.4	11	31.5
140	269	32.1	3	38	43	31.7	77	32.3	9	33.1
141	237	32.5	1	34	42	32.5	66	33.2	8	31.7
142	229	33.2	1	30	35	32.2	68	33.7	10	34.3

Annex 20 (continued)

BOYS — MEAN WEIGHTS FOR VARIOUS HEIGHTS

Height cm.	Whole group Number	Kg.	7-8 years Number	Kg.	9-10 years Number	Kg.	11-12 years Number	Kg.	13-14 years Number	Kg.
143	220	33.5			25	33.7	81	33.4	17	34.7
144	189	34.1			13	33.5	68	33.7	15	34.9
145	165	34.8	1	35.3	11	35	53	34.7	17	35
146	179	35.3			10	35.1	67	35.4	12	35.8
147	178	35.7			6	35.3	54	35.1	23	36.6
148	163	37			5	37.5	51	36.6	32	37.1
149	126	37			8	36	44	36.8	24	38.3
150	136	38.3			4	38	47	37.7	24	39.1
151	118	38.3			6	34.6	31	37.2	25	39.4
152	112	38.7			1	36	29	37.5	17	40.2
153	73	39.7			1	38.5	21	40.8	16	40.4
154	70	41	1	51.1	2	42.7	13	38.5	30	41.2
155	62	40.9					10	40	22	41.6
156	64	41.8					9	42.2	18	41.5
157	49	42.5			2	36.2	9	44.4	17	43.4
158	38	43.3					6	43.8	16	42.4
159	27	44.6					7	42.7	10	44.6
160	28	45.5					4	45.3	17	46.7
161	20	46.4							13	46.5
162	14	46.9					2	48.9	9	46.4
163	15	45.2							7	46.2
164	10	44.8					3	45.5	2	45.4
165	11	50.8							4	50.7
166	9	50.7					1	52.7	5	51
167	6	48.2							3	49.3
168	7	51							3	47.2
169	1	49.2							1	49.2
170	5	57.6							2	57.7
171	2	59.6							2	59.6
172	5	52.3							2	57.2

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