THE PHYSIOLOGICAL FEEDING
OF
INFANTS AND CHILDREN

THE PHYSIOLOGICAL FEEDING OF INFANTS AND CHILDREN

A HANDBOOK OF THE PRINCIPLES AND PRACTICE OF FEEDING

BY

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PREFACE TO THE FOURTH EDITION

THE last edition of this book was published in 1909, and it has been out of print since 1915. I have made several ineffectual efforts to rewrite and bring *The Physiological Feeding of Infants* up to date, but owing to many calls upon my time, progress has been slow. At times when I have reached the end of my revision of one part I have found it necessary to rewrite much of that which I have already prepared. I can only hope that the extended clinical experience acquired in the interim will lend added value to the book and compensate for any disappointments caused by this delay.

In my preface to the Third Edition I stated that I had not materially changed my methods since the previous edition was published, but in the twelve years that have elapsed since I wrote those words I have found it necessary to modify many of my views.

Among the several alterations which I have found it desirable to make, one is that I have entirely abandoned the method of gradually extending the intervals between feedings as the infant grows older. I hold very strongly that three-hourly feedings during the day with the omission of night feedings should be persisted in from the first day of life until the child is five or six months old, in order that advantage may be taken of the tendency to fall into regular habits which is so manifest in all young animals. Further, I have come to the conclusion that it must be wrong to increase the protein content of the food —"strengthen" the food, as it is usually called—as the child grows older. Breast milk, which is admittedly the best food for infants, does not contain a larger protein content as lactation proceeds, but remains relatively constant for eight or nine months. The argument that because infants cannot at first digest the full proportion of protein they must necessarily be deprived of their nutritional rights is just as unsound as it is to assume that when artificially fed infants have developed the capacity for digesting protein they require a larger proportion than is present in breast milk itself.

Throughout this book I have assumed that the more accurately artificial feeding is modelled on the natural method the better will it be for the child, and as far as the protein content of the food is concerned, taking into account the respective biological values of the two proteins, I have conformed to the standard of breast milk from the day of birth till the time of weaning, and have made provision for assisting digestion in those cases in which the infant is unable to deal with the full amount by its own unaided efforts.

In response to many requests I have included in the present edition the feeding of children over one year of age, both in sickness and in health, and I have made an attempt to deal with this important subject on a quantitative as well as on a qualitative basis. In doing so I am well aware that I am treading on dangerous ground, for the reason that our knowledge is incomplete with regard to the metabolic processes of children, especially in disease. Unless, however, we accept some more or less definite standard of requirements for normal children it is impossible to make adjustments for abnormal conditions. It is better to make a few mistakes than to make unmeasured and haphazard experiments. In the one case we can retrace our steps and mend our policy, in the other we have no policy or method to improve. I can only hope that the large amount of work entailed in making this somewhat ambitious attempt will find its reward in the help which it may afford to others in overcoming the extreme difficulties of dieting sick children on a physiological basis.

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35 HARLEY STREET, W.1.
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ERRATA.

Chapter 1. Throughout this chapter for calorie read Calorie with capital C.

Page 5. Paragraph 2, line 3, for "per ounce" read "per gramme."

„ 45. Paragraph 3, line 1, for "Stearopsin" read "Steapsin."

„ 84. Paragraph 3, line 5, for "stearopsin" read "steapsin."

„ 106. Table 23, for "Percentage of Tri-Glycerides" etc. read "Percentage of Tri-Glycerides in the fat of Cows Milk and Human Milk."

„ 130. Last line, for "136" read "278."

„ 149. Paragraph 2 line 1, omit "in Germany."

„ 169. Last paragraph, lines 9 and 11, for "100 F" read "100 C."

„ 297. Paragraph 1, line 6, for "Mechel's" read "Meckel's."

„ 428. Paragraph 3, line 10, for "no" read "on."

„ 497. Last line, for "245" read "246."

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PART I

GENERAL PRINCIPLES OF FEEDING INFANTS AND CHILDREN

INTRODUCTION

What is meant by Physiological Feeding—The Purposes of Food

When the first edition of *The Physiological Feeding of Infants* was published, now some twenty years ago, a reviewer drew attention to the inappropriateness of the title on the ground that the only form of feeding which deserved to be described as physiological —*i.e.* breast feeding—was the only form which was omitted. In subsequent editions this defect was remedied, and in this edition I propose to pay still further attention to the subject of natural feeding; but no method of feeding, whether natural or artificial, can be correctly described as physiological unless it is adapted to the requirements of the particular individual.

The purposes of food are fourfold: (1) for growth and repair of tissue; (2) for the production of work; (3) for the supply of heat; (4) for the manufacture of secretions.

Inasmuch as no two individuals have exactly the same requirements in these respects, it is clear that the food supply must be different in each case. The aim of physiological feeding is to adapt the food in each particular case as accurately as possible to the conditions which prevail. This aim is probably never completely fulfilled. If any element of food, be it a mineral salt or a protein constituent, is absent or deficient, some injury will be inflicted on the organism, but the resources of the human body are so elastic, and its capabilities for supplying or improvising substitutes so immense, that the damage inflicted is not necessarily great or irremediable, but one of the aims of physiological feeding is to detect symptoms of impending danger before serious damage has been inflicted.

If the supply of food is qualitatively unsuitable, damage will be inflicted on the organism in much the same way as it is when it is quantitatively incorrect. Knowledge with respect to the properties of food and the nutritional requirements of the body has of recent years become more exact, so that in the majority of instances it is possible, without putting individual cases to the test of actual experiment, to predict on theoretical grounds the result of any particular fault in the diet. On the other hand, the reactions of the body are so sensitive and constant that it is possible by experience and observation to draw accurate conclusions with respect to the appropriateness or the reverse of any particular dietary from clinical examination of the symptoms produced. On theoretical grounds it is not only possible but easy to calculate the food requirements of any particular infant or child. In making such calculations, however, allowances must be made for a large number of different conditions, such as digestive capacity, absorption, general metabolic efficiency, habit, climate and other variable factors. All these matters must be fully considered in any work which proposes to cover the ground of physiological feeding. In the first section of this book, which is confined to the principles of feeding, the subject matter will be dealt with in the following order :—(1) The theoretical quantitative requirements of the individual based on the caloric value of the food ; (2) the quantitative food requirements based on empirical observation ; (3) the qualitative make-up or balance of the food ; (4) considerations of digestion ; (5) considerations of absorption ; (6) considerations of secondary digestion or metabolism within the tissues ; (7) considerations of excretion ; (8) considerations of taste, habit, idiosyncrasies and psychological factors.

The aim of physiological feeding is to adjust the food accurately to the individual requirements. Food is required for the following purposes :—for growth and repair, for heat production, for work and for the elaboration of secretions. To adjust the food to these requirements it is not only necessary to have a knowledge of these theoretical requirements, but it is essential to make corrections and allowances for the individual behaviour of the child himself as discovered by personal observation. The one method should check the other.

CHAPTER I

FOOD: THE QUANTITATIVE REQUIREMENTS

The Calorie the Basis of Measurement—Method of estimating Caloric Requirements—The Caloric Requirements of Infants—Table of Caloric Requirements of Infants—Factors which influence Caloric Requirements —Empirical Method of estimating Caloric Requirements—How to recognise Excess—How to recognise Deficiency—Relative Excess and Relative Deficiency

THE QUANTITATIVE REQUIREMENTS—THEORETICAL CONSIDERATIONS—CALORIC VALUES

ANY substance that is capable of being burnt or oxidised will afford a certain amount of heat, and this is true of material undergoing slow combustion in the body or rapid combustion outside it. Substances which can be burnt within the body are regarded as foods, and the amount of heat which they produce is commonly estimated in heat-units or calories. *A calorie is the amount of heat that is required to raise the temperature of one litre of water through one degree Centigrade.*

If, for instance, a litre of water is raised 9·1 degrees Centigrade by the total heat generated when one gramme of oil is burnt, we say that the caloric value of the latter is 9·1 per ounce. Caloric values are usually expressed in terms of grammes, and not in ounces—that is to say, on a metric system. The caloric value of sugar is generally stated to be 4·1—that is to say, when one gramme of sugar is completely burnt the total number of heat-units or calories produced is 4·1. The caloric value of pure protein is the same as that of sugar and all other carbohydrates—namely, 4·1. On page 463 a table will be found giving the caloric values of some of the commoner foods. The caloric values in this table are given for ounces and not for grammes.

The caloric value of a food can be calculated by burning or oxidising a given weight of it in the presence of oxygen in an iron bomb or receptacle which must be strong enough not to burst in the explosion caused by combustion. If, for instance, a gramme of fat is confined in such a bomb with compressed oxygen and then exploded by an electric spark there will be an immense generation of gas and the production of much heat. The amount of heat produced can be estimated by plunging the bomb in water and noticing the number of degrees the temperature of the water is raised. If the amount of water is one litre, and the number of degrees to which it is raised 9·1, we say the caloric value of the fat is 9·1.

The energy value of food can be utilised in the animal body in several ways; to do work or produce kinetic energy. In the ordinary steam engine work is done by the generation of steam, which, by its expansion, drives a piston which is connected by means of a rod with a wheel: the rotation of the wheel can be utilised for producing work. In the more modern internal combustion engine the work is done by direct explosion of oil or petrol in a closed receptacle in which there is a piston, which is forced out by means of the explosion. In the human body the oxidation of food produces work in a different manner. Without entering into the details it may be stated in general terms that the combustion of the fuel causes a shortening of muscle spindles which can in the aggregate produce a very considerable shortening of a muscle composed of many individual cells or fibres, and in so doing can exercise a considerable pull on the bone or structure to which it is attached. For instance, the shortening of the biceps muscle can raise the fore-arm against very considerable resistance, and in so doing produce work. In a good steam engine something like one-tenth of the potential energy of the fuel consumed—that is to say, one-tenth of its caloric value—can be utilised for the purpose of doing actual work, while nine-tenths are wasted as heat. In the modern internal combustion engine, which works more economically, something like one-eighth of the fuel consumed can be converted into work while seven-eighths are lost in heat. The human body works more economically than any mechanical engine so far invented. It can convert one-sixth of the estimated potential energy of the food or fuel consumed into work with a wastage of only five-sixths as heat. As there are differences in mechanical engines with respect to their efficiency and economy in working, so are there differences in the efficiency of different human engines. The human engine can be the most efficient of instruments for doing work; on the other hand it is as a rule, under conditions of civilisation, one of the most wasteful, and this is owing to faulty and extravagant dietetic habits. But since at best the human body can only utilise one-sixth of the food consumed for the doing of useful work it is clear that six times as much food must be consumed as is theoretically required for the work it has to do.

The amount of food that is required during the 24 hours depends almost entirely on the amount of mechanical work to be performed. The average man has been estimated to perform about 1,400,000 ft. lb. of work in the 24 hours. In order that he may produce this amount of work he must consume a certain amount of food. Now, how many heat-units or calories are required to produce this amount of work on the assumption that the human engine is of average efficiency? One calorie or heat-unit corresponds in value to 425 kilogramme-metres or 2975 ft. lb. of work. If one calorie can produce 2975 ft. lb. it is a simple calculation to estimate how many calories will be required to produce 1,400,000 ft. lb.; the exact number is 471. From this it follows that an average man doing an average day's work must consume sufficient food to afford 471 calories, but, as we have already stated, the human machine can only convert one-sixth of the available calories into work, and therefore an average man must consume food to the value of six times 471, or in other words of the value of 2826 calories. It is obvious that since such a large proportion of the food consumed is converted into heat the man who does an average amount of work must at the same time produce a large amount of heat, and that a man who does a larger amount of work must produce a still larger amount of heat. One of the chief strains which are imposed upon the human organism is the dissipation of the large amount of heat which under all circumstances is produced in doing hard work. As far as the amount of food required by infants is concerned, it is clear that little is demanded by the actual amount of "*external*" work performed, although a certain amount of kinetic energy is used up in movements of arms, legs, head, and so on. Most of the work performed is "*internal*" work, such as is required for carrying on the functions of respiration, circulation, digestion, and so on. The requirements for food for basal metabolism—that is to say, for an infant remaining at rest—are exceedingly small under normal conditions. The actual amount has been estimated by calorimetric experiments on living infants. The amount of heat produced by infants remaining at rest depends on their basal metabolism. The basic metabolism is the metabolism of an infant doing practically no external work—that is to say, lying at rest. Infants who cry a great deal, or who are energetic in their movements, will have a metabolism considerably in excess of the basic limit. On an average, however, it has been estimated that, taking into consideration their relative inactivity during the first six months of life, the metabolism of infants is represented by about 50 calories per pound of body weight—that is to say, an infant under six months of age and weighing 10 lb. would require

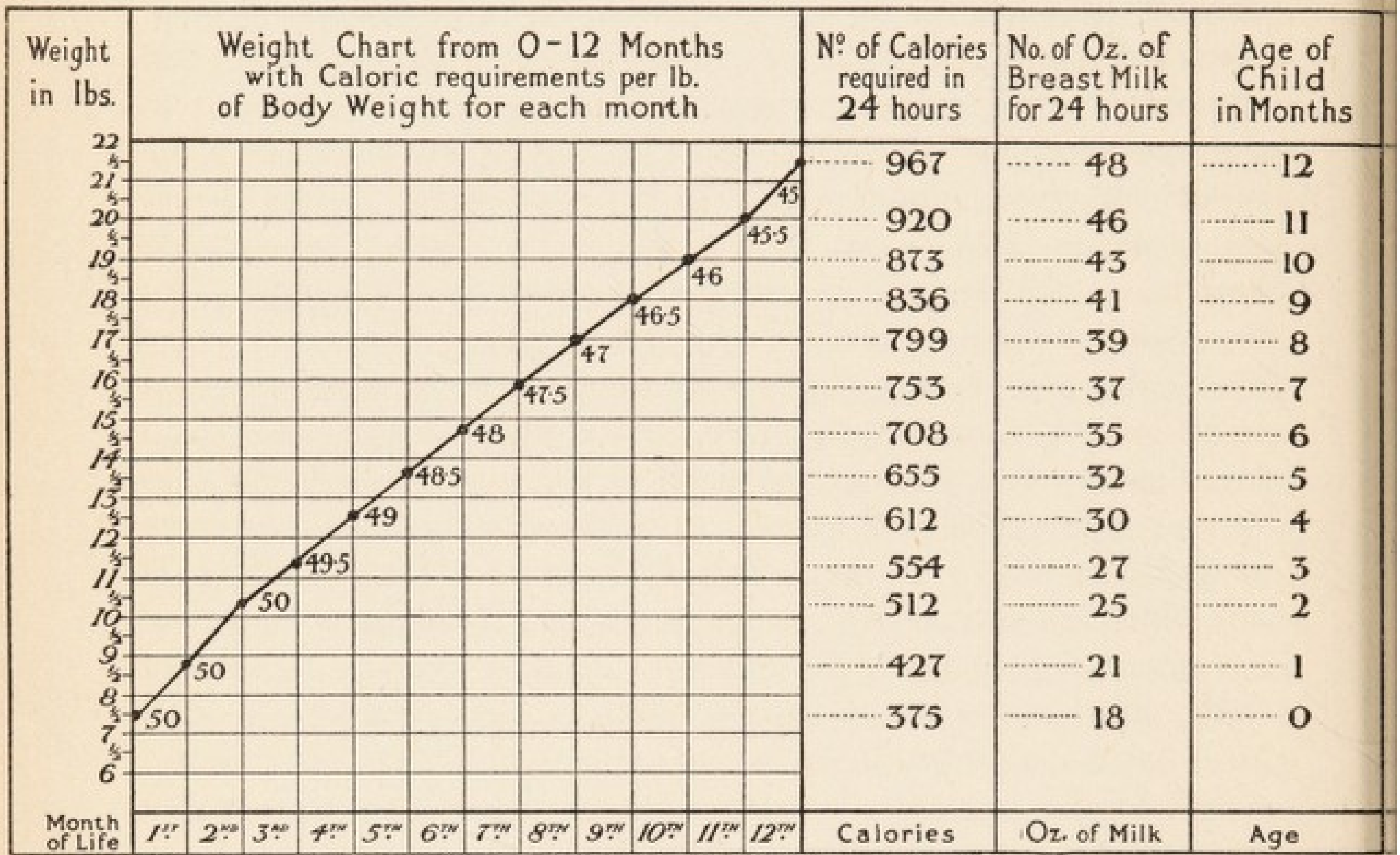

Fig. 1.—Chart to show the Caloric Requirements of the Average Infant from 1 to 12 Months old. The number of calories per lb. of body weight are indicated in the curve. There is a gradual fall from 50 to 45 calories per lb. of body weight

10 × 50 or 500 calories in the 24 hours, and calculating that each ounce of breast milk affords 20 calories it would mean that about 25 oz. of milk would have to be consumed. After six months of age the number of calories per pound of body weight gradually falls to 45 at the twelfth month. The number of calories required by an infant twelve months old and weighing 22 lbs. would be 990. On the accompanying chart I have mapped out the number of calories required by the average infant during the first year of life.

On the left-hand side of this chart are given the weights of the baby at different ages, and on the right-hand side the number of calories required. These figures are extremely useful in estimating the approximate amount of food required by the average baby at different ages, but they cannot be relied upon to be absolutely accurate in any particular case, for babies will not conform to rule. Some are active, others are inactive in their movements. Some babies have acquired wasteful, others economical habits of metabolism. Some infants digest and absorb all the food they consume, others for various reasons may be unable either to digest or to absorb. Further than this, the conditions of the environment will make considerable differences in the amount of food required; for instance, cold will stimulate metabolism and create demand for heat, and various meteorological conditions, such as thunderstorms for instance, may so upset the nervous equilibrium of the child that considerable disturbances of metabolism may result. Dr P. Lavialle [1] has shown by some extremely interesting calorimetric experiments that different articles of clothing worn by infants effect variations in the loss of heat by radiation and conduction, and therefore introduce variations in the amount of food required for keeping up the body temperature. He showed for instance that by the wearing of a simple bonnet which covered the head there was a saving of heat in the 24 hours equivalent to 65 calories, or some 3 oz. of milk, and so on with respect to other garments. Pursuing this argument to its logical conclusion it might be thought that if an infant could be clothed sufficiently there would be no loss of heat and no requirement of food on this count—in other words, that its basic metabolism could be reduced to zero. This, however, is not strictly true, for heat will always be lost from the lung surface by the heating of the air inspired, and further, mechanical work must always be performed in the acts of respiration, circulation, and so on, even if the child does not cry or move its limbs; and in performing this work a considerable amount of heat will always be produced, which must be dissipated in some way or other, or else the temperature of the body would rise indefinitely. From the foregoing statements it is clear that the food requirements of infants will depend chiefly on the muscular movements performed and the general activity of the limbs, although there is a basal requirement for the performance of the functions of the body below which it is impossible to reduce the supply.

[1] Congrès National des Gouttes de Lait, ténu à Fécamp, Mai, 1912. *Report*, p. 79.

Those who have attempted to estimate the basal metabolism of infants by placing them in calorimeters, and measuring the heat produced during conditions of rest, seem to have forgotten that metabolism is enormously influenced by surface stimulation—*i.e.* by cold air, changes of temperature, surface evaporation, and so on. Professor Leonard Hill has shown how metabolism can be increased twofold by exposure to fresh air, on a balcony for instance, as compared to the metabolism in the shelter of four walls. Under normal circumstances infants do not live under conditions at all comparable to life in a calorimeter; and hence calorimeter estimations are not applicable to them.

The food requirements of the body are conveniently stated in calories. One calorie is the amount of heat required to raise one kilogramme of water one degree Centigrade. One calorie is consumed in performing 2975 ft. lb. or 425 kilogramme-metres of work. Since every individual must perform a certain number of ft. lb. of work he must receive food of an equivalent caloric value, and since the human engine can only utilise one-sixth of the total caloric value of food in doing work, it must consume six times the theoretical amount required. On an average the number of calories required by infants has been estimated to be about 50 calories per pound of body weight during the first six months of life, between six months and twelve months the requirements are gradually reduced to about 45 calories per pound weight. Although these figures constitute a good point of departure, and a goal to aim at in regulating the dietary, they must be modified by special conditions, such as the degree of activity and the general efficiency of the child as a working machine, the character of the clothing, the external conditions, such as temperature, ventilation, movement by air, and so on.

THE EMPIRICAL METHOD OF ESTIMATING THE QUANTITATIVE FOOD REQUIREMENTS

If a large number of breast-fed infants are kept under observation and the amount of food consumed by each in the 24 hours is estimated by the "test feed," we can arrive at the average amount of milk consumed at various ages and under various conditions. This has been done in the case of a certain number of infants, and the results in a measure confirm the estimates obtained by the calorimetric method. Although in most cases these average estimates can be relied upon as a basis for comparison, nevertheless, since each infant is a law unto itself, it is not safe to rely upon them without checking the effects by individual observation.

Infant feeding would be quite easy if we were able to judge by immediate results whether the food was accurately adjusted to the baby's requirements or not. The results of under-feeding or over-feeding are not, as a rule, immediate: they are remote, and manifest themselves only after a more or less prolonged interval. The physiological or empirical method of feeding infants is largely based on an accurate and close observation of the infant himself. It is the chief aim of this method to refer symptoms to their true causes, to watch for and observe every reaction of the infant which can in any way throw light on the influences of the food supplied, and to modify the supply in accordance with the results observed. In trying to adjust the food to the physiological needs of the infant, there is always some danger of modifying the infant to the food instead of adapting the food to the infant. How are we to judge by observation of the reactions whether any particular dietary applied in the case of any individual infant is or is not quantitatively adjusted to the physiological requirements ? Let us assume that the particular infant is in the first case supplied with a dietary which conforms to the theoretical requirements of an infant of corresponding age and weight, how are we to judge whether this diet, which is theoretically correct, is really correct in this particular case ? If the diet is unsuitable in quantity the reaction of the infant ought to indicate whether the fault is one of excess or one of deficiency. The reactions which will guide us may be connected with the functions of digestion, absorption, internal metabolism or excretion. Any one of these sets of functions may show by the special reactions the character of the fault. If, for instance, the food is excessive the digestive system may demonstrate the fact by rejecting the food by vomiting, by diarrhœa, or by some other symptom indicative of some strain imposed on the digestive processes, such, for instance, as flatulence or colic. Such evidence does not necessarily prove that the diet is excessive from the point of view of the energy requirements, it only indicates that the food is unsuitable from the point of view of the digestive functions. If may indeed be unsuitable from a qualitative point of view as well as from a quantitative one. If more food is consumed than can be absorbed, even though it be perfectly digested, evidence of the fact is usually to be found in the stools; for instance, large, fatty or soapy stools suggest, if they do not prove, that more fat is being consumed than can be utilised by the tissues or can be absorbed from the digestive tract. Quite a different group of symptoms are manifested when the food is excessive from a nutritional point of view. If the digestive functions are well developed, or over-developed, larger quantities of food than are required for purely nutritional purposes can be digested without giving rise to any symptoms of indigestion. The indications of excessive nutrition are unfortunately long deferred, so that they may very easily escape detection at the time, and ultimately be referred to wrong causes. Since food is only required for the four purposes of nutrition—namely, for growth and repair, for heat production, energy production and the elaboration of secretions—if food over and above these requirements is given, digested and absorbed, the excess must be disposed of in some manner which will not be advantageous or physiological. Speaking quite generally, food is absorbed in the form of protein, sugar and fat, and as such circulates in the blood, affording the necessary raw material for the activities of the body. There are, however, many natural provisions to prevent the quantity of any one of these circulating constituents of the blood from accumulating beyond a certain degree of concentration. When the blood becomes saturated with any one of these elements beyond the fixed limit of concentration, certain processes are called into play for preventing any further degree of concentration. To a very large extent the blood refuses to take up or absorb from the intestine further supplies of any particular element in respect of which it has become saturated, but quite apart from this cutting off of the supply, there are various methods of reducing the degree of concentration already existing in the blood. For instance, the presence of an excess of sugar in the blood is prevented by storage in the tissues in the form of glycogen or fat, into which sugar is readily converted. A constant percentage of the protein content is maintained by the expulsion of excess by various means. There is no provision for the laying up of reserves of protein in the tissues. Albumin can be removed, in extreme cases, in an unaltered form in the urine; on the other hand the more usual method is by oxidation or combustion into urea, ammonium combinations, carbonic acid and water. In this manner it can be eliminated apart from any serious straining of the excretory functions. Under certain conditions, when the excess of protein is more than can be got rid of by complete oxidation processes such as those described, and insufficient to require removal in the urine without change, a third method is resorted to—namely, incomplete combustion—a convenient process for the reason that it can be quickly effected, uses up less oxygen and produces less heat in the operation, but it entails considerable strains in other directions owing to the difficulty of removing from the body the large molecular bodies which are produced. These acid bodies must necessarily be neutralised at the expense of valuable mineral bases. It is possible by accurate clinical means of observation to recognise when these methods for the removal of excess are brought into play. Certain symptoms are produced which enable a careful observer to detect the presence of excess, and in some cases the precise element which is superabundant. With efficient mechanisms the infant can dispose of considerable excess without suffering any serious impairment of health, but the less the degree of strain on the various organs concerned the better will it be for the body as a whole, and the better the expectation of prolonged life and good health. With defective or diseased organs strains which might otherwise cause no inconvenience may lead to serious symptoms. This is noticeably so in the case of the kidneys, which at all times have to sustain much of the work of eliminating from the body the products of metabolism. In settling, therefore, whether any particular diet is correctly adjusted as regards quantity to the physiological requirements, we rely on clinical evidence of strains imposed on the mechanisms which dispose of excess. The following are some of the more common clinical evidences which prove that mechanisms are being brought into play for the disposal of an excess. Evidence of strain on the storage capacities of the body is shown by too rapid increments in body weight, by undue distension and hardness of the skin and subcutaneous tissues, and by pronounced mottling of the skin. Evidence of the elimination of unchanged food elements is afforded by (1) sugar, albumin and excess of mucus in the urine; (2) excessive mucous discharges from mucous surfaces—in other words, by catarrhal wheezings, snufflings, snortings and secretions from the nose and throat; (3) excessive secretions of the sebaceous and sweat glands, eczematous oozings and greasy skin. Evidence of excessive combustion of food elements to their normal end products is shown by the production of much heat, apart from the taking of much exercise, and by its dissipation by flushing of the cheeks and other exposed parts of the body, by sweating, panting, rapid breathing and by increased output of carbonic acid in the expired air. Evidence of incomplete oxidation is shown by the symptoms associated with depletion of mineral elements from the body and other symptoms connected with a chronic condition of acidosis—namely, those of soft bones, anæmia, hyperactivity of the blood-forming centres in bone (enlarged epiphyses), irritability of the nervous system, the presence in the urine and fæces of an excess of those mineral elements which are required for the neutralisation of acid radicles, such as ammonium, calcium, potassium, sodium, magnesium, iron, etc., a high specific gravity and an ammoniacal condition of the urine, the deposition of excess of urates on its acidification and standing, and by all those other symptoms and manifestations which are recognised as being the usual accompaniments of the rachitic state.

The empirical method of estimating whether in any individual case a given dietary is excessive, depends on the observation of symptoms which point to the calling into play of mechanisms for disposing of any surplus.

THE SYMPTOMS DEPENDING ON A DEFICIENCY

It is more difficult to detect a deficiency in the quantity of the food supplied. Cases not infrequently occur in which infants have continued in apparent health for many months in succession on the most exiguous rations. Within my own personal experience I have come across cases in which breast-fed infants, three or four months old, have not only continued to exist, but even apparently to thrive, on as small an allowance as 6-10 oz. of breast milk in the 24 hours. I have also met with cases of artificial feeding in which infants have apparently progressed normally on as little as 1 oz. of condensed milk in the 24 hours, the equivalent of about 5 oz. of breast milk, with a caloric value of 100 instead of the 400 or 500 calories required on theoretical grounds. If breast-fed or bottle-fed infants can remain in health in spite of the fact that the food allowance is markedly below the normal for the age and weight, it is quite clear that the basal metabolism has been reduced to a degree which must be regarded as a real danger. If infants are kept artificially warm, and display no spontaneous movements, it is conceivable that the metabolic processes can be reduced to the low level of a hibernating animal. The grave disadvantage of starvation of this kind and a reduction of the metabolic processes to a low level is that habits of slow metabolism may thereby be acquired which give the infant very poor reserve powers in the face of unusual strains. The general effect of relative starvation on the digestive functions is under-development of all the organs and functions concerned. The stomach is small, the intestines are short and the liver and spleen are under-developed. The infant is seldom sick or troubled with flatulence or colic, while the motions are, as a rule, small and constipated, although in certain cases a tiresome mucous diarrhœa supervenes. In fact the whole condition of the digestive tract appears, as a rule, to be satisfactory and normal. It is only when its reserve powers are put to the test that its inefficiency and intrinsic weaknesses are revealed. The gastric and intestinal functions break down at the weakest point. Vomiting, diarrhœa or flatulent distension occurs according to the situation of the weak spot. As far as absorption is concerned there is no evidence of starvation, beyond the fact that the stools are usually small and free from fat and soap. There will naturally be no storage of fat, the weight will be below normal, growth will be slow, but as a rule the infant does not look ill and the skin is not dry and inelastic, nor the complexion muddy, as in cases of intestinal disturbance. Evidences of suppressed metabolic activity can be detected by examination and analysis of the urine. The total solid excretion is low both as regards its mineral and organic content. In fact most of the evidences of under-feeding are of a negative character unless starvation happens to follow after a period of normal feeding or over-feeding; in such cases hunger, restlessness and sleeplessness may give expression to the unsatisfied cravings of the tissues for food. Any dietaries seriously below the normal estimated standard, even though no immediate symptoms supervene, call for correction, for the reason that they imply modification and depression of the metabolic functions. These necessarily involve lowering of the reserve powers and incapacity to deal with the natural emergencies which will arise as the child grows older.

RELATIVE EXCESS AND RELATIVE DEFICIENCY

It will be clear from the above statements that when we speak of excess or deficiency in connection with the supply of food, we mean relative and not absolute excess or deficiency. The same diet may be excessive for one child and insufficient for another of exactly the same age and weight, and naturally the same is true for older individuals as well as infants. Take, for instance, the case of a navvy, a class of man who does particularly hard work. Such an individual may require food of the value of 4000 to 5000 calories to enable him to do his work without drawing on his reserves, if such a man were suddenly to take to a sedentary occupation, such as that of a clerk, for instance, his physiological food requirements might drop to 2600 calories. If he still continued to pursue his former dietetic habits in his new occupation, and continued to consume food of the value of 4000 calories, his diet would be excessive to the extent of 1400 calories, and his mechanism for disposing of excess would be greatly embarrassed in so doing. In other words his diet, which formerly might have been physiologically correct, has now become relatively excessive.

CHAPTER II

FOOD—QUALITATIVE REQUIREMENTS

The Ternary Elements of Food—Proteins, Carbohydrates and Fats—Their Uses and Physiological "Balance"—The Vitamines—Mineral Elements—Lecithin—Extractives and other accessory Food Factors

The human body may be compared to a mechanical engine which requires a certain amount of fuel in order that it may perform its work; in the previous section we had under consideration the actual amount of fuel or food required by the human engine working under various conditions. In this section it is proposed to discuss not the quantity but the quality of the food required.

In the case of mechanical engines different sorts of fuel are required by those of different type: one must have coal, another petrol, another gas, and so on, and although in certain cases alternatives in the choice of fuel are permissible, no engine works at its maximum of efficiency unless the right kind of fuel is used. It is the same with the human engine, and indeed with all animal engines—they all work best and most economically if they are provided with the special variety or varieties for which they are hereditarily or by individual experiences adapted. A herbivorous animal will perform its organic functions better on a diet of grass and vegetable food, for which its organs of digestion and its metabolic habits are specially adapted, than on one for instance of meat, for which the corresponding organs of a carnivorous animal are by nature designed. As an omnivorous animal, the human being carries on his organic functions most efficiently on a mixed diet; although he can, under stress of circumstances, obtain his energy from meat, from green vegetables, from cereals or from fruit exclusively. The science of dietetics is chiefly concerned with providing the best combinations.

Speaking quite generally, it may be stated that different classes of fuel are most economically employed for different organic functions—for instance, the best fuel for doing actual muscular work is carbohydrate food, such as sugar or starch, while fat is the most economical fuel for producing heat, and protein foods quite essential for growth, the repair of tissues, and for the elaboration of the secretions. In the last-mentioned uses of food it must be remembered that the human engine differs from the mechanical engine in that it is able to utilise the fuel with which its furnaces are stoked for the manufacture of all necessary lubricating materials, as well as all those elements which are necessary for the growth and repair of its parts.

A diet which is capable of affording all the energy required for the performance of all the organic functions may be a very wasteful and extravagant one when regarded from the point of view of suitability in other respects. For instance, it may too severely tax the digestive, metabolic or excretory functions. A diet consisting of a pure protein may afford exactly the same number of calories as one consisting of a corresponding weight of sugar, and yet it would be most uneconomical in a physiological sense to provide a pure protein diet for an individual who has to perform much laborious work. In this case the want of economy depends on the great wear and tear which would be occasioned to the kidneys in the excretion of a great amount of urea and other nitrogenous end products. On the other hand, if the diet consists under such circumstances mainly of carbohydrate material, the waste products—viz. carbonic acid and water—can be eliminated from the body without any concomitant strain on the excretory organs. Similar advantage accrues by the use of fat or oils when the generation of much heat by the internal furnaces is required owing to environmental cold; weight for weight, the caloric value of fats is more than twice that of either proteins or carbohydrates, so that with a given output of heat twice as much protein or carbohydrate food would have to be consumed as would be necessary if fat were substituted.

It is extremely interesting to observe how these principles apply to the feeding of young mammals. The chemical composition of the milk of each species, as far as the combination of proteins, carbohydrates and fats is concerned, is accurately adapted to the requirements of the offspring. If the young animal develops rapidly its mother's milk contains a high proportion of protein; if its natural environment is cold the milk has a high content of fat, while the carbohydrate percentage is sufficient to bring up the caloric value of the milk to the required value. An examination of the table on page 229 will show how accurately these principles apply. It will be noticed, for instance, that a young rabbit, which doubles its weight in 6 days, is provided with 15% of protein in its milk, whereas the infant, who doubles his weight in 180 days, receives only 1·5%. The young of the reindeer, whale and dolphin, who have to contend with an extremely cold environment, are supplied with milks containing 17%, 20% and 43% of fat respectively, whereas the human baby receives only 3·7%.

It is unnecessary to labour this point further than to emphasise once more that the best combinations of fuel can only be provided by taking into consideration the special requirements of the consumer.

Without trusting too much to the infallibility of nature, it may be assumed that the proportions of the three food constituents of human milk are more or less accurately adjusted to the requirements of the human infant. If this is so, it is obvious that undiluted and unmodified cow's milk cannot be a sound or physiological dietary for the young baby.

The infant can undoubtedly survive on a diet of unmodified cow's milk, in the same way that a calf would in all probability also survive on a diet of human milk, but such substitutions can only be made by doing violence to the digestive, metabolic and excretory functions of the young animal on whom such experiments are made.

As far then as the mere supply to the infant of energy-producing foodstuffs is concerned, it may be stated in general terms that this should be afforded by representatives of the three main elements—viz. proteins, carbohydrates and fats—in the same relative percentage combinations as exist in human milk—that is to say, all substitute foods should be made up to the standard of breast milk.

It may further be pointed out that there is no logical reason for assuming that any advantage accrues by altering the relative proportions of these elements at any period of infancy. Under natural conditions of breast feeding the food, so far from becoming stronger with respect to its protein content, actually tends to become weaker as the infant grows older. In artificial feeding it has become an established practice in this country, in those cases in which modified cow's milk is employed, to make the dilutions stronger and stronger, until finally "whole" milk is provided. This practice is most indefensible. If the larger percentages are indicated in those cases in which growth is more rapid, and the smaller when growth is less rapid, it follows that a reversal of the usual practice would be more in keeping with the physiological requirements. Further, if sugar or other carbohydrate elements are most economically utilised for the purposes of muscular work, it would seem an additional argument for providing a larger ration of this element as the infant grows older and becomes more active, which is exactly the reverse of the ordinary practice, which is to increase the relative proportion of the protein at the expense of the sugar.

It has already been stated that the fuel of the human machine, unlike that of the mechanical engine, must contain material for the enlargement and repair of its parts, and for the elaboration of lubricants. In a complete food, therefore, must be included certain accessory factors which are necessary for these purposes. These factors are, under normal conditions, present in sufficient quantity in the milk of each species of mammal; it does not, however, follow that, because they are present in sufficient quantity in any particular kind of milk which is intended by nature for the nourishment of one particular kind of animal, they are present in sufficient amount for the nourishment of another kind of animal, especially when that milk has been diluted with water.

Our knowledge with respect to those particular accessory food factors to which the name vitamines has been applied has advanced greatly in recent years.

Vitamines are bodies which appear to be attached in some loose manner to vegetable proteids, to become detached, and sometimes even to be partially destroyed, when the fresh foods in which they exist are cooked, digested or submitted to severe mechanical manipulation.

The part these vitamines play in the metabolic processes of the body is equally obscure. They seem in some way to produce harmonious relationships between the food consumed and the tissue cells which make use of them. Their action may indeed be allied to that of the hormones which activate cell metabolism. Without them cell activities are incomplete, and certain more or less definite symptoms develop sooner or later.

Three independent vitamines, or possibly groups of vitamines, are now recognised to have an important bearing on the nutritional processes of the body. They are as follows :—

(1) The fat-soluble "A" factor, or growth vitamine.

(2) The water-soluble "B" factor, or anti-neuritic vitamine.

(3) The water-soluble "C" factor, or anti-scorbutic vitamine.

The Fat-Soluble "A" Factor.—This vitamine is present in green leaves and the embryos of certain cereals, probably in combination or attached to vegetable proteids. When liberated from these combinations, by cooking, digestion or other means, they become insoluble in water, but remain soluble in fats, in fact they behave, as regards solubility, very much like lipoids. They are probably absorbed from the intestines in company with fats. Young and growing animals apparently require a certain quantity of this accessory factor for normal growth and development, and when deprived of it show impairment of growth, and according to some authorities they become less resistant to infective disease. It exists normally in most animal fats, in which, or attached to which, it is probably stored after absorption from the intestinal tract. Hence infants fed on cow's or breast milk which contains a full complement of cream are in no danger of suffering from the particular "deficiency disease" which is due to deprivation of this vitamine. It is claimed, however, that nursing mothers, and indeed cows as well, may provide milks deficient in this fat-soluble factor if their diet has been noticeably poor in green or other foodstuffs which contain this body. Thus the milk of cows during the winter months, when the food chiefly consists of oilcake, swedes and dry fodder, may itself be poorly provided as regards the "A" factor, and so may the milk of nursing mothers whose diet is deficient in green vegetables. Cod-liver oil is rich in this vitamine, whereas linseed, nut and olive oils contain little or none.

The symptoms in infants due to deprivation of the fat-soluble "A" factor have not been so accurately studied as those arising in young animals under similar conditions. Puppies soon become debilitated, growth ceases, and certain bony changes take place comparable to those seen in rickets.

The Water-Soluble "B" Factor.—This element, alternatively known as the anti-beri-beri vitamine, is found in the cortical portion of cereal grains, such as rice, wheat and maize. It is in part or entirely removed in the refining processes to which such cereals are usually submitted. It appears that there exists some quantitative relationship between the amount of these cereals consumed and the amount of the vitamine which is necessary to prevent the development of the characteristic symptoms of the disease beri-beri or of allied neuritic disorders. The larger the amount of the cereal consumed, the larger must be the quantity of vitamine supplied. This factor probably plays an unimportant part among the nutritional disorders of infancy, except in those cases in which the diet largely consists of patent and proprietary foods derived from refined cereals.

It is quite possible that the symptom-complex of some of the "deficiency diseases" developing in infants represents a combination of results due to the privation of more than one accessory food-factor.[1]

The Water-Soluble "C" Factor.—This anti-scorbutic element appears to be essential for all growing animals. It exists under natural conditions chiefly in the juices of fresh vegetables and fruits,[2] and in a lesser degree in animal juices, such as milk and muscle-plasma. This vitamine is gradually destroyed when exposed to temperatures above 50° C. and it is rapidly de-activated when heated above 80° C. It quickly deteriorates in the presence of alkalies, even in the cold, but it is relatively stable to acids below 50° C. The symptoms caused by want of this vitamine are characteristic. They are fully described on page 353.

Although this factor is present in all fresh milks its efficiency becomes impaired in greater or less degree when such milks are boiled, pasteurised, condensed or dried. It is also possible that the deficiency may reach a dangerous level when cow's milk is greatly diluted with water.

Mineral Elements.—Both organic and inorganic salts are necessary for normal nutrition, and they must be supplied to the growing organism not only in adequate amount, but in certain more or less definite combinations. The uses to which mineral matter is put in the body are as follows :—

1. For the purposes of tissue formation. A large amount of calcium and phosphorus is required for bone formation, iron for hæmoglobin, magnesium and phosphorus for nerve cells, etc.
2. For the neutralisation of acid bodies, and for their transport

[1] Robert M'Carrison. *B. M. J.*, 12th July 1919, p. 36.
[2] J. C. Drummond. *Lancet*, 12th October 1918, p. 482.

out of the body. All those conditions which lead to an increased production of acids also intensify the demand for such "carriers," and in this service many mineral bases may be lost to the body in the urine and fæces. Since the amount of acids produced in the system depends partly on the nature of the food, and partly on the uses to which it is applied, it is clear that the physiological requirement for mineral matter is not a fixed and unalterable quantity. Nutrition at once languishes if the normal alkali reserves are overdrawn.

3. For the elaboration of secretions. Sodium chloride is required for the manufacture of the hydrochloric acid in gastric juice, and various alkaline salts are required for the pancreatic, salivary, biliary and mucous secretions.

The total mineral content of breast milk is much less than that of cow's milk; in the former the percentage is 0·18-0·28, while in cow's milk it is 0·6-1·0. Relatively, there is more potassium in breast milk than there is in cow's milk, while there is less sodium, phosphorus and calcium, but more magnesium, iron and chlorine, as may be seen from the following table, which gives the percentage of the various mineral elements in the ash contained in the two varieties of milk :—

Table 2

Mineral	Breast Milk (Authority Schloss)	Cow's Milk (Authority: Schloss)
K_2O	28·77	24·74
Na_2O	10·26	10·79
CaO	20·44	21·35
MgO	4·66	2·71
Fe_2O_3	[0·25]	0·04–0·4
P_2O_5	22·0	29·54
Cl	16·61	13·63

Whether there is any teleological significance in these discrepancies between the mineral content of different varieties of milk is doubtful, but it appears abundantly plain that breast milk contains an adequate supply of all mineral material, with the exception perhaps of iron towards the end of lactation. Cow's milk, even when diluted to half its strength, contains an adequate amount of all mineral m. terial excepting iron.

When substitutes other than cow's milk are employed for the exclusive feeding of infants, as, for instance, when patent foods are given, care must be taken that there is no deficiency of any mineral material. Some of the cereal preparations contain a noticeably small amount. The figures given in the above table constitute a good standard for the mineral requirements of infants.

It is claimed that mineral matter in organic combination is better assimilated than in the form of inorganic salts. Why this should be so is not altogether plain, for such combinations are liable, in part at least, to be broken down in the stomach by hydrochloric acid. It is probable, however, that easily oxidised salts, such as the lactates and citrates, are of service in the neutralisation of acid bodies formed in the blood or tissues. Such salts readily yield up their metallic bases, while the acid radicals are quickly oxidised to carbonic acid and water, both of which can be removed from the body without further mineral depletion.

Speaking quite generally, it may be stated that both breast milk and cow's-milk modifications contain sufficient ash for the purposes of normal nutrition. It is only when large calls are made upon mineral bases for the neutralisation of acid bodies, as in conditions of acidosis from whatsoever cause arising (see p. 341), that supplementary mineral supplies are called for. I cannot help thinking that some of the benefits arising from the employment of citrated milk depend in certain cases on this neutralising power.

In their animal experiments with synthetic foods M'Collum and Davis [1] used the following mixed salts :—

$NaCl$	5·19	parts
$MgSO_4$	7·98	,,
NaH_2PO_4	10·41	,,
K_2HPO_4	28·62	,,
$CaH_4(PO_4)_2$	16·20	,,
Ca. Lactate	39·00	,,
Ferric Citrate . . .	3·54	,,
Iodine	a trace	

No doubt a somewhat similar formula would serve for the preparation of mixed salts for the feeding of babies and young children.

Lecithin.—Lecithin, or perhaps, more correctly speaking, the

[1] *Journal Biological Chemistry*, 1915, xx. 161.

lecithin bodies, must be regarded as accessory food factors of some importance. They are connected in some way with the regulation of the rate of growth, and may have some possible relationship with the fat-soluble " A " factor.

Although it has not been definitely proved, there is good reason to believe that cholesterol has an antagonistic action to lecithin, and that harmonious growth is dependent in some measure on equilibrium between these two bodies. Cholesterol exists in small amount in normal milk. Lecithin exists normally in breast milk to the extent of ·058%, and in cow's milk to the extent of ·048%. In view of the importance of lecithin in the animal economy, it must be remembered that in cow's-milk dilutions its percentage may be reduced below the margin of safety. If necessary it can be independently supplied in the form of yolk of egg, or in one or other of the many available pharmaceutical preparations.

Extractives.—Various extractives are found in milk, their quality and quantity being, to a certain extent, dependent on the diet. Whether they play an important rôle or not in the nutrition of the nursling has not been proved, but from my own personal observations I have come to the conclusion that when infants are artificially fed on cow's milk their nutrition is improved by the addition of a small quantity of meat extractives, such as are contained in ordinary bouillon.

CHAPTER III

DIGESTION

The Meaning of Digestion—The Digestive Functions—Gastric Digestion of Proteins, Fats and Carbohydrates—The Motor Functions of the Stomach—The Development of the Stomach—Gastric Capacity—Gastric Motility—Action of Sphincters—Intestinal Digestion—General Description—Digestive Functions Proper—The Digestion of Proteins, Fats, Carbohydrates and Cellulose—Dates at which the Digestive Ferments appear—Influence of Bacteria on Intestinal Digestion—The Motor Functions of the Bowel—The Ileo-Cæcal Sphincter—The Motor Functions of the Colon—Defæcation

DIGESTION

In the same manner that in the mechanical engine the fuel must be supplied in a suitably prepared form for economical combustion, so in the animal body must the food undergo certain preliminary manipulations before it can be utilised to the full extent of its value.

If coal has to be broken up into suitable fragments by the stoker, if gas must be generated by a special process of distillation, and if oils must be purified by the refiner before they can be utilised by engines of special type, so must food be prepared and disintegrated by the processes of cooking, mastication and digestion before it can be consumed in the organic furnaces of the animal body.

Speaking generally, the human engine can burn three types of fuel—viz. proteins, carbohydrates and fats—but each must be presented in a special and simplified form. For instance, the tissues cannot, without alteration, make use of a protein body such as caseinogen. This and every other form of protein must first be reduced to its simplest form, and then out of its fragments must be reconstructed a new protein body of the required type. Whenever foreign proteins are subjected to the catalytic action of the digestive enzymes in the stomach and intestines they are broken up into their constituent elements, in the same way that a word may be broken up into its component letters, and out of these elementary fragments a new protein may be synthesized, just as a new word may be reconstructed out of the original letters. For instance, by the disintegration of caseinogen into its component parts (polypeptides and peptides), it may be reduced to a condition out of which a new protein body, such as the serum-albumin of the blood, may be reconstructed. In a manner quite comparable, the word Lactalbumin may be broken up into its component letters, L, A, C, T, A, L, B, U, M, I, N, and rearranged so as to constitute the word Albulactmin, or, what is perhaps more analogous to the process which actually takes place, to form the word Albulactin, leaving out the superfluous letter "m." In the reconstruction of new organic bodies out of the disintegrated fragments of some other body there is often waste of some unutilised fragment or fragments.

What takes place in connection with the digestion and reconstruction of protein bodies also occurs in a qualified degree in the case of carbohydrates and fats.

Efficient digestion, therefore, depends on a capacity to disintegrate the comparatively complicated molecules of the crude material commonly consumed as food into relatively simple fragments, whilst absorption and assimilation are concerned with the passage of these elementary bodies into the blood, and with their synthesis into new bodies of the particular type required. At birth the infant's capacity to carry out these complicated operations is extremely limited, and this power is only acquired slowly by experience and practice. For instance, during early infancy the digestive juices do not contain an adequate quantity of the diastatic ferments which are required for the hydrolysis of starch into sugar, neither can foods such as nuts or cheese, which require preliminary mastication before they can be attacked by the digestive ferments, be utilised as foods prior to the development of the teeth.

If any variety of food be supplied to infants before the necessary functions of digestion have been adequately evolved, or if at any period of life food unsuitable as regards quantity or quality be given, it will undergo putrefactive or fermentative fragmentation under the influence of bacterial activity. The products of such disintegration cannot be utilised for the synthesis of new bodies of the required type. If they are absorbed at all they act as foreign and poisonous substances. For instance, if starchy food be given to an infant before its starch-digesting functions are developed it will be attacked by bacteria and converted into acetic, butyric and other acids, which, so far from being of physiological use, act as irritants of the bowel, or, if absorbed, as poisons of the system. The physiological feeding of infants is intimately concerned with the provision of food which conforms to the existing digestive capacities, and which is also of the appropriate character to elicit and develop potential capacities which might otherwise lie latent. Straining of the digestive mechanisms leads either to disorganisation of function or to compensatory hypertrophy, which may at a later date introduce undesirable complications.

The digestive functions are, properly speaking, of two kinds: firstly, those concerned with the resolution of food into its simple components; secondly, those connected with its transport through the alimentary tract, commonly called the "motor" functions.

THE DIGESTIVE FUNCTIONS

The digestion of food takes place partly in the mouth, partly in the stomach and partly in the intestines.

Salivary Digestion.—As far as the young infant is concerned, oral digestion by saliva is of negligible importance, and at no period of life has it any serious bearing on the dissolution of food. The main function of the buccal secretions are :

(1) To keep the mouth moist and alkaline in reaction ;
(2) To cleanse the teeth by irrigation ;
(3) To lubricate food and enable it to be swallowed in the form of a slippery bolus.

Contrary to popular belief, the salivary glands are active from birth and contain a small quantity of a diastatic ferment—ptyalin. During teething the reflex irritation lends a great impetus to the functional activity of these glands.

Gastric Digestion.—The stomach serves several important functions in the series of events which are included under the general term "digestion." These may be shortly stated as follows :—

(1) It acts as a reservoir for food, and regulates the rate of flow into the intestines.
(2) It advances or completes the liquefaction of solids, the preliminary stages of which in all except young infants take place in the mouth.
(3) It sterilises, in greater or lesser degree, the food before it enters the intestines.

These functions may be now considered briefly. The regulation of the rate of flow into the intestines is one of the most important of the motor functions of the digestive tract, and will be discussed fully in a later section. The liquefaction of solid food is also largely dependent on another motor function of the stomach, which will be referred to in an independent section; it may, however, be mentioned that even in early infancy this function is necessitated by the coagulation of the natural liquid food which nurslings consume. This coagulation has an important teleological significance, for it represents a natural means of training or educating the stomach to deal with solid food during a period of life when, for obvious reasons, liquid food can alone be swallowed.

The digestion of food in the stomach is mainly concerned with the resolution of complex proteid bodies into comparatively simple substances of the nature of albumoses and peptones, all of which are soluble. The process of cleavage of proteids does not proceed beyond this point in the stomach, although later on in the intestines fragmentation is carried to the final stages of amido-acids.

The preliminary resolution of proteids is effected by the combined actions of pepsin and hydrochloric acid. In infants the main proteid which calls for resolution into albumoses and peptones is caseinogen, though to a lesser extent the albumins—lactalbumin and lactoglobulin—have also to be dealt with. The fact that caseinogen first undergoes coagulation in the stomach before it is digested to the stage of albumoses and peptones, greatly complicates the problem of gastric digestion in infants.

The coagulation of caseinogen is effected by the action of the enzyme rennin acting in combination with an acid. Whether rennin is different from, or identical with, pepsin has not yet been determined; it is quite possible that there are many varieties of pepsin and that rennin is one special variety generated in the stomach when caseinogen is the proteid requiring digestion.

Rennin has been found in the stomach of infants on the first day of life, and pepsin has been extracted from the gastric mucous membrane of a five-months-old fœtus. Hydrochloric acid is secreted by the stomach of the youngest infants, but more often than not it cannot be detected in the free state owing to its ready combination with casein.

Lactic acid, which is commonly found in the stomach of infants fed on cow's milk, is due to the fermentation of milk-sugar. The digestion of proteids in the stomach is complicated by the fact that the caseinogen is in the first instance coagulated before it undergoes, in common with other proteid bodies, resolution into albumoses and peptones. This preliminary coagulation has, as already stated, an educational significance, for the digestion of caseinogen can proceed quite normally—that is to say, without producing symptoms—when this stage of the process has been omitted.

The Preliminary Coagulation of Caseinogen in the Stomach.—Casein is a proteid with rather peculiar properties, for while on the one hand it can combine with acids, it can on the other also combine with metallic bases to form so-called caseinates—for instance, in union with hydrochloric acid it forms hydrochloride of casein, and in combination with sodium it forms sodium caseinate.

Calcium caseinate has the following formula—Ca_4 casein—and constitutes the form in which it exists normally in milk; it is soluble in neutral and alkaline media. When it is acted upon by rennin in acid or neutral solutions it is changed into an insoluble body called calcium paracaseinate. The reaction which occurs is represented by the following equation:—

$$Ca_4 \text{ casein} = Ca_2 \text{ paracaseinate} + Ca_2 \text{ paracaseinate.}$$

On the other hand, if calcium caseinate is changed into sodium caseinate by the addition of sodium citrate; the action of rennin is to split the sodium caseinate into two molecules of sodium paracaseinate, which are soluble in water. This is the explanation of the influence of citrate of sodium in inhibiting or delaying the coagulation of milk in the stomach. If, on the other hand, a soluble calcium salt, such as the chloride, is added to a citrated milk, in which all the casein exists in the form of sodium caseinate, a reconversion into calcium caseinate occurs, and the milk once again becomes coagulable by rennin, as is shown in the following equation:—

Sodium paracaseinate + calcium chloride = calcium paracaseinate (insoluble) + sodium chloride.

The next stage in the digestion of casein consists in the conversion of the paracaseinate, which has been formed by the interaction of rennin, into hydrochloride of casein, and this body is then further resolved into albumoses and peptones in the same manner as ordinary proteins, such as the soluble whey albumins.

Readers who are interested in the subject of the coagulation of milk are referred to Morse and Talbot's *Diseases of Nutrition and Infant Feeding*, p. 147. (Macmillan & Co., 1915.)

The Digestion of Fat in the Stomach.—The digestion of fat does not proceed far in the stomach, although the fat-splitting ferment "lipase," necessary for its resolution, is commonly found in the gastric contents of infants. The operation, as far as it goes, consists in the splitting of the neutral fats—olein, stearin, palmitin, etc.—into their components—glycerine and fatty acids.

The latter bodies then combine with available neutral bases to form soaps. This cleavage process only takes place in alkaline media and ceases when the reaction becomes acid; it is clear, therefore, that the normal acid reaction of the stomach must inhibit any considerable degree of fat digestion. In the stomach, however, certain preliminary stages of fat digestion take place which are antecedent to and necessary for complete digestion. They are as follows:—

(1) Fat is freed from a condition of emulsification and liberated in the form of droplets of oil of varying size.

(2) Fat is set free from the close combination in which it normally exists in muscle-fibres and connective tissue-cells.

As far as infants are concerned, fat is commonly consumed in the form of an emulsion—viz. as it exists in cream. The individual globules are encapsuled in a membrane of albumin or casein, so that the first stage of fat digestion is concerned with the solution of this membrane by the action of pepsin. In gastric digestion, however, the demulsification of fat is facilitated by the churning action of the stomach, a process quite analogous to that which occurs in the making of butter.

The churning of the butter fat and its subsequent splitting would proceed much further than is actually the case were it not that a considerable portion of the fat becomes caught in the meshes of the casein curds which are thrown down by the action of rennin and hydrochloric acid. Thus ensnared in the protecting substances of the coagulum, the fat is kept out of contact with the ferment lipase which would otherwise exert its catalytic action on it.

Excess of fat in the stomach delays the emptying of the gastric contents into the duodenum and thus may be a causative factor in the production of pyloric spasm.

The Digestion of Carbohydrates in the Stomach.—It has already been explained that the starch-splitting function of saliva is at no time an important one as far as the digestive processes in the mouth are concerned, it must now be emphasised that the whole process of the digestion of starch ceases in the stomach as soon as the gastric secretions become acid. If any form of starch is consumed the reaction of the stomach rapidly becomes acid, unless acid-fixing foods such as proteids or gelatine enter the stomach at the same time; in such an event the digestion of starch can continue for some further period.

In the infant the digestive function of ptyalin plays a still more insignificant rôle, while in breast feeding it plays no part at all. The function of ptyalin is to split insoluble starches into soluble and relatively simple molecules of maltose or malt-sugar.

The Digestion of Soluble Carbohydrates in the Stomach.—The digestion of soluble carbohydrates or sugars is not a normal function of the stomach. This operation is reserved for the intestines, where it proceeds under the influence of various enzymes contained in the succus entericus. Sugars, however, at times undergo abnormal cleavage in the stomach through the action of bacteria. For instance, milk-sugar may be split into lactic acid by one or other of the lactic-acid micro-organisms which are almost invariably swallowed in the milk. This conversion cannot be regarded as favourable to the digestive processes, nor in a physiological sense is it economical.

The Influence of Alkalies on Gastric Digestion.—The addition of lime water, sodium bicarbonate or other alkalies to milk tends to neutralise the hydrochloric acid which is normally secreted in the stomach, and thus delays, or prevents, the coagulation of caseinogen by rennin which occurs in acid media.

Although from the point of view of gastric digestion it may be of advantage in certain conditions of irritability of the stomach that this coagulation should be prevented or delayed, none the less it has a certain disadvantage in that it permits undigested and liquid milk to pass into the intestines in a condition in which the preliminary stages of cleavage have not taken place—in other words, the stomach is relieved at the expense of the intestines.

It has been claimed [1] that lime water and other alkalies only temporarily reduce the acidity of the gastric contents, and that in the final event more hydrochloric acid is secreted than would otherwise be the case—in other words, the habitual use of alkalies tends in the long run to lead to over-activity of the oxyntic glands in the gastric mucous membrane.

[1] Clark. *Amer. Jour. Med. Science,* May and June, 1919, pp. 672 and 872.

The Effect of Acids on Gastric Digestion.—The addition of hydrochloric acid promotes the coagulation of caseinogen and, at any rate at first, expedites the digestion of such proteid bodies, but ultimately it may have an unfavourable influence on the secretion of this acid, in the same way that alkalies operate in the contrary direction. In cases in which the gastric contents, as proved by the wash-out, remain permanently alkaline the independent administration of dilute hydrochloric acid may be indicated, for there are grounds for assuming that the pyloric reflex will not be normally elicited or developed unless the contents of the stomach become acid; further, in the absence of hydrochloric acid there is a serious danger of lactic acid fermentation taking place to an undue extent.

The Influence of Cereal Diluents on Gastric Digestion.—The advantages or disadvantages of the addition of such diluents to milk mixtures have long been a subject of controversy. As far as gastric digestion is concerned, decoctions of this kind have the advantage of hindering the formation of unduly heavy curds of casein, and in this way modify the coagulum of cow's milk and make it more like the clot normally thrown down by breast milk. Starch in solution affords a protective coating to the caseinogen, and prevents a too rapid reaction between the latter body and the ferment rennin. It has been proved that, from the latter point of view, quite weak decoctions of starch are no less efficacious than those which are stronger, and that there is no advantage in exceeding a strength of ·75%.

It is usually stated that young infants cannot digest starch, and therefore should not be allowed to consume cereal decoctions until their starch-digesting capacities have developed. As a matter of fact even new-born infants have some slight power of dealing with starches, and their capacity in this respect develops at a rate which is proportional to the exercise of the function. It is perfectly safe to give quite young infants minute quantities of starch from the tenth day onwards, and the quantity may be increased as the corresponding digestive function develops. My own personal opinion is that it is advantageous rather than otherwise to adopt from the very first the principle of this gradual development of the starch-digesting functions.

The Influence of Gelatine on Gastric Digestion.—Gelatine, in my opinion, is not as much used in infant feeding as its merits deserve. Its food value is not as great as albumin, but it is a valuable protein-sparer, and it has at the same time the great advantage of being a good acid-fixer. It acts very much in the same way as cereal decoctions in protecting the caseinogen of cow's milk from heavy coagulation. Gelatine may be employed in 2% solution as a diluent of milk or, better still, in the form of a gelatinous broth made from bones.

The Influence of Bacteria on Gastric Digestion.—In the adult, lactic acid appears to play a subordinate part in the digestion of proteids in that, to some extent, it activates pepsinogen, and can take the place of an equivalent of hydrochloric acid. In infants, however, and especially in breast-fed infants, its rôle is quite insignificant, and its presence is due to the fermentation of milk-sugar under the influence of bacteria. In bottle-fed infants this accidental fermentation is sometimes excessive, and of unfavourable augury for the reason that catarrhal inflammations of the gastric mucous membrane may thereby be set up. An adequate secretion of hydrochloric acid behaves prophylactically in preventing the undue development of bacteria in the stomach.

THE MOTOR FUNCTIONS OF THE STOMACH

The normal development of these functions has a most important influence on the whole series of digestive processes which occur in the alimentary canal. As already explained, the stomach acts as a reservoir to regulate the rate of flow of partially digested food (chyme) into the duodenum, the digestive functions proper being of quite a subordinate character. The motor functions include the reflex mechanisms which control the opening and closure of the pyloric and œsophageal sphincters as well as the peristaltic movements which carry out the churning movements and maintain the pressure necessary to ensure the evacuation of the gastric contents through the pylorus. The establishment of these mechanisms takes place quite early in the history of the new-born infant, but their normal development can be seriously interfered with by methods of feeding which stimulate too strongly the nerve mechanisms concerned.

The Development of the Stomach.—Before birth the shape of the stomach is more or less cylindrical, representing merely an enlargement of the simple tube which forms the general alimentary tract. Towards the end of fœtal life, and during the early days of infancy, the stomach assumes its characteristic shape, with a considerable bulging or sacculation to the left.

The anatomical relationships of the stomach in the early days of life are well adapted to facilitate the onward flow of liquid food

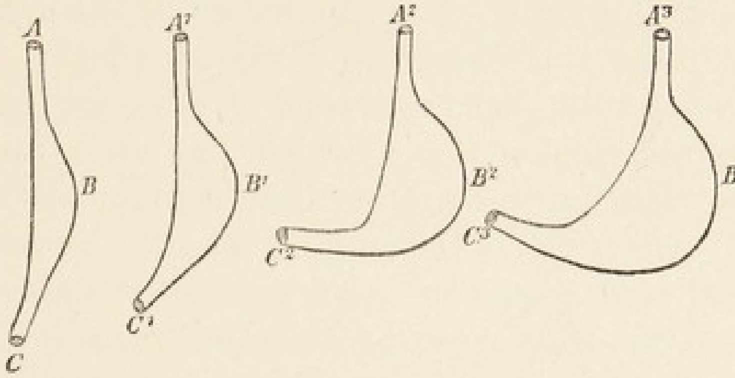

Fig. 3.—To show the successive stages of the development of the Fœtal Stomach. *A*, Œsophageal opening. *B*, Fundus. *C*, Pylorus.

towards the intestine; as the sacculated fundus develops, conditions are introduced which delay this flow, and promote the retention of food in the stomach for a sufficiently long period to enable the preliminary stages of digestion to proceed. The anatomical differences between the immature and fully developed stomach have an interesting significance from the point of view of function; in infancy the function of the stomach is mainly that of regulating flow, in later life it is largely digestive also.

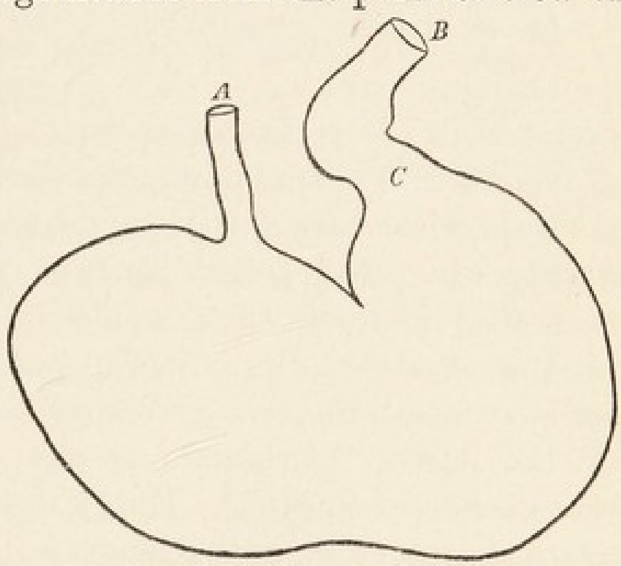

Fig. 4a.—Stomach of Horse. *A*, Œsophagus. *B*, Pylorus. *C*, Funnel-like approach to pylorus.

The position of the stomach alters as development proceeds; in the fœtus and young infant it runs more or less vertically from its œsophageal connection to its pyloric insertion. At the time of birth it has already assumed an inclination towards the right, and as development proceeds it possesses a more and more horizontal orientation. The position of the stomach at birth and its general alignment with the œsophagus makes explicable the facility with which infants vomit.

It is interesting to observe how in the horse's stomach the anatomical relationships, which are in direct contrast to those obtaining in the infant, make vomiting extremely difficult. There is an old tradition that if a horse is sick it dies. Although not absolutely true, this old belief has a sounder basis of fact than most fanciful tales of this kind. An examination of the accompanying diagram will make this clear. Any violent effort to expel the contents of a horse's stomach will tend to evacuate them through the large pyloric orifice "B," which has an infundibuliform approach "C" leading to it, rather than through the œsophageal opening "A" which enters the stomach at right angles by means of a straight narrow opening. The significance of this is quite obvious from the point of view of infant management; the act of vomiting which is so easily elicited is apt to become a fixed and inveterate habit if it is allowed to gain ascendancy during the first few days of life.

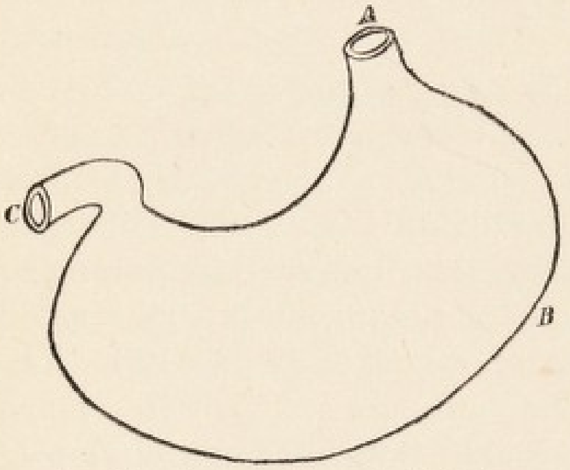

FIG. 4B.—Infant's Stomach at Birth.
A, Œsophagus. *B*, Fundus. *C*, Duodenum.

The Gastric Capacity.—According to Holt[1] the capacity of the stomach at birth is 1·2 oz. or 36 c.c. It increases gradually, until at six months it is nearly 6 oz. The measurements which are given on next page were made post-mortem, but they do not represent the true capacity during life. The actual amount that an infant can consume at a feed is more than would be expected from the capacity of the stomach after death, owing to the elasticity of the walls of the stomach and to the fact that a certain amount of the gastric contents can pass out of the stomach during the period of feeding. Holt's figures probably represent the average size of babies' stomachs, but in certain instances they greatly exceed his measurements, as can be proved by washing out and measuring the quantity of fluid which the viscera will contain. I have often found in cases of gastric dilatation that the amount of fluid the stomach is capable of holding is twice as great as that given in these tables.

[1] Holt, *Diseases of Infancy and Childhood*, p. 309. 1911.

TABLE 5

Table of Gastric Capacity in Infants

Age of infant	1 day	2 wks	4 wks	8 wks	12 wks	5–6 mths	10–11 mths
Capacity of stomach in oz.	1·2	1·5	2·0	3·37	4·5	5·75	8·14
Capacity of stomach in c.c.	36	42	60	100	132	172	244

In fact, from birth onwards, the capacity of the stomach is largely dependent on the amount of food which has been habitually consumed at a meal and also on conditions which promote stasis or catarrh of the stomach. For instance, dilatation rapidly takes place when excess of fat or other cause delays the emptying of the stomach.

Gastric Motility.—Within limits, the rate at which the stomach empties itself is largely dependent on the digestibility of the food and " in the case of infants " on the degree of dilution of the milk; the weaker the milk, the more rapid the flow. Conditions which prevent the coagulation of milk, such, for instance, as the addition of sodium citrate, promote the rate of flow also.

The movements of the stomach wall which determine the onward flow of the gastric content are of two kinds: (1) those which take place in the cardiac portion, and (2) those which take place in the pyloric section. The movements of the cardiac part consist of slow, rhythmical and peristaltic waves which induce currents in the direction of the pyloric section. This part of the stomach—*i.e.* the cardiac portion—acts as a reservoir in which the food lies more or less undisturbed except in so far as it is agitated by the aforementioned currents.

The pyloric portion affords the motive force which keeps up the pressure and facilitates the emptying of the stomach by a succession of forcible peristaltic waves, which follow one another in sequence in the direction of the pylorus. These movements can be clearly followed on the fluorescopic screen after a bismuth meal.

The Action of the Cardiac Sphincter.—The action of this sphincter is controlled by a very delicate reflex nervous mechanism. The muscle relaxes when food is carried down the œsophagus by a series of peristaltic waves which represent the consecutive contraction and relaxation of the muscular bands which encircle the tube. The relaxation of the sphincter muscle represents the final act of the completed peristaltic movement of swallowing; it is, in fact, a complicated co-ordinated reflex. This sphincter also takes part occasionally in another co-ordinated reflex in which the extrinsic muscles of the abdominal wall and the muscles of the diaphragm share when food is expelled from the stomach in vomiting or when wind is got rid of. In both of these acts the pressure within the stomach is raised to a considerable degree, and when at its height the sphincter is suddenly relaxed with the result that the contents of the stomach are forcibly ejected through the œsophageal opening. The establishment of these reflexes on normal lines is a matter of some importance; if the sphincter becomes hypertrophied or unduly sensitive, spasm may easily be provoked. The discharge of wind from the stomach is essential at times, but habits of vomiting or belching are most undesirable.

Spasm of the Cardiac Sphincter.—This, like pyloric spasm, shortly to be described, is by no means uncommon in infancy, and when it occurs it seriously interferes with the normal act of swallowing. Under such conditions milk or other fluids swallowed collect in the œsophagus instead of passing onwards into the stomach. The amount of food that can be taken is consequently limited, and subsequently it is slowly regurgitated into the mouth in a series of gulps to which the term rumination has been given. Hypertrophy of the sphincter occurs as the result of prolonged spasm much in the same way as in the case of hypertrophy of the pyloric sphincter, and the two are at times associated. Speaking generally, it may be stated that the nervous mechanism of this valve is very susceptible to educational influences; it may, through faulty methods of feeding, assume a perverted action.

The Action of the Pyloric Sphincter.—The mechanism of this valve is designed to regulate the rate of flow of the gastric contents into the duodenum. When, in the fully developed stomach, the contents of the so-called antrum pylori are acid, and in an adequately digested condition, the sphincter relaxes and allows the exit of a small quantity of chyme; the sphincter then closes and prevents any further flow, until such time as the chyme in the duodenum has been neutralised by the alkaline secretions it contains. In this way the delicate intestinal mucous membrane is protected from any excessive flooding with food which is beyond its digestive capacity. The rate of flow is thus automatically regulated.

The normal establishment of this delicate reflex probably takes place quite slowly in infants, but it is of extreme importance that it should be efficiently developed by exposure to the right sort of experiences. Spasm of the sphincter, with subsequent hypertrophy of its musculature, is liable to occur in young infants when for any reason the stomach retains its contents for a prolonged period—as, for instance, when excess of fat is consumed, or when unduly heavy curds of cow's milk are formed in the stomach.

Since an acid condition of the chyme is one of the conditions of relaxation of the sphincter, a strongly alkaline reaction in the food which is swallowed will delay the emptying of the stomach. Fluids, such as barley water, which have no power of absorbing acid, soon pass through the pylorus owing to the acidity, whereas proteins or gelatine, which can unite with acids, delay for some time the moment at which the required degree of acidity arrives for the opening of the pylorus. In quite young infants the presence of solid food, such as the coagulum formed in milk, appears to delay the exit of the stomach contents more markedly than an actually acid reaction. The rate of flow, therefore, will depend on the resultant influence of two factors: (1) the development of an acid reaction in the stomach during the course of digestion, and (2) the capacity of the intestinal juices to neutralise the acid chyme on its arrival in the duodenum.

From the point of view of spasm of the pyloric sphincter and hypertrophy of the muscles, the interesting suggestion has recently been made that overaction or uncompensated action of the adrenals may be a predisposing cause. With an excess of the internal secretions of these glands there is an increase of excitability of the non-striated muscular fibres of mechanisms of this kind and consequent tendency to spasm.

DIGESTION IN THE INTESTINES

General.—It has already been stated that the stomach subserves the function of a reservoir to a greater extent than that of an organ for digestive purposes proper, in that it regulates the admission of food to the intestines, where the main stages of digestion occur, at a rate which is adjusted to the existing functional capacities.

As in the case of the stomach, the digestive functions of the intestines are of two kinds: (1) those which are concerned with the resolution of food into the required form for absorption and assimilation; and (2) those which are concerned with its transport through the entire length of the intestines, with the final discharge of waste material in the form of fæces.

From all points of view, the digestive functions which take place in the intestines are of immense importance, and not least because, if food is not adequately digested in this section of the alimentary tract, either because it is excessive in amount, or refractory to the digestive processes, it almost necessarily undergoes improper fragmentation through the agency of bacteria in the lower reaches of the bowel. The products of this wasteful fermentation or putrefaction are usually of an irritative, if not actually toxic, character. There can be little doubt that most of the troubles of infancy and childhood are directly or indirectly due to one or other of these results.

In early infancy both the digestive and motor functions of the bowel exfoliate normally if the food is quantitatively and qualitatively adjusted to the requirements—that is to say, if it affords stimulation of the right kind and of the right strength. If the food imposes undue strains, the whole machinery of digestion may become disorganised; on the other hand, if it is not sufficiently stimulating, the functions may not become normally developed. A careful study of the stages of development when natural feeding runs its due course is most instructive. The gradual transition from the easily digested and non-stimulating colostrum to the less digestible milk of full lactation is no less designed to promote the evolution of the functions of digestion proper than are the gradual increments in quantity supplied during the successive periods of infancy calculated to elicit normal motor functions.

Failures in artificial feeding are generally traceable to want of observance of the principles which appear to govern the natural method. Each stage in the whole series of digestive and motor events appears to act as the activator or excitant of the one which succeeds it; if one fails, the whole chain of processes breaks down: the strength of the chain is the strength of its weakest link.

The acid chyme which is discharged from the stomach at a co-ordinated rate serves as the stimulus which evokes secretion on the part of the intestinal mucous membrane of that important enzyme, secretin, which acts as the hormone for pancreatic activity, in the same way that the movements of the intestine, passing from one segment to another, maintain the normal sequence of those peristaltic waves which effect the steady and regular transport of the bowel contents from the duodenum to the rectum; if these are unduly violent or unduly sluggish the whole series of digestive processes are adversely affected.

THE DIGESTIVE FUNCTIONS PROPER

The combined result of the action of the pancreatic, intestinal and biliary secretions is to complete the digestive processes initiated in the mouth and stomach.

The Digestion of Proteins.—Protein substances are resolved into relatively simple bodies of the nature of short chains of amido-acids (poly-peptides) or into single amido-acids (peptides) mainly through the agency of the proteolytic ferment trypsin, one of the chief enzymes of the pancreatic secretion, and to a less degree through the action of erepsin, another proteolytic ferment secreted by the intestinal mucous membrane.

Until recently it was believed that protein bodies were only digested to the stage of peptones and absorbed as such, while amido-acids were regarded more or less as by-products; it is now recognised that the process of cleavage proceeds much further, and that amido-acids are the normal and not the abnormal forms in which absorption takes place.

The Digestion of Fat.—The exact condition in which fat is absorbed is still open to question and will again be referred to (p. 54), but there appears little doubt that unaltered neutral fats, even in the form of the finest emulsion, cannot pass through the intestinal wall; if this were possible the expression "digestion of fat" would have little meaning, for fat is usually consumed in the form of an emulsion and could then be absorbed without any digestive change. None the less, the emulsification and demulsification of oils seem both to be important parts in the digestion of fat and to precede cleavage into glycerine and fatty acids.

Neutral fats are acted upon by the fat-splitting ferment lipase, with the result that glycerine and fatty acids are formed; the latter unite with the alkaline bases contained in the biliary, intestinal and pancreatic secretions to form soaps. These soaps—

at any rate, the soluble potassium and sodium soaps—either help to emulsify still unaltered neutral fats, or are absorbed as such. It is quite possible that the emulsification of neutral fats by means of agitation with solutions of soap helps to promote the action of the fat-splitting ferment by presenting a larger surface.

The conditions which determine on the one hand the formation of soluble potassium or sodium soaps, or on the other hand the insoluble calcium or magnesium soaps, are by no means clear. As far as infants are concerned, we know that a considerable quantity of insoluble soaps are present in the lower part of the bowel and constitute a by no means unimportant part of their typical stools; it may well be that excess of fatty acids beyond that which can be absorbed is neutralised with calcium or magnesium in order to provide a suitable basis for a semi-solid stool.

That fats are not easily or quickly digested and absorbed in the bowel may be assumed from the elaborate safeguards provided by the pyloric mechanism to ensure only a slow admission of chyme to the duodenum when it contains any considerable proportion of fat.

Fat digestion is delayed or arrested by any condition which interferes with the biliary or pancreatic secretions. That the capacities for digestion are often exceeded is proved by the great frequency of fat dyspepsias in infants, and in this connection the important bearing of fat excess in the production of pyloric spasm is once again emphasised.

The varying degrees of digestibility of different kinds of fat is a matter of everyday experience. In the case of the infant the fine state of emulsion in which the butter-fat exists in breast milk is supposed to make this kind of fat better tolerated than any other variety; it is very doubtful whether this superiority is due to the small size of the individual oil droplets of which the emulsion consists. Although there is nothing to distinguish one kind of fat-splitting ferment from another by ordinary tests, it is possible that each variety of fat requires its own special enzyme, and that the human infant can more easily provide the particular type which is required for the splitting of the butter-fat contained in breast milk than one suited for the digestion of such foreign fats as, for instance, olive, cod-liver, linseed or soya-bean oils.

Although the majority of oils suitable for consumption consists for the most part of varying proportions of olein, palmitin and stearin, they also contain, in small quantity, a number of other free fatty acids which give them their distinctive flavours, and may render them more or less stimulating to the mucous membrane of the alimentary tract. It is difficult otherwise to explain the so-called bilious effects of some of these oils.

Although a fat-splitting ferment appears to be very widely distributed in the tissues generally, the only important representative, as far as intestinal digestion is concerned, is the enzyme contained in the pancreatic secretion and to which the name stearopsin is applied.

The Digestion of Carbohydrates.—As already stated, carbohydrate digestion mainly occurs in the intestines; the preliminary cleavage of starch in the stomach does not proceed far owing to the fact that the activity of the ptyalin contained in saliva, and which is swallowed with the food, is arrested as soon as the contents of the stomach become acid.

In the case of infants starch digestion is, as a rule, a matter of little importance, for their normal diet contains little or none of this element. The digestion of soluble sugars consists in the conversion of all varieties, whether maltose, cane-sugar or milk-sugar, into their simple monosaccharid elements—*i.e.* dextrose, lævulose or galactose. As may be seen from the accompanying

Table 6

To show the particular Monosaccharid Sugars into which Carbohydrates are converted in the Process of Digestion

Milk-Sugar	Cane-Sugars	Starches and Maltose
Is inverted by the specific enzyme lactase contained in the succus entericus into Dextrose + Galactose	Are inverted by the specific enzyme saccharase contained in the succus entericus into Dextrose + Lævulose	Starches are converted into maltose by the diastatic ferments contained in saliva (ptyalin), in pancreaticsecretion (amylopsin), in succus entericus and in other juices; while maltose itself is inverted by the enzyme maltase contained in succus entericus into Dextrose + Dextrose

table, starches, if they are consumed, are first converted into maltose by an amylolytic ferment, mainly contributed by the pancreas, but partly also supplied by the intestinal secretions. Maltose, which like cane-sugar and milk-sugar is a polysaccharid sugar, is further split up into its simpler component monosaccharid sugars by the action of the enzyme invertin which is secreted in the succus entericus. Carbohydrate digestion takes place, for the most part, in the upper part of the small intestine, whence the monosaccharid sugars are chiefly absorbed. It is only when carbohydrates are consumed in excess or hurried through the small intestines that they become subject to bacterial fermentation in the large bowel ; little or no sugar is, under normal circumstances, to be detected in the stools, although starch granules entangled in cellulose fibre are almost a normal constituent when cereals or vegetables, which have not been very carefully cooked, constitute any considerable part of the dietary.

If carbohydrate food does not undergo cleavage into its simple monosaccharid elements through the agency of the physiological enzyme constituents of the digestive juices, it finally becomes exposed, mainly in the large intestine, to the action of bacteria, with the formation of such decomposition products as lactic, acetic, proprionic and butyric acids, and such gases as carbonic acid, hydrogen and methane. A small quantity of alcohol is also sometimes generated if yeasts are present. These results necessarily have pathological consequences of greater or less moment.

Cellulose.—There is no enzyme normally present in the intestines which is capable of digesting cellulose, none the less, a considerable quantity exists in the dietary of adults, and it appears to subserve a useful purpose in stimulating peristalsis and forming a *point de puis* for the intestinal motor functions. Herbivorous animals cannot exist long without a plentiful supply of cellulose, and even adult human beings do not thrive well without it. In infants peristalsis appears to be maintained by means of stimulation from other sources, possibly by excess of fatty acids.

Cellulose is invariably attacked by bacteria in the large intestine, with the production of the above-mentioned acids and gases. These acids probably subserve a useful purpose in maintaining an acid reaction of the colonic contents, inhibiting thereby to some extent the alkaline putrefactive processes which occur in proteids, a useful provision owing to the poisonous character of the decomposition products of nitrogenous food.

DATES AT WHICH THE DIGESTIVE FERMENTS OF THE INTESTINES APPEAR

Trypsin.—This most important ferment, which rapidly effects in an alkaline medium the cleavage of protein bodies into their amino-acid constituents, has been demonstrated in the pancreas of the new-born infant (Langendorff); its precursor, trypsinogen, has been proved to be present in the pancreas of a six-month fœtus.

Amylopsin.—This pancreatic ferment converts starch into maltose, and is much the most important enzyme with this function present in the whole of the alimentary tract, not excluding the salivary ferment ptyalin. It has been demonstrated in the pancreas of the new-born infant (Moro), while Ibrahim has found it so early as the sixth month of fœtal life.

Stearopsin.—Stearopsin, the third important ferment present in the pancreatic secretions, is the main enzyme concerned in the splitting of neutral fats, although other lipases are present in the succus entericus. This ferment is also present at the time of birth, and has frequently been demonstrated early in fœtal life.

Invertin.—This is an important enzyme in the digestion of carbohydrates, for it converts cane and other polysaccharid sugars into their elementary monosaccharid constituents. It is apparently secreted by the intestinal mucous membrane, and has been demonstrated to be present in the mucosa of new-born infants.

Enterokinase.—This ferment, which activates trypsinogen, has not only been found in the intestinal mucous membrane of new-born babies, but also in meconium (Ibrahim).

Secretin.—This ferment is the activator of pancreatic secretion (Bayliss and Starling). It has been demonstrated in the mucous membrane of full-time babies at birth.

Erepsin.—This enzyme is secreted by the intestinal mucous membrane, and to a certain extent can replace either pepsin or trypsin. It is capable of changing casein, albumoses and peptones, but not other native albumins, into amino-acids. It is found in all babies, including those which are immature (Langstein).

The Influence of Bacteria on Intestinal Digestion.—The whole question of the bacteriology of the intestines is too vast a subject to deal with here otherwise than in the most general terms.

The intestinal contents are sterile until soon after birth, when infection invariably takes place, and chiefly through the mouth.

Both fermentation and putrefaction are held in reasonable check in the stomach as well as in the small intestines, although the latter are by no means sterile; under abnormal conditions bacterial activity gains ascendancy with pathological results. In the large bowel, which is very adequately shut off from the small intestine, bacteria play a very active part; indeed, the dried residuum of fæces consists of bacteria to the extent of 11% to 60%; a large proportion of them, however, are not living. Owing to limitations of movement, the number of bacteria present in constipated fæces is not nearly so large as when the stools are liquid. The character of the bacterial flora depends very largely on the nature of the food consumed: in breast-fed infants it is mainly gram-negative, in the artificially fed it is mainly gram-positive.

The main result of bacterial activity in the large bowel is to decompose the residuum of food which resists the hydrolytic action of the physiological enzymes; the fermentation of cellulose by this means, and the concomitant production of acids, exercises a beneficial influence in restraining the proteolytic bacteria from decomposing nitrogenous matter. The healthy mucous membrane of the intestinal tract offers an effectual barrier to the invasion of the tissues by bacteria. Any damage caused to the mucous membrane by mechanical or other means will permit of the passage of micro-organisms into the lymphatic channels and blood circulation where their development is not so readily held in check. The chief danger is during the first few days of life, when the bactericidal defences are in a relatively undeveloped condition, and when the mucous membranes are particularly vulnerable. From this point of view meconium must be regarded as a highly useful medium both in protecting the mucous membrane from mechanical damage and in exercising a modified control over the development of bacteria; the disadvantages of clearing out this prophylatic agent from the bowel of new-born infants are obvious.

The whole question of the bacteriology of the intestinal tract in infants so bristles with difficulties that it is most unsafe to rely on differential counts as a basis for rational treatment. Although certain specific varieties of bacteria are found in cases of cholera infantum and other pathological bowel conditions, the combinations in which they exist appear to be of at least as much importance as the character of the individual species. Bacteria of intensely active properties are often found in perfectly healthy infants, and in such cases it must be assumed that their virulence has been mitigated by the company which they keep, or through some other concomitant change in the environmental medium. Among the few facts that are reliable may be included that of the ease with which the whole character of the bacterial flora may be altered by a complete change in the diet, and some of the empirical results which are obtained by this means are most encouraging. For instance, a change from a milk diet to one consisting of simple barley water may, in quite a short period of time, restore an infant to health who has previously shown unmistakable evidence of intestinal intoxication; or again, if the stools are found to be acid, they can be made neutral or alkaline by dietetic means, so that a previously sick baby may become perfectly healthy. The subject of bacteriology will again be referred to in the section which deals with the excretions.

THE MOTOR FUNCTIONS OF THE BOWEL

The transport of food through the intestines is dependent on a series of rhythmical contractions which pass along the entire length of the bowel from duodenum to rectum. It is of great importance that these motor functions should be conducted efficiently; if they are too energetic the chyme is hurried through the digestive tract too fast to allow of complete hydrolysis and absorption. If the peristaltic movements are too slow, constipation or stasis may result, and if the activities are inco-ordinated or spasmodic, colicky pains or abdominal discomfort may ensue. It cannot be insisted on too strongly that education and habit play most prominent parts in eliciting and stereotyping the character of these functions. If during the early days of life these important functions are developed on unfavourable lines, either through bad feeding or accidental circumstances, a fixed and faulty habit of activity is liable to be established, and the task of re-education becomes extremely difficult.

It is only quite recently, and thanks chiefly to the bismuth meal and the fluorescopic screen, that the mechanical principles on which the fully developed motor functions of the intestinal tract depend have been elucidated; as far as the evolution of these functions during infancy is concerned, there is still much to learn.

In the adult, food is carried through the small intestines at the rate of about $1\frac{1}{4}$ inches per minute by a series of rapid peristaltic waves which are initiated in the duodenum, and travel along the whole length of the small intestine until they are arrested at the ileo-cæcal sphincter. Each independent peristaltic wave is separated from that which follows it by an interval of time which ranges from a few seconds to a few minutes. In the infant these intervals are liable to fluctuate within wide limits. Between succeeding waves the intervals are filled by a particular kind of swaying movement which keeps the intestinal contents in a condition of agitation, and which ensures thorough mixing and promotes absorption. This swaying movement is effected by what is called "segmentation," a phenomenon which consists in the formation of constrictions of the bowel by contracting bands of the circular muscles which divide up the length of the intestine into short water-tight compartments. This segmentation is evanescent, and it is soon replaced by a new series of constrictions which arise in the centre of each of the original compartments. As the new constrictions are formed the old ones disappear, and the bowel contents are thereby kept in a continuous condition of gentle agitation.

The function of the peristaltic movements is to effect the forward passage of the chyme, while that of the segmentation activities is to keep it well agitated, and to maintain adequate pressure so that it is brought into intimate relationship with the absorbing surfaces of the mucous membrane.

Segmentation also promotes the flow of blood in the venous-plexuses and of chyle in the lacteal system. These complicated muscular co-ordinations are very imperfectly effected in young infants, and they are extremely liable to become established on pathological lines unless all the determining factors which call them into play are of a favourable kind. The total time occupied by the passage of chyme from the duodenum to the ileo-cæcal valve is in the adult about four hours; in the infant the rate of transit is more variable. The chyme, however, does not pass into the cæcum immediately on arrival at the end of the ileum, but is prevented from so doing by the action of the ileo-cæcal sphincter, which is a specially modified band of the transverse muscular fibres of the last inch or so of the ileum. Intestinal stasis at this point is therefore a physiological phenomenon which is apparently designed to delay the entrance of still undigested chyme into the cæcum, where it becomes subject to the action of bacteria.

Ileo-cæcal Sphincter.—The action of this sphincter has close resemblances with that of the pylorus, and it is controlled by a special modification of Auerbach's plexus, which at this point is composed of a relatively excessive development of what Keith has called "initial nodal tissue," which is transitional tissue—neither wholly muscular nor wholly nervous—similar to that which occurs in the sinus of the heart. This sphincter under normal conditions remains tonically closed. It relaxes periodically and allows a narrow stream of chyme to spirt into the cæcum under high pressure. This relaxation is associated, as a rule, with the intake of a meal into the empty stomach, and the reflex which governs it passes under the name of the gastro-ileac reflex. Since, in the adult, meals commonly succeed one another at intervals of about four hours, this gastro-ileac reflex comes into play about four hours after the previous intake of food; it continues in operation, allowing of the intermittent passage of chyme, for about two hours, by means of which the cæcum and ascending colon gradually fill from below upwards. In the infant this intermittent flow is not confined to such regular periods as in the case of the adult, and chiefly for the reason that the intervals between feeds are shorter and more often than not irregularly arranged. It is possible that for the stereotyping of this automatic mechanism on permanent and favourable lines long intervals between feedings from the earliest days of life are to be recommended.

Incompetence or overaction of this sphincter must obviously interfere with the whole series of motor functions of the bowel. Although the sphincter is controlled by its own local nerve centres, situated in Auerbach's plexus, and by central influences reaching it through its sphlanchnic connections, recent investigations point strongly to the conclusion that certain internal secretions, notably adrenalin, influence the resulting effect of the nervous control. Excess of adrenalin, or an uncompensated adrenalin influence, will tend to produce overaction and spasm of the sphincter; thyroid secretions, which are to a certain extent antagonistic to those of the suprarenals, may have a counterbalancing influence in leading to relaxation of this modified sphincter. A correct and physiological balance between the various internal secretions is probably concerned in the normal action of this sphincter as well as of other mechanisms of the bowel.

The Motor Functions of the Colon.—The manner in which the transit of chyme into the cæcum is regulated has already been described, from thence onwards, transport is slow. Food takes in the adult about three hours to pass from the ileo-cæcal valve to the hepatic flexure, about three hours more to reach the splenic flexure, and from four to six hours to reach the junction of the descending colon with the ileo-colon, and about one hour later it arrives at the pelvic colon. The transit through the colon is very slow as compared to the rate of flow through the small intestine.

Transport of the colonic contents is effected by means of intermittent peristaltic movements which move the whole of the contents bodily along considerable lengths of the colon. The term "mass peristalsis" has been applied to this specialised form of locomotion. Mass peristalsis is difficult to observe by means of the bismuth meal and the fluorescopic screen, for the reason that it generally occurs during the partaking of a meal. Quite apart from these peristaltic movements the colonic contents are kept in a condition of gentle agitation by certain irregular contractions which pass backwards and forwards along the length of this section of the bowel, but which do not participate in the forward movement of the chyme.

In the infant all these muscular co-ordinations are carried out in a far more irregular manner than in the adult, and the frequency of the stools is largely dependent on them; as in the case of the ileo-cæcal sphincter their periodicity is chiefly determined by the number of the feedings. Once again this emphasises the importance of regularity in the times of feeding and of long intervals between successive meals.

Defæcation.—Although it is not safe to draw conclusions from observations made on the adult, it may be assumed that the act of defæcation in infants and children is conducted on substantially the same mechanical principles as in the case of full-grown individuals. Unfortunately, the only reliable investigations on this subject have been made on full-grown adults, so that there still remains much to be learnt on this subject with respect to the evolution of the mechanisms concerned; it cannot, however, be a matter of doubt that the manner in which this function is ultimately carried out in adults must be dependent on early education, and on habits engendered in youth.

It seems clear that when fæces enter the upper part of the rectum there is, under normal conditions, an urgent reflex call for evacuation: the distension of the rectal wall thereby engendered affords the required stimulus. Under normal conditions the whole of the rectal canal is empty except at the commencement of the act of defæcation, and it is only when the controlling nervous mechanism has lost, or has failed to acquire, its due sensitiveness that scybala or fæcal matter are tolerated in this situation.

Between the successive acts of defæcation, excrementitious matter collects in the pelvic colon or lower part of the so-called sigmoid flexure, and is prevented from entering the rectal canal by reason of a rather sharp kink which exists at the junction of the pelvic colon with the rectum; at this point the circular muscle fibres are specially developed so as to constitute a potential sphincter quite comparable to the ileo-cæcal sphincter.

The pelvic colon fills from below upwards by intermittent contributions of fæcal matter afforded by the occasional peristaltic movements which pass along the length of the colon, and for the most part during the intake of food. Under normal conditions fæcal matter is liquid, or at least semi-solid, unless it has remained in the pelvic colon for a considerable period of time. In the case of infants the periods of feeding succeed one another at such short intervals that time is not allowed for the stools to become solid before being passed. There is, in the case of infants, a great tendency for an action of the bowels to occur with the taking of each meal inasmuch as automatic habits of this kind are very easily engendered and become permanently fixed. It is clearly of advantage that the feedings should be sufficiently spaced out for the fæcal matter to become of a semi-solid consistency.

The Education of the Functions of Defæcation in Infants.— It is of great importance that all the neuro-muscular mechanisms concerned in defæcation should be developed on normal and favourable lines at a time when they are most amenable to educational influences.

Meconium plays an active part in this educational process. At the time of birth the intestines, large and small, contain a considerable amount of this material, which consists chiefly of mucus and bile, with a certain quantity of epithelial cells and other detritus from the amniotic fluid swallowed by the fœtus. After birth, as the functions of respiration become established, and the locomotor activities of the bowel are set in motion by sucking, a certain proportion of the contained meconium is forced into the pelvic colon. When this part of the bowel becomes sufficiently distended the act of defæcation is initiated, the pelvi-rectal sphincter relaxes, fæces enter the rectum and are immediately expelled from the body. As a rule, this act takes place immediately after or during a feed, the stimulus of food entering the stomach acting as the stimulus for the pelvi-rectal reflex. In this connection it must be remembered that of all fluids colostrum is probably the least stimulating to the stomach, although there is generally attributed to it a decided aperient action.

The function of colostrum is not to clear meconium out of the bowel, but rather to initiate in orderly sequence the whole series of motor events which result in advancing the bowel contents along a short distance and thus filling the pelvic colon to that degree of distension which is requisite for evacuation. Meconium is the only material during the first three or four days of life which can be used as a basis for the formation of a stool, and consequently, if swept out of the body by artificial or natural means, there is nothing to take its place until, with the establishment of lactation, sufficient unabsorbed milk finds its way into the lower part of the bowel. When meconium has thus been cleared out of the bowel there is a great temptation to correct the constipation, which almost necessarily results, by giving repeated doses of castor oil or other aperient. In this way the neuro-muscular mechanisms become dulled and irresponsive to normal stimuli, and a habit of constipation is calculated to result.

CHAPTER IV

THE ABSORPTION OF FOOD

General Remarks—Absorption of Fats—Absorption of Carbohydrates—Absorption of Proteins

General Remarks.—The processes of digestion proper are concerned with the resolution of complex food substances into simple forms which can pass through the mucous membrane and enter the circulatory system either by way of the portal or lymphatic system. It is with the details of this transference that the following sections will be concerned.

It will be understood from what follows in the succeeding paragraphs that this process cannot be explained on a simple physical or chemical basis. Although diffusion, osmosis, dialysis, filtration and inbibition undoubtedly play a part in the transportation of soluble food products from the cavity of the bowel to the distal side of the mucous membrane, these processes cannot offer a complete explanation of the phenomena of absorption and its eclectic discrimination between products which are wanted and those which are unnecessary or superfluous. Above and beyond all these simple physical processes there is some hitherto unexplained force concerned in absorption which, for want of a better name, and to cloak our ignorance, we call " vital."

Each one of the individual epithelial cells which paves the huge absorbing surface of the bowel—said to be some 140 square yards in area—contributes its puny quota to the vast total of vital energy which attracts, as it were with magnetic force, the sources of energy prepared for it by the digestive fluids. This attraction of food products to the living cell must, for want of better knowledge, be classed among the kindred phenomena which are observed when the leucocyte attracts to itself particulate substances such as bacteria, or when injured tissues attract to themselves vast aggregations of leucocytes in so-called inflammatory conditions, processes which are known as " chemotaxis."

The degree of attraction for food elements exercised by the cell, as well as the degree of attraction exercised by the blood and lymph for the food substances temporarily held by the cells themselves, must depend on their individual hunger: hungry cells or hungry fluids will attract, saturated cells or fluids will show no strong affinities for food material. These principles must clearly have a bearing on the degree to which the products of digestion will be absorbed from the bowel. Efficiency in absorption is essential for the prevention of that putrefaction of food material which always occurs when any residuum remains in the large intestine available for bacteria. Hence an accurate physiological adjustment between the demand and the supply of food must be an important condition of health, and any degree of over-feeding a source of potential danger.

At this point I would refer to a matter which is often forgotten—viz. that side by side with the passage of the products of digestion in the direction of the blood there is a reverse current from the blood into the bowel of various secretions, such as the saliva and gastric juice, which may, in the aggregate, exceed the actual volume of the fluid consumed. This explains the paradoxical fact that individuals or infants may vomit a larger volume of material than they have consumed, or may continue to pass voluminous motions after the taking of all food has been suspended.

It has already been explained that the complex molecules of which ordinary food consists are resolved into relatively simple bodies in the processes of digestion, and it will be remembered that both soluble and insoluble carbohydrate foods are reduced to the condition of simple monosaccharid sugars—dextrose, lævulose, galactose, etc.—and that all proteid bodies are reduced to the condition of amino-acids or strings of amino-acids (polypeptides), while neutral fats are split into fatty acids and glycerine. The manner in which these relatively simple molecular bodies are absorbed from the intestinal canal into the blood or lymph stream will now be explained.

Absorption of Fats.—The exact method in which fats are absorbed has been the subject of much controversy. Until comparatively recently it was believed that finely emulsified fat could penetrate into the substance of the epithelial cells, or squeeze in between the adjacent borders of two contiguous cells. This explanation is, however, at the present time, held in equal discredit with the somewhat fantastic theory that wandering leucocytes make their way into the interior of the bowel and, after engulfing particles of fat, return whence they came, to the enrichment of the blood contents. The majority of physiologists now subscribe to the belief that fatty food is absorbed in the form of soaps, or fatty acids, and that after penetration of the cell the fatty-acid radicles unite with glycerine to form neutral fats. It seems to be essential if absorption is to occur that all substances should be soluble. The solution of the elements of fatty food appears to be amply provided for, in that sodium and potassium soaps are both soluble in water, while the soaps of calcium and magnesium are soluble in bile, and free fatty acids in bile acids. In this way the elements of neutral fats can be assimilated whatever be the reaction of the intestinal contents.

If the greater proportion of the fatty-acid radicles are absorbed in the form of neutral soaps, and these soaps unite with glycerine within the cell to form neutral fats, it is clear that there must be a corresponding surplus of metallic bases to help to swell the available alkaline reserves in the blood—an important detail.

It is clear that fats are for the most part absorbed in the small intestine, in fact, by the time the intestinal contents have reached the lower end of the ileum 95% of the fat has, under favourable conditions in adults, been absorbed, and as a matter of fact the total removal of the large intestine does not appear to prejudice the degree of fat absorption.

Insoluble soaps of calcium and magnesium normally constitute no inconsiderable part of the stools of infants, and under certain conditions they form the greater proportion. To what extent the fatty-acid radicles of these insoluble soaps found in the stools are derived directly from non-absorbed fats, or to what extent they are indirectly due to excretions of the mucous membrane of the large bowel, is not definitely known, but it is at least highly probable that a very considerable part of such soap stools consists of fatty-acid radicles deliberately excreted as superfluous fat, and to this quantum must be added also an appreciable amount of fatty acids, the result of degenerative changes in the vast aggregate of epithelial cells which are shed, in process of ordinary wear and tear, from the mucous lining of the whole of the alimentary tract.

All those conditions which interfere with the absorption of fat must contribute to the formation of soap stools, and among them must be included deficiency in the pancreatic and biliary secretions ; catarrhal, atrophic and otherwise unhealthy conditions of the mucous membrane of the small intestine, and especially tuberculosis, peritonitis and other diseases which cause obstruction to the lacteal stream, lead to the same result. It is highly probable that at least one variety of marasmus in infants is due to a defective absorption of fat owing to atrophy of the cellular elements of the mucous membrane of the small intestine. If it be true that the fat-soluble vitamine—accessory factor "A"—is assimilated in combination with fat and in no other manner, it is reasonable to infer that in those cases in which there is a defective absorption of fat from any cause there may also be a defective assimilation of this essential accessory food factor, with concomitant specific results.

Failure in fat absorption accompanied by copious soap stools carries with it the additional disadvantage that the system is necessarily depleted of the valuable basic elements calcium and magnesium, both of which are used up in the neutralisation of the free fatty-acid radicles. As will be shown later, this has an important bearing on those disturbances of "calcium balance" which are concerned in the pathogenesis of rickets (see p. 334).

Fat is absorbed in a soluble form from the small intestine, either as a soap or as a free fatty acid. Within the cells of the villi there is a reconstitution of neutral fats by the union of the fatty-acid radicles with glycerine. These neutral fats, in a condition of fine division or emulsification, proceed by way of the lacteals to join the blood-stream and supply the tissues. The absorption of fat appears essential for the conveyance to the tissues of the fat-soluble factor "A." It may also be a means of reinforcing the alkaline reserve of the blood by the liberation of free basic elements.

Failure in fat absorption leads to the production of soap stools and the depletion of calcium from the system, which may be a factor in the production of rickets.

CARBOHYDRATE ABSORPTION

It appears that carbohydrate food, provided it is soluble, can be absorbed from any part of the alimentary tract, but under normal conditions only the merest traces are absorbed except from the small intestine; in fact, by the time the intestinal contents have reached the ileo-cæcal valve they have been sucked dry of all soluble carbohydrate material. On the other hand, it must be remembered that insoluble carbohydrate food in the form of starch granules is often contained in the fibrous meshes of vegetable foods, and thus ensnared, is protected from the hydrolytic action of the digestive enzymes. When the diet, therefore, consists to any large extent of vegetable foods a considerable quantity of unaltered starch may reach the large bowel, and here the cellulose meshwork, together with its contained starch granules, may be attacked by bacteria, with the production of noxious gases and acids.

In the case of infants no such phenomena are liable to occur, for the reason that vegetable foods are not consumed. On the other hand, young infants in whom the digestive processes are still undeveloped cannot digest starch unless presented in very small quantities and in the most digestible forms. Hence, if young babies are improperly fed on starchy foods, part of the latter may escape the legitimate digestive processes, and reach the large intestine in an unaltered form, and become exposed to bacterial fermentation.

Carbohydrates can be absorbed by the ordinary physical processes of osmosis, diffusion, inbibition, and so on; but that the vital activities of the cell are dominantly concerned in their assimilation is suggested, if not actually proved, by the remarkable selective preference shown by the cell for certain kinds of soluble carbohydrates over others of a less valuable kind. When the monosaccharid sugars—dextrose, lævulose and galactose—lie side by side in the intestinal contents with the polysaccharid and uninverted sugars—lactose, maltose and saccharose (cane-sugar)—the latter are rejected, while the former are freely assimilated, although, within limits, both varieties of sugars are readily diffusible.

There is a teleological significance in this discrimination, for while the monosaccharid sugars are immediately available for use by the tissues, the polysaccharid sugars behave as foreign bodies and are of no energy value to the organism.

In certain events polysaccharid sugars do find their way into the circulation, but as a rule this only occurs when the quantity consumed exceeds the resources of the digestive functions which bring about their inversion into monosaccharid sugars. Thus cane-sugar, malt-sugar or milk-sugar consumed in excess may enter the circulation in an unaltered state. There is again a teleological significance in the predilection for starchy foods shown in human tastes. If starchy foods are consumed, their slow hydrolysis into the soluble sugar maltose provides against any excessive quantity of polysaccharid sugar existing in the bowel contents at any one moment, so that time and opportunity is afforded for the inversion of such maltose as exists into the monosaccharid sugar dextrose. Consequently a longer drawn-out reinforcement of the blood with carbohydrate food is ensured when starch is consumed than when the intestines are flooded with large meals of soluble sugars.

Starches have no superiority over sugars as sources of energy —indeed, before they can be utilised for the purposes of energy production they must first be converted into soluble sugars. They have, however, the substantial advantage that they provide a more sustained supply of carbohydrate food. The rate at which the circulation is reinforced with absorbed carbohydrate material is of economic importance to the organism, for the blood is only capable of holding a very small percentage of sugar—not more than 0·15%. If the degree of saturation rises above this limit the excess is expelled from the circulation, and is either stored as fat or glycogen, or is eliminated by the kidneys in the urine. Since the rate of storage of glycogen or fat is in all cases limited, and in some cases exceedingly slow, it is clear that with excessive carbohydrate assimilation there may easily be considerable waste and loss of valuable energy. In the case of babies we frequently see evidences of the straining of the mechanisms for storage or excretion by abnormal increments in bodily weight, or by the presence of sugar in the urine, both of which symptoms are of unfavourable augury.

As the result of innumerable experiments it has been proved that soluble carbohydrates pass into the system by way of the capillary radicles of the portal veins. It may, however, well be asked whether such a transference can take place directly into the blood without the intervention of the lymphatic system. Is not the alternative view possible that all such absorbed carbohydrate material first enters the lymphatic capillaries, and thence, owing to its highly diffusible properties, passes into the blood capillaries ? It is almost impossible to believe that the individual cells of the intestinal villi can rest directly on the walls of the blood capillaries without any intervening lymphatic radicles, even though the latter be very fine. I only mention these facts because it appears to be generally believed that in absorption of food from the interior of the intestine two entirely independent and distinctive processes are concerned : (1) absorption directly into the blood capillaries ; (2) absorption direct into the lacteal system. It seems more reasonable to suppose that all absorbed products find their way into the lymphatic spaces, and that thence the more diffusible elements enter the blood capillaries.

Carbohydrate food under normal conditions is assimilated in the form of simple monosaccharid sugars by the epithelial cells of the small intestine. Although sugars of larger molecular size (polysaccharid sugars) can also be absorbed to some extent, the selective activities of the cell is evidenced by the relatively small amount of the polysaccharid sugars and the large amount of the monosaccharid sugars which are normally absorbed. Starches, provided that they can be digested, possess an advantage over sugars as articles of diet because their leisurely conversion into soluble sugars ensures a slower and more evenly sustained reinforcement of the blood with carbohydrate supplies. Excess of starch is especially dangerous to the baby because in the latter the starch-digesting functions are poorly developed, and unconverted starch reaching the large intestine is attacked by bacteria, with the result that noxious products of fermentation are produced.

PROTEIN ABSORPTION

Views with respect to the form in which protein foods are absorbed into the system have, of recent years, undergone revolutionary changes. It was formerly believed that nitrogenous bodies were changed into peptones, and absorbed as such by the epithelial cells of the intestinal mucous membrane. Although leucin, tyrosin and other amido-acids were known to be final products of pancreatic digestion, they were regarded as by-products and not as essential factors in proteid digestion. We now know that this view is incorrect, and that the formation of such amido-acids is a normal and not an abnormal result of protein digestion. Practically all physiologists are agreed that protein absorption takes place in the form of such amido-acids or combinations of them, and that there is later a reconstitution of these bodies into one or other of the different varieties of proteins which are found in the tissues. The difficulty which at the present time presents itself is to decide whether this reconstruction takes place within the cells of the absorbing surface, or whether the independent fragments, after absorption into the blood-stream, are picked out by the various tissue cells as they may be required. At the present day, opinion inclines to the latter view, and the reason why large accumulations of separate amino-acids are not found in the blood at any one moment is explained on the ground that if they are not required for reconstruction purposes they are rapidly de-aminated by the liver cells, and possibly by other tissues, on the one hand, with the production of urea, and on the other, with that of a carbohydrate which can be employed for energy production. In this connection it may be stated here that according to Starling the energy of protein food does not lie in the coupling together of amino-acid molecules, but in the combustion of the carbon to carbonic acid in the nitrogen-free portion; this explains how it is that there is no loss of energy in the breaking up of the complex protein molecule into those simple amino-acid molecules which result from protein digestion.

During the process of protein digestion, and up to the final stage of dissolution into independent amino-acid elements, the following bodies are formed: (1) meta-proteins; (2) proteoses; (3) peptones; (4) poly-peptides; (5) di-peptides; (6) mono-peptides or amino-acids.

Under favourable circumstances any one of these bodies may be absorbed, but there appears to be exercised by the absorbing cells a definite preference for the smaller molecules—viz. the mono-peptides and poly-peptides—for the obviously teleological reason that these smaller fragments are more available for the purposes of nutrition. On the other hand, proteoses or bodies of even larger molecular size may be absorbed if the processes of digestion do not proceed beyond these stages. We know that in young babies, before the functions of protein digestion are fully developed, the unchanged proteins of colostrum or milk may be absorbed directly into the circulation—a result which constitutes a serious danger if the protein bodies thus absorbed are foreign elements and not of the required specific make-up. If, for instance, cow's milk is consumed by the new-born baby the soluble serum albumins or whey proteins which are present in it may be absorbed, and, if they are, they will constitute foreign bodies in the blood for they are not of the same specific make-up as the soluble albumins which form part of human blood. Dangers, therefore, attach to the feeding of young babies with any forms of milk or soluble albumin other than those afforded by their own mothers. If foreign albumins gain access to the circulation of an infant they produce definite reactions and the formation of specific precipitins.

The ultimate channels by which the protein fragments are absorbed are clearly the radicles of the portal system, for after ligature of the thoracic duct there is no appreciable diminution in protein absorption. Nevertheless, it may be legitimate to raise the same doubt that has been expressed in connection with the absorption of the products of carbohydrate digestion—viz. whether it is not more probable that absorption takes place in the first instance by way of the lymphatic channels rather than directly into the blood capillaries.

Under conditions of normal digestion protein bodies are resolved into single amino-acids, or short strings of them (poly-peptides), and in this form are carried by the blood to the tissues. Here the particular amino-acids, which are required for the repair or specific purposes of the cells, are selected and the residuum is de-aminated by the liver, the carbohydrate moiety being further oxidised with the production of heat or other form of energy. The ammoniacal radicle is converted into urea.

Under certain conditions soluble albumins are absorbed into the blood in addition to peptones and other bodies representing the fore-stages of protein digestion. When this is the case they act as foreign bodies. Protein absorption takes place into the portal system, but whether or no through a preliminary passage through the lymphatics is not determined.

CHAPTER V

METABOLISM

General Statement—Metabolism of Proteins, Carbohydrates and Fats

GENERAL ACCOUNT OF METABOLISM

THE term metabolism is employed to cover all those changes which occur in food after its ingestion, and hence includes the catalytic processes of digestion within the alimentary tract. But as far as this section is concerned, the term will be restricted to the changes which occur after the absorption of the products of digestion into the general system. Some of these changes are synthetic in character—that is to say, relatively simple bodies are built up or united so as to form more complicated substances. Such processes are technically known as "anabolic" or constructive changes. On the other hand, the majority of these changes consist in the breaking-up of comparatively complex combinations into more simple forms. The latter processes are known as "catabolic," a term which in its literal meaning implies change in a downward direction.

All the preliminary processes in connection with digestion and absorption are merely means to an end—viz. the conversion of such crude sources of energy as are provided in food into specialised and simplified forms which can be dealt with by the tissue cells for their special purposes—*i.e.* for the purposes of growth, for the production of work, for the production of heat or for the elaboration of secretions.

The sum total of food requirements in any particular case is represented by the amount of the energy requirements needed for these four purposes. As has been already referred to (p. 5), the measure of the bodily needs for potential sources of energy is most conveniently expressed in terms of calories. If, for instance, the total caloric requirements of any individual infant is represented by 500 calories, the supply of food must or should also afford an equivalent number of calories, or units of energy.

Since every food, whether it be protein, carbohydrate or fatty in nature, has its own particular energy value, it is quite easy to calculate how many ounces of any one of them, or of any combination of them, must be consumed to afford the required number of units of energy. It is not, however, a matter of indifference to the human organism in what exact combination the required number of units is afforded. There is a physiological optimum which, speaking quite generally, is, as far as the human infant is concerned, represented by the relative proportions in which the different food elements exist in human milk.

Although proteids, carbohydrates and fats can be utilised for the purposes both of heat and energy production, it is only proteins that can be employed for growth and for the products of glandular activity. There are very definite requirements in the infant both for growth and for the elaboration of secretions, but when these requirements have been satisfied it is very questionable how safe it is to increase the protein supply.

Metabolism of Proteins.—In a physiological sense it is very expensive to attempt to satisfy the requirements of heat production and muscular work with protein food; chiefly for the reason that such food never yields up its full heat or energy value, but leaves the body in a semi-oxidised condition, which not only represents a waste of energy, but also entails further losses in being eliminated from the body in the form of urea, or uric acid. Carnivorous animals are able to obtain their energy from nitrogenous foods without straining their metabolic resources because their excretory organs are designed to carry off large amounts of nitrogenous waste. The kidneys of omnivorous animals like ourselves would not long stand the strain which would be imposed upon them if the diet were too exclusively composed of albuminous elements.

The amount of protein required in the diet of any particular individual will therefore depend largely, but not exclusively, on the general organic make-up as well as on the rate of growth. It is, however, very obvious that there can be no advantage in a one-sided nitrogenous dietary. If we can assume that the amount of protein is more or less correct in breast milk for the human infant, it is clear that no advantage is gained by exceeding this amount. In breast milk the ratio of the nitrogenous to the non-nitrogenous elements is as 1 to 7, and this ratio is probably correct throughout the whole of infancy, although in later childhood and adolescent life the physiological ratio may vary from 1 to 7 to 1 to $12\frac{1}{2}$. This so-called "nutritive ratio" is a matter of great physiological import. Wide departures from it are very common when certain of the modern methods of feeding are employed. If whole milk, without modification, is given to infants, the ratio of nitrogenous to non-nitrogenous elements is as 1 to 2, and the same obtains when dried milks, reconstituted by the addition of water, are given to infants without further modification.

An infant fed on whole milk or on dried milk plus water has a dietary which is suitable for a rapidly growing calf, but undue strains are thrown on the organs which excrete nitrogenous waste, while the general processes of metabolism are directed along abnormal lines.

The exact situations in which nitrogenous metabolism takes place in the human body cannot be stated with certainty. It is generally believed, however, that the nitrogenous products which are absorbed from the intestines, and which consist of amino-acids or combinations of them, are made use of by the various tissue elements as and when they are required for synthetic purposes, and that the remainder are carried to the liver, where they are de-aminated with the production of a nitrogenous and a non-nitrogenous moiety. The ammoniacal or nitrogenous portion is then converted into urea, or employed as an ammonium base for the neutralisation of free acids, while the non-nitrogenous portion goes to swell the general carbohydrate content of the blood, where it is used for energy-producing or storage purposes.

One important fact to remember in connection with nitrogenous metabolism is that what is eaten to-day cannot be kept till to-morrow; no storage of excess is possible as in the case of carbohydrates and fats. Consequently all excess must be immediately disposed of in one or other of the various ways which are available. In accordance with what may be called the law of physiological expediency, all nitrogenous excess over and above that which is required for useful purposes, will be disposed of by that method which for the time being inflicts least damage on the organism as a whole. The method which may be regarded as most physiological is the method of de-amination in the liver, with the production of urea, a body which can be eliminated by the kidneys with comparatively little strain or effort. Another method is by the formation of ammonium, which immediately unites with some free-acid radicle to form a neutral salt. Although, under normal circumstances, the elimination of this nitrogenous waste does not entail serious strains on the kidneys, nevertheless, it cannot be doubted for one moment that the main cause of the breakdown in function of both liver and kidneys is overwork of these organs. In the case of adults so-called "liver attacks" and gouty manifestations of various kinds can confidently be referred to the excessive consumption of meat and other nitrogenous foods, and although exactly similar attacks are not recognisable in the baby, none the less, they certainly suffer from quite comparable conditions.

Although it is clearly one of the objects of physiological feeding to supply the individual with exactly the amount of protein food that is required for the purposes of growth, repair and the manufacture of secretions, nevertheless, from a practical point of view, it will always be found necessary to supply an excess, for the reason that no known variety of protein contains the exact proportions of constituent peptides which are required for the building-up and repair of the many different tissue cells represented in the body, and any deficiency of any required amino-acid must hinder normal development (see p. 105).

The Metabolism of Carbohydrates.—This matter presents many difficulties. It differs essentially from that of nitrogenous metabolism in that storage can take place—in other words, what is eaten to-day can be kept for to-morrow—at least within certain prescribed limits.

All carbohydrate food is absorbed, and enters the circulation in the form of monosaccharid sugars—viz. dextrose, lævulose, galactose, etc., and the percentage of such sugars in the blood is maintained, within very narrow limits at a definite standard of from 0·1 to 0·2. If the degree of concentration rises above this level the excess is excreted by the kidneys, or it is stored in the tissues in some insoluble form, such as glycogen or fat, which cannot be washed away by the circulating fluids.

The amount of sugar that can be disposed of in the body before it is excreted by the kidneys and thus wasted is known as the "index of utilisation" or sugar-tolerance. This index varies very considerably, not only in different individual babies, but also under different conditions. It depends on—

(1) Rate of absorption.

(2) Storage capacity.

(3) The output of energy.

(4) The oxidation capacities in the blood and tissues.

In infants sugar-tolerance is comparatively low, and glycosuria supervenes more often than is usually suspected. The difficulty of collecting the urine is the explanation of the fact that glycosuria is not more often detected. Although infants can comparatively easily store up excess of carbohydrate, in the form of glycogen or fat, they have but limited means of utilising it as a source of energy until they begin to crawl or walk.

Within limits, infants are capable of oxidising carbohydrate food without storage and without elimination in the form of unaltered sugar: this oxidation can be either complete or partial. If complete, there is a production of heat which is equivalent to the full caloric value of the sugar, and the end products will be carbonic acid and water; if incomplete, the combustion products will be acids of large molecular size and there will be a restricted production of heat. It is difficult to predict in any particular case which is most advantageous to the body as a whole—complete oxidation with the production of much heat, or incomplete oxidation with the production of less heat, but with the formation of acids of large molecular size, such as lactic acid, proprionic acid, oxalic acid, etc., which must be neutralised at the expense of the alkaline reserves of the blood; the particular method employed will, in accordance with what I have ventured to call "the law of physiological expediency," be the one which causes least damage to the system.

Whether, therefore, in any particular case the amount of carbohydrate material consumed is excessive or not will depend on a large number of different factors. The storage capacity varies very greatly in different infants, a capacity which is related in certain instances with the size and functional efficiency of the pituitary gland; the capacity for oxidation is dependent, to some extent at least, on the oxidases in the blood and the supply of oxygen, while the amount of carbohydrate which can be utilised at any moment for the production of energy will depend on the muscular activity of the infant, and on the muscular tonus. In conditions of diabetes there is a total breakdown of carbohydrate metabolism, sugar cannot be stored, neither can it be oxidised, so that if it is not used as a source of energy it remains unoxidised, and appears in the urine as sugar or as semi-oxidised products.

The actual amount of sugar that can be utilised by the infant differs considerably, according to the variety of sugar. The limits of utilisation for different kinds of sugars have been defined as follows :—

(1) Milk-sugar from 3·1 to 3·6 grams per kilogramme of body weight (Grosz).

(2) Grape-sugar, 5 grams per kilogramme (Langstein and Meyer).

(3) Maltose, 7·7 grams per kilogramme (Reuss).

(4) Lævulose, 1 gram per kilogramme (Keller).

(5) Cane-sugar, about 8 grams per kilogramme (Reuss).

(6) Glucose, 5 grams per kilogramme.

If, therefore, a baby weighing 10 kilogrammes passes sugar in the urine after a feed of 50 grams of glucose, 35 grams of milk-sugar, 80 grams of cane-sugar or 70 grams of maltose, it may be assumed that there is some degree of intolerance for the sugar in question.

The Metabolism of Fat.—Much controversy centres round fat metabolism, chiefly as regards the extent to which it can be substituted for an isodynamic amount of carbohydrate food. It has been claimed that it is immaterial as far as nutrition is concerned whether the normal relationship between nitrogenous and non-nitrogenous food, which for the infant is as 1 to 7, is maintained by a large proportion of carbohydrate and a small proportion of fat, or *vice versa*. The problem is greatly complicated by considerations of primary digestion, and further by considerations of absorption. Many infants have a very definite intolerance of fat, and when this is the case it may usually be traced to disabilities of digestion rather than to metabolic incompetence. The claim that the non-nitrogenous food requirements can be satisfactorily fulfilled by a disproportionately large proportion of carbohydrate food and a correspondingly small quantity of fat is not borne out by clinical experience, which suggests, if it does not prove, that as long as fat can be adequately digested and absorbed it cannot be reduced below a certain minimum without concomitant prejudice to nutrition. There can be little doubt that the physiological ratio between carbohydrates and fats for infants under one year of age is as 2 to 1 by weight—in other words, the ratio existing in breast milk. In this connection it must be remembered that the maintenance of a correct ratio between the non-nitrogenous and the nitrogenous elements, as well as of a correct ratio between the carbohydrates and the fats, is not the only, or even the most important, factor to be considered; one really important matter to consider is how much fat is actually required. This quantity can be roughly calculated provided that we know the total quantity of breast milk or its equivalent which is required in the 24 hours—an estimation which is very easily made in accordance with the directions given on page 8. The total amount of fat required is 3·5% of the total amount of breast milk. If, for instance, the requirement for 24 hours is 25 oz. the total amount of fat required is 0·87 oz.

There appears some evidence for believing that fat may act as a vehicle for the carriage of certain important accessory factors from the digestive tract into the circulatory fluids, but quite apart from this, fat serves as a valuable source of heat, weight for weight it produces twice as much heat as carbohydrate material. The milk of mammals living in cold climates contains a larger amount of fat than that of mammals living under warmer conditions; if any justifiable deductions can be drawn from this, we ought to supply a rather large fat ration for babies living in cold climates, and for all babies during the cold months of the year.

Both a deficiency and an excess of fat are disturbing factors with respect to nutrition; with a deficiency there is a definite impairment of growth, a want of resistance to disease, and a tendency for defective mineralisation of bones and teeth. With an excess of fat there is often found an incomplete oxidation, and an excessive production of oxybutyric acid, di-acetic acid and acetone, all of which products appear in the urine. A more characteristic consequence of excess of fat is the elimination of fatty acids by the mucous membrane of the bowel in combination with calcium and magnesium—in other words, an excretion from the body of soap stools. An excessive intake of fat has consequently the result that an abnormally large quantity of calcium and magnesium are lost to the system, an event which is closely associated with the rachitic condition (see pp. 335 and 342).

CHAPTER VI

EXCRETION

General Statement—Kidneys and Urinary Excretions—Fæces and Excretion by the Bowel—Abnormal Constituents of Fæces

The human organism is dependent for health and comfort on the efficient performance of the excretory functions. If from want of elimination waste products are allowed to accumulate in the system, toxic symptoms soon supervene. Waste products are removed from the body by the lungs, by the skin, by the bowels and by the kidneys; any one of these, or any combination of them, may fail in duty, but failure of one may, within limits, be compensated for by a corresponding over-activity of another.

An infant may be correctly fed as regards quantity and quality of the food, all the accessory factors may be supplied in full amount, digestion, assimilation and metabolism may be normal, and yet if the excretory functions are inadequately performed ill health and malnutrition will inevitably supervene.

Under normal conditions of health the waste products which are eliminated from the body are comparatively simple and fully oxidised bodies from which the full energy value has been extracted. These waste products consist, for the most part, of urea, carbonic acid and water. In certain abnormal conditions albumin, sugar, lactic acid and other bodies which still possess energy-value, are allowed to leave the system in an unused condition. When this occurs not only is there a waste of potential energy, but various strains and injuries are inflicted on the system in the act of elimination. A definite source of waste of potential energy occurs in the elimination of mucus in the urine, in the fæces, and in the discharges from the nose and from open mucous surfaces. The fæces are not so much composed of the detritus of undigested or unabsorbed food as is generally believed; they consist of genuine excretory products contributed by the liver and the mucous membrane of the alimentary tract.

It is the object of physiological feeding so to regulate the diet that there is no waste of unutilised material—in other words, that the full energy-value of the food is extracted so that no unaltered or semi-oxidised food products need be excreted from the body.

THE KIDNEYS AND THE URINARY EXCRETIONS

The physiology and pathology of the urine in infancy involves, from the standpoint of clinical medicine, many difficult and important problems, but as far as diet has an influence on such excretions the position is far less complicated. The influences of diet on the functions of digestion manifest themselves early. If they developed a little sooner than they do, many serious results could be obviated. The influence of diet on nutrition is as a rule much longer deferred, so that the really serious consequences of an ill-assorted or improperly balanced dietary are in many cases obscured until serious damage has been inflicted. On the other hand, by careful examination of the urine such results may sometimes be anticipated and prevented. Under normal conditions the urine contains a more or less definite percentage of certain physiological constituents; if in any respect the quantity or the proportion of such constituents departs from the normal, or if abnormal constituents can be detected by the available methods of clinical analysis, impending disturbances of nutrition may be diagnosed, and possibly prevented by a readjustment of the diet. A careful examination of the urine is one of the most valuable sources of information with respect to the correctness or otherwise of any particular dietary. There are a great many points in connection with the character of the urine which call for examination.

The Quantity of the Urine.—The amount of urine voided in the 24 hours clearly depends on a variety of different factors, chief amongst which are:

(1) The quantity of fluid consumed.
(2) The quantity voided in the fæces.
(3) The quantity lost by evaporation from the skin.
(4) The quantity lost as vapour in the expired air.
(5) The retention of fluid in the tissues.
(6) The height of the blood-pressure.
(7) The functional activity of the kidneys.

In view of the various conditions which determine the amount of the excretion, it is quite clear that there is no such thing as a physiological quantity ; all that one can say is that when all the conditions are physiological certain quantities may be said to be normal.

The following table is given by Pfaundler and Schlossmann, vol. iv., page 13 (J. B. Lippincott Co.) :—

TABLE 7

To show Average Daily Excretion of Urine

	Minimum	Maximum
In the first 24 hours after delivery	2·0 c.c.	61·0 c.c.
2nd day	11·0 c.c.	145·0 c.c.
3rd day	13·3 c.c.	171·0 c.c.
4th day	17·5 c.c.	179·0 c.c.
5th day	22·5 c.c.	222·0 c.c.
6th day	70·0 c.c.	280·0 c.c.
7th day	93·0 c.c.	338·0 c.c.
8th day	100·0 c.c.	331·0 c.c.
From 9th day to 2nd month	150·0 c.c.	400·0 c.c.
From 2nd month to 6th month	210·0 c.c.	500·0 c.c.
From 6th month to 2nd year	250·0 c.c.	600·0 c.c.

A comparison of the amount of urine excreted by bottle-fed infants as compared with breast-fed infants shows that during the first few days of life the former excrete more fluid than the latter. I do not think, however, that any important deductions can be drawn from such observations, chiefly for the reason that the amount of colostrum (see Table 18, p. 95) or milk consumed by the breast-fed infant is, as a rule, considerably less than the fluid supplied when artificial feeding is resorted to, and secondly because with artificial feeding more fluid is usually lost in the fæces, owing to the irritation set up by the unsuitable substitute foods which are usually supplied.

Premature infants as a rule void very small quantities of urine, probably for the reason that the kidneys are still in a condition of undeveloped functional efficiency.

After the fourth or fifth month the ratio between the amount of fluid consumed and that passed *per vias urinales* remains fairly constant, so that for every 100 parts consumed 68 are voided in the urine.

Although too much reliance must not be placed on the following statement, a general estimate of the amount of breast milk consumed in the 24 hours may be arrived at by multiplying the total quantity of urine passed by the factor $\frac{100}{68}$. I mention this fact because discontented and unsatisfied breast-fed infants are often relegated to the bottle on the assumption that the milk supply is deficient although if the total quantity of urine passed were to be estimated it would be evident that, whatever else was wrong, the total supply of milk was not inadequate.

Frequency of Micturition.—Young infants almost invariably pass water frequently, and this continues until they acquire some control of the bladder functions. It is not unusual for new-born babies to pass water every half-hour; as they grow older the frequency decreases. It cannot, however, be too strongly emphasised that the frequency depends very largely on the manner in which the infant is trained and on its amenability to the educational regimen. Mentally defective infants, as well as those with irritable and unstable nervous systems, are difficult to train, and micturate more frequently than normal infants. Without insisting too strongly on the connection between pituitary inefficiency and want of control of the sphincter of the bladder, it is at least explicable on theoretical grounds that want of control over the bladder functions may be associated to some extent with abnormalities in the supply of the internal secretions of this and other glands. In the great majority of cases, however, frequent "wetting" is due either to bad training or excessive feeding.

Reaction of the Urine.—The urine of the new-born is as a rule strongly acid, but after the fourth or fifth day it becomes faintly acid or alkaline. After the first month of life any marked acidity should be regarded with suspicion, for it usually implies an existing or impending acidosis.

The degree of acidity can be estimated by titration with deci-normal sodium hydrate with a suitable indicator. As a rule, the acidity is greater in artificially fed infants, owing to an increase in quantity of phosphoric acid, which may be due to the disturbances of digestion which are usually set up by inappropriate foods, or to the excess of phosphorus which is present in cow's milk and many other foods.

The Specific Gravity of Urine.—This is usually low during the whole period of infancy, but specially low during the early months of life, a fact which is explained by the liquid character of the natural food, and by the retention of a large proportion of the solid contents of the food for the purposes of growth. As compared with the urine excreted after the first week of life, that which is passed during the first two or three days has a comparatively high specific gravity, owing to the small quantity of colostrum consumed. The following table, taken from Holt's *Diseases of Infancy and Childhood*, represents the average specific gravity :—

TABLE 8

	Specific Gravity
1st to 3rd day	1·010 to 1·012
4th to 10th day	1·004 to 1·008
10th day to 6th month	1·004 to 1·010
6th month to 2nd year	1·006 to 1·012
2nd to 8th year	1·008 to 1·016

The Nitrogen Content of the Urine.—Since the storage of nitrogen is entirely dependent on growth, and is always independent of the amount of protein or nitrogenous constituents in the food, it is quite clear that after growth requirements have been satisfied, the amount of nitrogen in the emunctories will correspond with the amount of nitrogenous elements in the food. Physiological growth, so far from being increased by an excessive intake of nitrogenous food, may actually be decreased owing to digestive and metabolic disturbances set up by the over-feeding.

The total amount of nitrogen excreted in the urine is consequently proportional to the amount of protein consumed ; a large amount of nitrogen is disadvantageous to the health of the infant, because its mere excretion entails strains on the functions of the kidney.

The actual form in which the nitrogen is excreted in the urine has great clinical significance, the more nitrogen that appears in the form of urea and the less that appears in the form of ammonium the better is it, and for the following reasons.

Urea is the natural and physiological end product of nitrogenous metabolism ; when, however, acid products other than carbonic acid are formed in the system, they must be neutralised immediately, at the expense of some basic element, such as sodium, potassium, calcium, ammonium, etc. In accordance with the law of physiological expediency the cheapest base will be the first to be utilised ; within limits ammonium is the cheapest base, and consequently will be largely utilised for the purposes of neutralisation, with a corresponding reduction in the urea output. Relative excess of ammonium salts in the urine is an indication that large amounts of acid bodies requiring neutralisation are being produced in the system—in other words, that there exists, or is impending, a condition of acidosis.

The relative amount of nitrogen in the urine excreted, in the forms of urea and ammonium salts respectively, gives definite information with respect to the degree of acidosis. The following table from Langstein and Steinitz gives the relative proportions in which the nitrogen is excreted under conditions of breast and artificial feeding:—

TABLE 9

	Ammonia Nitrogen	Urea Nitrogen
In breast feeding . .	23·0	69
In cow's milk feeding . .	7·0	86

There is a very decided difference in the relative proportions of nitrogen, represented as urea, uric acid, ammonium and other nitrogen-containing substances (including mucus), in the urine of infants and of adults, as the following table, taken from Feldman's *Principles of Child Physiology*, shows:—

TABLE 10

The Total Nitrogen in the Urine	Adults Per Cent.	New-born Per Cent.
As urea	80–90	69
As uric acid	1·53	5·4
As ammonia	4·20	8·5
As other nitrogenous bodies .	4·11	17·1

Keller finds that in certain cases of digestive disturbance the amount of ammonium excreted in the form of ammonium salts may represent 50% of the total nitrogen excreted. The clinical indications when the amount of ammonium nitrogen excreted exceeds the normal is the treatment of a condition of acidosis (see p. 344).

Uric Acid.—Uric acid is a constant constituent in the urine of infants, the amount increases consistently with the age of the child.

In the following table are given the average amounts that are passed in the 24 hours at different ages :—

TABLE 11

Age	Total 24-hourly Quantity of Uric Acid (In Grams)	Amount in Grams per Kilo. of Body Weight	Amount Per Cent. in Urine
12 to 30 days .	0·0784	0·0170	0·2964
1 to 3 months .	0·1078	0·0202	0·2609
3 to 6 months .	0·1647	0·0198	0·2726
1 to 2 years .	0·2603	0·0278	0·3429
2 to 3 years .	0·3102	0·0251	0·3783
5 to 6 years .	0·4794	0·0279	0·4463

Uric acid results essentially from the transformation of purin bodies present in the food, and from the disintegration of the nuclei of the tissue cells, including, of course, leucocytes of all varieties. There can be little doubt that all those conditions which lead to a great multiplication of leucocytes in the blood lead also to corresponding excess of uric acid in the urine. A physiological increase in the number of leucocytes almost invariably follows after the consumption of food, a physiological leucocytosis which, as a rule, rapidly subsides; some increase in the amount of uric acid in the urine is to be expected as a result of the food ingested, whether or no such food contains purin bodies. With overfeeding there is a corresponding increase in the amount of uric acid.

The absolute amount of uric acid in the urine at birth is comparatively small, but owing to the relatively high degree of acidity, and the small amount of water excreted by the kidneys, the tendency to the formation of uric-acid concretions in the urinary passages is very considerable. I have within my own experience met with several instances in which such concretions have actually blocked up the membraneous portion of the urethra and rendered necessary the passage of a catheter. Since the presence of uric-acid crystals in the urine may produce serious reflex symptoms, occasionally amounting to actual convulsions, this possibility must always be considered when young infants give evidence of such symptoms. The administration of alkalies and water will, as a rule, effect the solution of uric acid and enable it to be voided in a non-irritating form.

Excess of uric acid in the urine of infants after the first few days of life must always be regarded seriously, for it indicates either overfeeding, suboxidation processes in the tissues, or some condition inducive of a leucocytosis.

Salts in the Urine.—Too much significance must not be attached to the mineral content of the urine, for so great is the physiological necessity to maintain the salt percentage of the blood at a certain definite standard that no excess of mineral elements is allowed to accumulate in the blood, hence the salts in the urine correspond very closely with the excess over and above that required to maintain the required degree of concentration in the blood—in other words, very largely with the salt intake in the food.

The output of salts in the urine will also depend on the demands of the growing tissues for these elements. Owing to the great demand for phosphorus and for calcium in the infant, in consequence of the rapid rate of development of the central nervous system and of bone, the amount of these elements in the urine is very low. Hence, in the urine of infants phosphates are either absent or present in very small quantity, and calcium shows a negative balance—in other words, less calcium is excreted in the combined emunctories than is taken into the system in the food.

The following table, showing the amounts of phosphorus excreted by children at different ages as well as the amount per kilogramme of body weight, is taken from Feldman's *Principles of Child Physiology*, page 516 :—

TABLE 12

To show Amount of Phosphorus in the Urine of Children of Different Ages

Age	Weight of Child in Kilos.	Total Amount of Phosphoric Acid excreted in Urine in 24 hours in Grams	Amount of Phosphoric Acid per Kilo. of Body Weight
12 to 30 days .	4·556	0·0609	0·0132
1 to 3 months .	5·327	0·1634	0·0303
3 to 6 months .	6·962	0·1595	0·0237
6 to 12 months .	8·288	0·2490	0·0304
1 to 2 years .	9·357	0·4320	0·0461
2 to 3 years .	12·360	0·8970	0·0725

Phosphaturia is a condition in which abnormal amounts of phosphates are excreted in the urine; it is practically always associated with a similarly high output of calcium. Under such conditions the child seldom does well. He fails to put on weight, and generally suffers from intestinal disturbances as well. The cause is probably to be sought for in a lessened demand for both these elements for the purposes of growth, owing to one or other of the many factors on which abnormal nutrition depends.

Nitrates and Nitrites.—Mayerhofer claims that normal breast-fed infants do not excrete nitrogen in the form of nitrates or nitrites, although these salts are found in the urine of infants suffering from gastro-intestinal troubles. As milk contains no nitrates it is reasonable to suppose that when these salts are found in the urine of milk-fed babies they owe their origin to the proteolytic action of bacteria in the bowel.

The Significance of Urinary Analysis in Infants and Young Children.—Mayerhofer maintains that systematic analysis of the urine in children enables one to detect the early evidences of malnutrition before serious disturbances have had time to develop. Thus in a healthy well-fed infant there should be no glycuronic acid, no phosphates, no nitrates, no sugar, no albumin, neither should there be excess of calcium, uric acid or ammonium nitrogen.

THE FÆCES AND EXCRETION BY THE BOWELS

If a somewhat disproportionate number of pages is devoted to this subject, the importance of the evidence afforded by a careful examination of the stools must be my excuse.

In the first place I would like to emphasise the fact that, for the most part, the stools, and especially those of infants, consist of genuine excretory matter from the liver and mucous membrane of the bowel, and do not represent the residua of undigested food. Water of course is, as far as bulk is concerned, the chief constituent, but of the solid matter, soaps, bacteria and mucus form the greater part.

It always strikes me as very misleading to speak of "undigested" stools when referring to the lumpy unhomogeneous stools which are so often passed by infants in conditions of ill health or inappropriate feeding. As a rule, such stools do not contain any appreciable quantity of undigested matter; they contain the usual and normal constituents, but in a different physical state owing to a too rapid transit, or because there is an excess of mucus. It is equally misleading to speak of curds or undigested curds, for such a description conjures up the idea of undigested coagula of milk or clots of casein; casein curds are found in infants' stools only in extremely rare conditions. The little white pellets which are so commonly met with in the stools of infants consist of semi-dry strands of mucus in which are entangled amorphous masses of insoluble soaps, fatty-acid crystals and bacteria. If the term "curd" had reference to the soapy nature of the majority of these little pellets it would be more reasonable, but as it stands it certainly gives a false impression, and often leads to the reduction of the casein in the food when no such change is called for by the condition.

An examination of the stools can give information with respect to the chemical constituents, the reaction, the bacterial flora and the physical condition. Mere naked-eye examinations often provide useful evidence of what is occurring within the bowel, but personally I find I learn more of the suitability, or the reverse, of the method of feeding by washing out characteristic portions of the stool in a large bowl of water, and by teasing and needling out selected portions, than I do by any other means. I cannot say that I have much confidence in bacteriological examinations. I have more often been misled than enlightened by reports of bacteriologists. The subject of the bacteriology of the intestinal tract must be of immense and fundamental importance, but at present bacteriological methods afford little help to clinical medicine in elucidating the problems of physiological feeding.

The Quantity of the Stools.—It is quite obvious from what has already been stated with regard to the constituents of fæces that the total amount will depend less on the amount of food consumed than on (1) the amount of water absorbed; (2) the excretions of mucus and other matters by the bowel wall; and (3) the number of bacteria.

All these contributory factors are themselves dependent on a great number of varying circumstances.

With a perfectly constant dietary the amount of fæces passed in the 24 hours may undergo astonishing variation, which depends to some considerable degree on the physiological demand for the various food elements. If there is excess in the supply as compared with the demand for the time being, food will be less well absorbed, bacteria will have more to live on, while waste or unwanted products, such as mucus and fatty acids, will be excreted in excess by the lining membrane of the bowel.

The percentage of water in the fæces of infants varies very much; it ranges from 72% to 85%, according as the stools are loose or formed.

It is claimed that breast milk leaves less residue than artificial food, in the ratio of about 3 to 1 (Lange and Berend). I cannot confirm this. If, in both cases, the feeding is physiologically adapted, I find the fæces of breast-fed are quite as bulky, and contain quite as large a residuum of dry matter, as those of the artificially fed; in fact, it entirely depends on the feeding. According to Camerer a breast-fed baby passes from 1 to 3 grams of fæces per 100 grams of milk consumed.

I do not believe there is any constant ratio between the amount either of breast milk or of cow's milk consumed and the amount of solids in the fæces. The amount of solids will depend entirely on the degree in which the food supplied corresponds, or fails to correspond, with the physiological demands, and the amount of fluid will depend on the requirements of the individual baby for water for other purposes, on the activity of the kidneys, skin, etc. It may be stated as a general rule that a well-fed, normal baby, whether subsisting on breast milk or on artificial food, passes in the 24 hours about 3·5 grams of fæces for every kilogramme of body weight.

The Number of the Stools.—The frequency of the motions differs very considerably in different infants: it varies with the food, with the number of the feedings, but most and chiefly on the training and management of the child himself. The act of defæcation is a complicated reflex, associated largely with the entry of food into the stomach and with concomitant psychological events. Even quite young babies, not more than a week or so old, can be trained by a skilful nurse to pass their motions into a soap dish, or other utensil, without soiling the napkins.

Without training, infants often pass a motion at each feeding, the filling of the stomach acting as the associated reflex which initiates the action. With good training two or three motions a day are amply sufficient.

It is well to remember that starvation does not always lead to constipation: frequent small actions, consisting almost entirely of mucus, are quite common in extreme cases of inanition, while over-feeding, especially as regards fat, quite normally produces large constipated soap stools.

The Consistency of the Stools.—The consistency is largely dependent on the frequency: the more frequent the stools, and the more rapidly the intestinal contents are hurried through the bowel, the more liquid the motions. If a baby passes only two motions a day the consistency will be comparatively stiff, or they may be actually formed. In breast feeding a consistency of butter or scrambled eggs is quite usual. When modified cow's milk is the artificial food, the sort of stool to aim at is one which is about as soft as butter, formed, and when cut with a knife is of absolutely homogeneous consistency.

The great advantage of a formed motion, in contradistinction to one that is liquid or pultaceous, is that in the act of passing it a certain amount of work is imposed on the intrinsic and extrinsic muscles concerned in the act of defæcation: by use and exercise these muscles develop well and become strong.

The Reaction of the Stools.—Speaking in quite general terms, the reaction of the stools in breast-fed babies is acid, while that in bottle-fed babies is neutral or alkaline; but the reason of this is that breast-fed babies as a rule consume more fat; if in artificial feeding the relationship of the protein to the fat is the same as in breast milk the reaction of the stools generally becomes acid. The reaction depends in some degree on the rate of transit of the intestinal contents through the large bowel. The reaction in the small intestine is alkaline, but this alkalinity is changed in the colon if the fæces are not too rapidly hurried through the lower part of the bowel. This change from alkalinity to acidity is chiefly due to fermentative changes set up by the bacterial flora. When, however, much protein decomposition occurs in the large bowel, or when excess of casein is present in the food, the reaction is usually alkaline. A slight degree of acidity in the stools is of favourable augury, and should be the reaction to aim at in artificial feeding; the great excess of the protein elements in cow's milk and its highly indigestible character make the attainment of this end somewhat difficult without careful modification.

The method of testing the reaction of the stools is to stir up part of a motion in water and examine with litmus or some other indicator. If it is required to test the reaction quantitatively the following plan is suggested.

A sample of fresh fæces is taken and thoroughly well mixed, and of this 20 to 30 grams are weighed out. This is diluted with 10 times its volume of boiled distilled water and titrated with deci-normal caustic soda or hydrochloric acid according to the reaction, using phenolphthalein as the indicator.

From the measure of the deci-normal solution required the acidity or alkalinity of 100 grams of fæces can be calculated. A healthy stool of a breast-fed infant requires 25 c.c. of deci-normal caustic soda per 100 grams to effect neutralisation. Such a degree of acidity is expressed as 25°.

The Colouring Matter in the Stools.—The pigment which under normal conditions in adults gives fæces their characteristic colour is hydrobilirubin or stercobilin, which is formed from the bilirubin of the bile by reduction processes in the cæcum and upper part of the large intestine. In infants, and especially in breast-fed infants, the normal colour is due to unchanged bilirubin; the green colour if present is due to biliverdin and is the result of oxidation processes. This oxidation may itself be due to the presence of oxidases or to hurried transit through the large bowel. Moderate degrees of green coloration are not necessarily of serious import, and the change from yellow to green which often occurs in the stools some hours after they have been passed is quite normal.

The pink coloration which is so often noticed on the napkin is due to some peculiar change in the bile pigment, and is not a serious condition. Green coloration may in rare instances be due to the bacillus pyocyaneus or other chromogenic bacteria; it may be differentiated from biliverdin in that it does not give a display of colour on the addition of fuming nitric acid.

The absence of bile in the stools is a serious symptom in infants, but it must not be assumed that because the stools are nearly colourless they are quite devoid of bile pigments.

Constipated actions are often somewhat pale or colourless, and so are fatty stools.

Test for Hydrobilirubin.—A small quantity of fæces must be rubbed up in a mortar with an equal part of concentrated solution of corrosive sublimate (mercuric chloride, 25 gm.; sodium chloride, 2·5 gm.; distilled water, 300 c.c.) and allowed to stand for 24 hours. If hydrobilirubin is present a deep red colour develops.

Bile salts are not usually present in the fæces except in cases of diarrhœa. Pettenkofers' test is used for their detection.

The Composition of Fæces.—As already stated, the stools of infants consist for the most part of water, fat, mucus, bacteria and salts.

The following table gives the relative proportions of solids and water in the stools of breast-fed and bottle-fed babies respectively :—

TABLE 13

The Stools of	Water	Dry Residue
Breast-fed infant . .	79·64	20·36
Bottle-fed infant . .	77·16	22·84

In the next table are given the percentage compositions of the dry residue of the stools of breast-fed and bottle-fed infants respectively :

TABLE 14

	Breast-fed Babies	Bottle-fed Babies (Cow's Milk)
Insoluble salts . .	9·5%	13·2%
Soluble salts . .	1·5%	1·8%
Total nitrogen . .	4·5%	5·9%
Fat	52·9%	34·5%

The Salts.—It will be noticed that the percentage of ash in the dry residue of the fæces of infants is higher when the food consists of cow's milk than in breast feeding. This is partly due to the fact that the salts of breast milk are better assimilated, partly because cow's milk contains a higher percentage of salts, and partly because in artificial feeding, with all its dangers and pitfalls, a larger quantity of acid bodies are generated in the body, which must be neutralised as far as possible at the expense of basic elements.

Cammidge calls attention to the great excess of ash present in the fæces of individuals suffering from chronic colitis, an excess which sometimes amounts to 45-50% of the total solid residue. Seeing to what a great extent infants are liable to colitis one can well understand that such mineral depletion may result in a rickety condition. According to Blauberg, in cases of marasmus and infantile atrophy there is often an increase of the salts in the fæces representing 20% of the dry residuum. The basic elements found in fæces consist chiefly of calcium, potassium, sodium, magnesium and iron, usually in the form of carbonates, sulphates, chlorides and phosphates. The calcium is largely in combination with butyric and other fatty acids. In rickets it is largely in combination with phosphoric acid. The actual percentages of the various inorganic constituents in the soluble ash are given in the following table :—

Table 15

	Breast-fed	Bottle-fed (Cow's Milk)
K_2O .	15·00%	11·75%
Na_2O .	4·20%	. .
CaO .	31·15%	34·63%
MgO .	8·75%	6·47%
Fe_2O_3 .	1·91%	1·50%
Cl_2 . .	3·45%	2·70%
So_3 . .	3·81%	2·50%
P_2O_5 .	11·81%	15·53%

Although too much importance must not be attached to the calcium content of fæces, it is a useful indicator of impending or existing rickets. In this latter condition there is always a negative calcium balance—in other words, more calcium is excreted in the emunctories than is taken in with the food. It is by no means decided yet whether this excess of calcium in the fæces is the cause or the result of the rickety condition. For further details on this point see the chapter on Rickets, page 334.

The Nitrogen Content of the Fæces.—As stated in Table 14, the percentage of nitrogen in the dry residue of infants' stools is from 4·5 to 5·9, representing 29·69% of protein, if, indeed, the nitrogen exists in this form. It must not, however, be supposed that all, or indeed any part of, this nitrogen represents undigested and unabsorbed residues of protein consumed. This is not so : it represents nitrogenous matter contained in the excretory and secretory products, the detritus of broken-down cellular elements, mucus and bacteria. The relative proportions referable to these sources vary very considerably in different circumstances.

The Fat in Fæces.—The amount of fat found in the stools of infants is very variable. It is dependent on a variety of factors :

the amount of fat in the food, the efficiency of the digestive and absorption processes, the physiological requirements of the body for fat, and possibly on the amount of calcium in the food. The amounts given in Table 14, page 82, appear excessive; the average amount is more probably from 20% to 40%, except in the case of very young babies, who excrete large amounts, and in certain pathological conditions in which fat cannot be absorbed.

As in the case of nitrogenous bodies found in fæces so in the case of fatty material, the total amount recoverable from the fæces does not represent only an unabsorbed residuum from the food. A certain proportion, which has not yet been accurately determined, is derived from the excretion of fatty acids by the mucous membrane of the bowel. A small quantity is derived from the bodies of bacteria. The stools of starving individuals always contain fat.

Certain observers place reliance on the diagnostic evidence afforded by the condition in which the fat exists in the stools—namely, as neutral fat, fatty acids or insoluble soaps. An excess of neutral fat generally implies some digestive disability or failure of the supply of stearopsin or other fat-splitting ferment.

Excess of fatty acids suggests good digestive powers but want of assimilation and a deficiency in the supply of available bases for their neutralisation.

Excess of soaps indicates good digestive powers but a disproportionately large supply of fat as compared with the physiological demands for this food element, together with a liberal supply of calcium and magnesium.

The differential staining of the stools with diluted Carbol-fuchsin and Sudan iii enables us to distinguish between neutral fat, fatty acids and soaps, as is shown in the following table :—

Table 16

Stain	Neutral Fat	Fatty Acids	Soaps
Sudan iii .	Drops staining orange-red	Drops staining red or crystals staining orange-red	Crystals do not stain
Diluted Carbol-fuchsin .	Drops do not stain	Drops & crystals stain brilliant red	Crystals stain dull red

For further particulars the reader is referred to *The Fæces of Children and Adults*, by P. J. Cammidge.

ABNORMAL CONSTITUENTS OF THE STOOLS

Curds.—The so-called curds found in the unhealthy stools of infants usually consist of strands of mucus rolled up more or less tightly into balls, incorporated in which are varying quantities of fat (fatty acids, neutral fat or soaps) and bacteria. Stools which contain such bodies should be washed out in a large bowl of water and the individual "curds" teased up with forceps or needles. As the strands of mucus float out and become unravelled their nature and origin become very obvious.

In rare instances casein curds are found in the stools: they are firm and tough, cannot be broken up with pressure and sink in water. They are insoluble in ether and become as hard as stone when placed in a solution of formalin.

Mucous curds which contain fat are partly soluble in acidified ether on warming and shaking. The form in which the fat exists can be determined by applying the differential colour-test described on page 84. Mucus may be distinguished microscopically as a more or less homogeneous transparent substance. On being treated with 30% acetic acid it is precipitated and becomes cloudy, with irregular linear markings.

Mucus appears in the stools in a great variety of forms; in small quantity it is a normal constituent, since it is the natural lubricant of the rectum; it is only in conditions of irritation of the bowel, and in catarrhal or otherwise unhealthy states of the intestinal wall, that it assumes pathological significance. Entangled in the meshes of mucus may be found at times leucocytes, red-blood cells, epithelial cells and food residues, in addition to fat and bacteria. Physically it can be present in as many different forms as are found in the mucous discharges from the nose during the various stages of the common cold: it may be clear and glairy, opaque, like hard-boiled white of egg, or dry, brown and encrusted. Sometimes the mucus is bile-stained, and when this is the case a catarrhal condition of the upper part of the intestine may be suspected. Mucus containing hyaline cells has probably come from the colon. Numerous leucocytes point to an inflammatory condition of the bowel.

Casts can be very easily detected by the naked-eye examination of loose stools, but in constipated conditions they often escape observation. Solid motions should be carefully washed out in a large quantity of water.

Under the microscope mucous casts are found to consist of a faintly opalescent, hazy homogeneous matrix in which are entangled a varying number of leucocytes, epithelial cells, Charcot-Leyden crystals and blood elements. The number of epithelial cells affords useful evidence of the degree of damage inflicted upon the mucous membrane.

Blood.—Blood on the outside of a constipated stool indicates a crack or fissure of the anus, an erosion or ulcer of the mucous membrane of the rectum, or, very rarely, hæmorrhoids.

Blood mixed with mucus indicates either severe inflammation of the lower part of the bowel, the pelvic colon, or rectum, or rarely an intussusception. It is unwise to make a diagnosis of intussusception merely on the evidence of blood and mucus in the stools without strong corroborative indications. In the vast majority of cases it implies a dysenteric form of inflammation of the rectum and pelvic colon.

Tarry stools, containing hæmatin and other products resulting from the decomposition of blood, usually indicate gastric or duodenal hæmorrhage.

CHAPTER VII

CONSIDERATIONS OF TASTES, HABITS, IDIOSYNCRASIES, ETC.

Tastes, Habits, Idiosyncrasies—Anaphylaxis

THESE matters are again referred to in the section which deals with the feeding of children over one year of age. It is, however, expressly included in this part of the volume because I wish to emphasise very clearly that suggestion and other psychological factors play quite as important parts in the actions and behaviour of infants in connection with food and feeding as in the case of adults and older children with developed intelligence.

Taste.—Taste, in conjunction with the sense of smell, enables the individual to distinguish between foods which are agreeable and wholesome and those which are nasty and poisonous. These senses, if properly developed and controlled, become very valuable servants, but they can be very tyrannical masters.

Certain tastes are innate, others have to be acquired by experience. Very young babies have a natural liking for milk and sugar, and certain other varieties of good and wholesome food, and they have a very decided antipathy to strong-tasting, acid or pungent flavours; but to a very large extent their likes and dislikes are acquired and memorised. As a rule an infant appreciates a food for ever afterwards when his first introduction to it has been accompanied by favourable and satisfactory results. If it proves too stimulating to the sense of taste or smell, if it gives any form of pain or disagreeable sensation, or if it is too hot or too cold, the taking of this particular variety of food may evoke painful memories, or associated reflexes, which will lead the child to refuse it on subsequent occasions. It cannot be supposed such reflexes have at first any real basis of consciousness or intelligence: they are purely automatic or subconscious, but as the child grows older the automatic reflex becomes a perfectly well-defined conscious like or dislike. It is, therefore, obviously of importance that when an infant is given a new food for the first time there should be no disagreeable results connected with it.

I have known cases in which infants have taken very strong and permanent aversions to very good and wholesome foods because they have been too hot or too cold, or in some other way have appeared strange or unusual to the infant. Many an infant refuses to take solid food because, when first tried with a rusk or a crust, a small crumb has stuck in the back of the throat and given rise to a paroxysm of choking.

Food Habits.—Food habits are very insistent realities; they assume greater importance after infancy, but even infants are not exempt.

The statement is often made that the members of such-and-such a family cannot digest this or that food, that all the members of the family are large or small eaters, or that milk or some other food always makes them sick. Such habits are seldom hereditary, except in the sense that the "suggestion," which is the basis of the habit, is handed on from parent to child in certain families. Greediness and overeating certainly run in families, and are due to faulty estimates of food requirements which become perpetuated from one generation to another.

The infant who is overfed develops a correspondingly large stomach and active digestion; he grows into the overfed child and the hungry grown-up. Small eaters also owe their good fortune to their early experiences.

In the case of food idiosyncrasies it is important to know whether there is any genuine physical basis for them or whether they are merely cases of suggestion.

There are certain individuals who are very susceptible to the influence of foreign proteins and who react violently to them when they enter the circulation or lymph-stream. Marked sensibility of this kind is known as anaphylaxis. Infants are often anaphylactic to the proteins of cow's milk and present various symptoms when the latter is given to them.

Under normal conditions, when cow's milk is consumed the proteins—caseinogen and whey albumins—are broken up by the processes of digestion into simple poly-peptide forms which do not excite anaphylactic symptoms after absorption, but when the digestive functions are inefficient unaltered proteins may be absorbed, with serious results. Individuals who suffer from asthma, hay fever and certain forms of urticaria and eczema are usually anaphylactic to foreign proteins. This possibility must be borne in mind in investigating causes of food intolerance.

PART II

PRACTICE OF FEEDING INFANTS AND CHILDREN IN HEALTH

CHAPTER I

BREAST FEEDING

General Review—Preparation for Breast Feeding before Confinement—The Establishment of Lactation—Colostrum—Diet of Nursing Mother—Maintenance of Lactation

It is a strange fact that breast feeding, which has enabled the human race to survive some very troublous and perilous periods, both in its ontogenetic and phylogenetic history, should now, at a time when the conditions of the environment are so eminently under control, give place to most unnatural methods of feeding.

Human infants certainly do not become robuster with the progress of civilisation, but whether their nervous systems become more highly developed and complex, through the operations of natural selection and other causative agents or not, it is quite certain that the modern baby is much more nervous—that is to say, more sensitive to his environment—than his more primitive prototype.

The present-day baby is difficult to rear, breast milk or no breast milk, and hence when things go wrong, as they often do, the so-called resources of civilisation are at once invoked. If the infant is breast-fed he is weaned, if bottle-fed his food is changed. There is, however, seldom any justification for believing that if breast milk fails there will be any better results with an artificial substitute. The truth is that the breast-fed infant requires a considerable amount of management even though the milk be of the best quality; he requires time to accommodate himself to his new conditions, and care must be taken that he does not obtain too much or too little at a feeding, that he does not swallow air, and that he is not fed irregularly. To manage breast feeding well great experience and knowledge are required. It is only recently, however, that any systematic attempt has been made in maternity institutions or in hospitals to study or to teach this essential part of a nurse's duty.

PREPARATIONS FOR BREAST FEEDING BEFORE CONFINEMENT

In the following pages I shall insist over and over again that the two most important conditions that must be fulfilled to make breast feeding successful are (1) strong sucking on the part of the infant, and (2) a cheerful mental attitude on the part of the mother.

Steps can be taken before the confinement to promote, if not to ensure, these desiderata. The mother can be encouraged not only to believe in her capacity to nurse, but she can also be instructed in the technical details of nursing, and in the physiological processes of lactation. She will in this way know what to expect, and will not be disappointed if everything does not run perfectly smoothly.

In order that the infant may be able to suck strongly it is desirable, if not necessary, that he should have a good nipple to grip. Much can be done during the last few months of pregnancy to draw out depressed or flat nipples by suction with the breast-pump, by massage or other appropriate procedures. Unless the skin covering the nipples is suitably prepared it sometimes becomes sore or cracked, and thus, owing to the pain caused, gives rise to unpleasant anticipations and a psychological attitude of mind which are most unpropitious for successful nursing.

Forcible sucking on the part of the infant causes a good deal of wear and tear of the covering epithelium; moreover a certain amount of maceration also occurs. The nipples can be prepared to meet such contingencies by gentle massage or inunction with emollient creams prepared from lanoline, glycerine, etc. The old practice of hardening the skin with alcohol and astringents is strongly to be deprecated, as it is likely to lead to the formation of cracks and fissures.

During pregnancy there is a steady and continuous evolution of the mammary glands under the activating influence of certain internal secretions or "hormones" elaborated by the chorionic villi, or other cellular elements in the walls or contents of the gravid uterus. It is interesting to note that the same "hormones" circulating in the blood of the developing fœtus lead to similar changes in the breasts of the latter, a fact which explains the remarkable enlargements in the breasts of new-born infants of both sexes. This hypertrophic condition soon subsides when the sources of stimulation are cut off by the tying of the cord. The only event which is likely to interfere with the physiological involution of the breasts which normally occurs in new-born babies is irritation or friction. In former days midwives sometimes "dispersed" the milk, as they called it, by massage with the fingers; this practice frequently led to inflammatory reaction, and occasionally to actual abscess formation.

THE ESTABLISHMENT OF LACTATION

At the time of birth the breasts, though usually well-developed, are not functionally active. It is quite true that for some months before confinement a thin serous secretion can be expressed from the nipples, but this fluid merely represents an oozing from the full and congested vessels. It is not true milk. The latter does not, as a rule, make its appearance till the third day or later, and only then if the physiological stimulus of sucking has been adequately applied. During the first few days after birth, as during several months prior to the confinement, there is a serous discharge which can be drawn from the nipples by suction. This secretion is called colostrum, and it has properties of enormous physiological importance.

Colostrum is a fluid of deep lemon-yellow colour, containing a considerable number of fat droplets of more unequal size than in ordinary milk, as well as a variable number of large amœboid cells known as "colostrum corpuscles." These bodies are now generally regarded as specially large leucocytes. They are actively phagocytic in that they can engulf bacteria, such as staphylococci, coli bacilli, and tubercle bacilli—functions which are probably of value to the new-born baby.

The chemical composition of colostrum is as follows :—

TABLE 17

To show the Chemical Composition of Colostrum

Day of Life	Fat per Cent.	Protein per Cent.	Sugar per Cent.	Ash per Cent.
First . .	2·59	9·75	2·75	0·408
Second . .	2·17	7·45	3·50	0·340

It will be noticed from an examination of the above table that the protein content is very high as compared with that of milk—

in fact, about six times as high. This characteristic of colostrum is certainly of teleological significance, showing the need in new-born infants of physiological protein bodies. One interesting fact in connection with these proteins is that they possess the same hæmolytic action as the mother's blood—in fact, they are unchanged globulins derived from the maternal blood or lymph. They are coagulable at 72°C., and no doubt contain, or are associated with, the immune bodies which are known to be so largely represented in colostrum, and to a lesser degree in milk itself.

The specific gravity of colostrum is 1·028 to 1·072, the average being 1·040.

The reaction is strongly alkaline.

The fat in colostrum is not the same as that of milk, it contains more oleic acid than milk fat.

The sugar is for the most part lactose, but during the first day or so it usually consists of dextrose as well.

The salts are very much the same as in milk, but in larger proportion, especially as regards phosphorus, which is quite 100% higher than in milk.

Lecithin and cholesterin are both present in colostrum, and in greater amount than in milk.

The Amount of Colostrum.—The amount secreted depends very largely on the vigour with which the infant sucks. In sixty-four cases examined for me by Dr W. O. Pitt at the Maternity Department of the St Marylebone Workhouse, the average quantity obtained by the infants in 24 hours was as shown in Table 18 (see p. 95).

It is of interest to notice that in this consecutive group of 64 cases there was not a single failure to establish lactation, although most of the mothers were primiparæ and of the poorest class. At the end of 14 days the average gain in weight was 8 oz. Observe the fall in the average amount of milk secreted on the 11th day, when the mothers got up.

The Physiological Significance of Colostrum.—In the first place colostrum is a valuable and almost indispensable educational medium: the gradual change from colostrum to milk, which occurs between the first day of life and the time when true milk is excreted —generally the third or fourth day—gives the stomach and the intestines time and opportunity to settle down to their newly acquired functions. It is impossible to conceive of any nutritive fluid being less irritating to the stomach and intestines than colostrum, for, as already stated, it is practically maternal lymph, the same fluid that has bathed the fœtal tissues during the previous

TABLE 18

To show the Average Amount of Colostrum or Milk obtained during the first 14 Days of Life (64 Cases)

Age in Days	Total Quantity of Food taken in the 24 Hours		Average Quantity of Food taken at one Feed	Average Weight of Babies	
	oz. (avoirdupois)	drachms	drachms (avoirdupois)	lb. (avoirdupois)	oz.
1 .	0	9	2·28	7	1
2 .	1	15	5·23	7	1
3 .	4	12	8·11	6	10
4 .	6	4	9·98	6	15
5 .	6	11	11·70	6	15
6 .	7	3	12·39	7	1
7 .	7	9	12·43	6	15
8 .	7	13	13·29	7	3
9 .	8	1	13·80	7	2
10 .	8	4	13·93	7	2
11 .	7	14	13·36	7	0
12 .	8	8	14·88	7	4
13 .	8	13	14·69	7	4
14 .	8	11	14·70	7	9

NOTE.—The weights in this table are avoirdupois, with 16 drachms to the ounce. These babies were not fed 3-hourly, on the modern system, but 3 times the first 24 hours, 5 times the second, 8 times the third, and 10 times for the rest of the period of observation.

nine months of intra-uterine life. Hence there is nothing new or unfamiliar about colostrum ; it can be absorbed directly into the blood without preliminary digestion, and without provoking those hæmolytic reactions which take place when foreign proteins gain access to the circulation, and which no doubt are the cause of those disastrous consequences which often ensue when new-born babies are fed on cow's milk or whey mixtures.

The extremely small quantities in which colostrum enters the infant's stomach protect the latter from the undue distension and overloading which usually occurs in artificial feeding. It would be well if all those who are responsible for the management of nursing mothers were to study very carefully the table given on this page which shows the average consumption of colostrum.

When during this period babies cry, and give other evidences of supposed hunger, a timely recollection of these figures may act as a reminder that Nature deliberately starves the new-born baby in order that the digestive functions may have time to develop gradually. The disastrous results which follow unwise haste in the educational process are very familiar experiences with the pædiatric physician.

It is often stated that colostrum acts as an aperient and that it has a useful influence in clearing out the meconium. It would be difficult to find greater untruths compressed into any one sentence. It acts less as an aperient than any other known food, and if it really did clear out the meconium it would confer a great disservice, for, within limits, the longer meconium remains in the bowel to form the basis of the stools the better for the infant.

One of the most important physiological properties of colostrum, and one which is probably closely associated with its high protein content (8-9%), is the protection which it confers by reason of its contained immune bodies, and this is quite independent of the phagocytic action of the colostrum corpuscles. At the time of birth the infant's defences against bacterial invasion are ill developed and it has to depend very largely on the protection afforded by its blood—in other words, by its mother's blood—and on such reinforcements as it receives in the colostrum. It is fortunate that this material is so well provided with the very protective bodies which are most needed. For further particulars on this interesting subject the reader is referred to Feldman's *Principles of Child Physiology*, pages 174 and 550, also to Dr Janet Lane Claypon's *Milk and its Hygienic Relations*, pages 108-125.

PRACTICAL DETAILS OF THE MANAGEMENT IN THE ESTABLISHMENT OF LACTATION

At the time of birth the mammary glands are, as far as structure is concerned, quite ready to begin the manufacture of milk. All that is now needed is to supply the reflex stimulation which sets the machinery in action. This is afforded by the mechanical effects of sucking by the infant. The more strongly and forcibly the infant sucks the more probable is it that the secretion of true milk will succeed the colostrum period in physiological manner and in due chronological order. This event is, however, often retarded by feeble efforts on the part of debilitated or premature infants, or because the chief inducements to suck—namely, hunger and thirst—are removed by misguided supplementary feedings of milk or whey.

It is a wise precaution to estimate the amount of mammary secretion the infant obtains from the mother, even during the colostrum period, for in this way the mother may be reassured that everything is proceeding on normal and physiological lines, and sudden overloading of the stomach when the milk "comes in" can be avoided.

In order that the mammary glands may acquire regular habits of function, it is most important that the infant should be put to the breast at the same times every day. It is a great mistake to feed the infant at different intervals on succeeding days as is so often done. It is even more important to feed at the required periods on the first day of life than on the second, third or fourth, for habits of function are more easily established when an organ first begins to functionate than at any other period of its activity. The same applies also with respect to the establishment of regular habits of function in the stomach and entire digestive system of the infant.

If, as is probably the best procedure in the great majority of cases, it is proposed to feed the infant at three-hourly intervals during the day, without any night feedings at all, the new-born infant should be put to the breast three hours after birth, and the feeds should be repeated every three hours until 9 or 10 at night, when the last feed for the day should be given. There should then be no further feeds till 6 or 7 o'clock in the morning. This long interval of undisturbed rest at night is invaluable for the infant and a great boon to the mother, for regular habits of sleep are thereby very easily established, but if during the first few days of life the infant is encouraged and taught to wake up for night feedings it is very difficult to eradicate the bad habit. Old-fashioned nurses are wedded to night feedings, and it is sometimes very difficult to overcome their prejudices, but the satisfactory progress which is made by infants who enjoy the enormous advantages conferred by the long sleep at night fully compensates for the trouble sometimes necessary in attaining one's object.

The infant should always be wakened up at feeding times and never allowed to sleep longer than the prescribed limits; on the other hand, he should not be allowed to anticipate these limits, however insistent he may be to be fed; in this way only can regular habits be induced.

Great care should be exercised in thoroughly waking up the nursling before he is put to the breast: he should not be allowed to fall into lazy or indolent habits. At first he should not be allowed to remain at the breast for more than a few minutes, in order than the tender nipples of the mother may not be macerated or damaged by prolonged sucking; after the second or third day the duration of the feed may be extended, but it is of the greatest importance that each feed should be carefully estimated by the "test feed," to prevent under-feeding as well as over-feeding. Under-feeding at any particular meal, or at all meals, is very apt to spoil the temper of the infant and convert him into a discontented crying baby, while over-feeding brings inevitable consequences in its train which are just as serious.

It will be noticed, from an examination of Table 18, on page 95, that the average quantities of colostrum and later of milk obtained by the infant during the puerperal period are very small. Indeed, they must be very small if the nursling is to do well, and that they can do well on such small amounts is evident from the increases in bodily weight recorded in the table. If, however, in any particular case the amount of the secretion falls seriously below these average amounts, the infant cannot be expected to thrive and put on weight, if not from actual lack of food, at least from sheer want of water. Under such circumstances there are two alternative methods that can be adopted. Steps must be taken to increase the secretion, or supplementary feeding must be resorted to. The one step that is practically never justifiable is to wean the baby.

How to promote the Evolution of the Mammary Functions.—When the establishment of lactation is delayed the mammary glands can sometimes be stimulated into activity by massage, and the alternate application of hot and cold compresses. I have little confidence in galvanic or faradic electricity, a method of stimulation which has been advocated. The best means of all is to secure the services of a strong, lusty baby somewhat older than the mother's own infant: such a baby, if he sucks actively, may afford the required physiological stimulus.

There are no scientific grounds for trusting in the efficacy of any of the much-vaunted and much-advertised preparations which are sold as galactogogues; as far as it is known no drug or food can influence the establishment of lactation or the amount of milk secreted.

It is, unfortunately, a very common practice to overload the stomach of the nursing mother with food of all sorts, and especially with sloppy foods and gruels, in the hope that lactation may be promoted; this practice is very unsound and generally defeats its own ends by upsetting the digestion and general health of the patient.

The Diet of the Nursing Mother during the Puerperium.—The food of the nursing mother during the first two or three days after confinement requires to be carefully adjusted, for the woman is usually in a condition of fatigue, if not of actual shock. All the functions, therefore, including those of digestion, are to some extent depressed. During the first 24 hours at least, the food should be restricted in quantity and thoroughly digestible in character; it need not, however, be too sloppy. The chief reason why the total quantity should be restricted is because the blood of the mother during the early days of the puerperal period is flooded with the products of auto-digestion of the involuting uterus and adnexæ. This supplementary addition to the ordinary sources of food can be utilised for the purpose of milk formation, and no doubt this is, in part at least, an explanation of the quickening of the processes of involution of the uterus in nursing mothers, and of the delay that occurs when artificial feeding is resorted to.

The chief points that I have to criticise in the dietaries usually afforded to nursing mothers, in addition to the over-feeding to which I have already referred, are: (1) the food is too sloppy; (2) it is of too nitrogenous a character; (3) it does not contain enough fruit or vegetables. It is a very erroneous view to hold that vegetables and fruit produce wind and acidity in the mother and green stools in the baby. This is exactly the opposite of the truth, unless, indeed, the mother is so overloaded with other varieties of food, including milk, that any additional supply of vegetables or fruit acts as the final straw which breaks the camel's back.

As long as the mother remains in bed her food should be restricted, for the reason that, in spite of certain definite requirements for milk elaboration, the total energy requirements are less than usual owing to the reduced output of physical energy during her enforced rest. This fact is very often overlooked, and the supposed drain upon the food supply brought about by the function of the mammary glands is allowed to overshadow all other considerations.

During the puerperal period there should be three meals a day only, with no extras between meals, nor gruel before going to sleep at night. They may be arranged as follows :—

Breakfast.—Tea, coffee or cocoa, with 8 oz. of milk ; dry toast, butter, with jam or stewed fruit.

There is no advantage, but very much the reverse, in giving porridge, fish, eggs or bacon at this meal.

Lunch.—Poached egg, fish or cutlet, with small quantity of potatoes and liberal allowance of other vegetables, including green varieties. Stewed fruit with plain cake or biscuits.

There is no need to give milk puddings. The same ingredients as are usually supplied in milk puddings can be provided in biscuits, which have the advantage of being dry.

Tea.—A cup of weak China tea, with one thin slice of bread and butter.

Dinner.—Soup, with fish or meat. Vegetables and salad. Stewed fruit and plain pudding.

In this dietary there is no reference to fluids other than tea, coffee, soups, etc. The total amount of fluid in the 24 hours should be about two pints or a little over. Fluids are better taken about one hour before meals if they consist of water, mineral waters or barley water. Alcoholic beverages are not required unless the mother has been in the habit of taking them and would feel their loss if omitted.

Beer or nursing stout given for the sole reason of promoting the secretion of milk is given on entirely unscientific grounds, and can only do harm.

THE MANAGEMENT AND MAINTENANCE OF LACTATION

Troubles in connection with breast feeding do not arise exclusively during the period of the establishment of the milk flow, difficulties are often experienced later in maintaining the activity of the mammary glands.

Infants are frequently weaned quite unnecessarily under the erroneous belief that the milk does not agree, or is insufficient in quantity, when the real reason of the want of success may be due to quite different causes. No infant should be weaned and condemned to artificial feeding unless or until the quality or the supply of the breast milk can be proved to be at fault. It is quite a simple matter to measure accurately the amount of milk obtained by the infant, but even in those cases in which the total quantity falls short of the estimated requirements there is no ground for weaning unless the quality is also bad, for breast milk can always be supplemented by artificial feedings. To determine the quality of the milk is a far more difficult matter; a chemical analysis is practically useless, for the evidence afforded by this means of inquiry merely gives information with respect to the actual quantities of the three chief constituents—namely, the proteins, the fat and the sugar. I am quite sure I do not overstate the case when I say that out of a hundred infants who fail to thrive on breast milk not 5% owe their failure to faults in the relative proportions or to the qualities of these constituents which can be detected by chemical means.

An infant may not do so well when there is any serious departure from the physiological standard as when all these constituents are in perfectly normal proportions, but such irregularities do not make a baby ill. What does make a baby really ill is the presence in the milk of toxic substances which cannot be detected by the ordinary methods of chemical analysis. The only tests which can demonstrate the presence of these elusive poisons are physiological tests—namely, their influence on the baby himself or on some experimental animal.

Breast-fed infants often become ill and manifest serious symptoms if the menses of the mother return, but an analytical examination of her milk will not show a constitution different from that which has heretofore obtained, and on which the infant has thrived, and the same disappointing result follows when the quality of the milk is impaired from psychological disturbances or from epilepsy in the mother. There can be little doubt that subtle poisons arising in the mother as the result of metabolic disturbances find their way into the milk and upset the infant she is nursing, without affording any indication of their presence which chemical methods of analysis can reveal. I have long ceased to place any reliance on the evidence of the laboratory in such matters.

CHAPTER II

BREAST FEEDING (*continued*)

Chemical Composition of Breast Milk—Proteins—Sugar—Fat—Lecithin—Salts—Iron—Phosphorus—Foreign Substances—Drugs—Toxins, etc.—Influence of Diseases in the Mother—Influence of Diet on the Secretion of Milk—Amount of Milk secreted and Factors which influence it

In the following pages I propose first to discuss the chemical composition of breast milk, and then the extent to which faults in its composition may be altered by dietetic or other means; then I shall pass on to considerations of quantity, and finally to certain practical details in the management of the nursing mother and her child.

THE CHEMICAL COMPOSITION OF BREAST MILK

As is shown in the accompanying table (see p. 103), the composition of breast milk, according to different authorities, can vary within very wide limits.

It may be assumed, however, that the average composition of breast milk is as follows :—

Table 19

Protein Per Cent.	Sugar Per Cent.	Fat Per Cent.	Ash Per Cent.	Water Per Cent.
1·50	7·0	3·50	0·20	87·8

This I regard as the correct physiological standard, and to this standard all substitutes for breast milk recommended in the sections which deal with artificial feeding have been modified. It cannot be imagined for one moment that the chemical composition of breast milk is without teleological significance, or that the milk of another mammal can be substituted for it without doing violence or injustice to the digestive or metabolic functions of the human infant (see p. 229). Let me now describe in greater detail these various constituents.

Proteins.—The protein content of milk is usually estimated by determining the total nitrogen by the Kjeldahl method and multiplying this figure by 6·25. This method, however, is not exact, because there are other nitrogenous bodies in milk beside

TABLE 20

Variations in Composition of Human Milk

Authority	Protein Per Cent.	Sugar Per Cent.	Fat Per Cent.	Ash Per Cent.	Solids Per Cent.	Water Per Cent.
Pfeiffer . .	1·049 to 3·04	4·22 to 7·65	0·75 to 9·05	0·104 to 0·446	8·23 to 15·559	84·441 to 91·77
Johannessen and Wang . .	0·9 to 1·3	5·9 to 7·8	2·7 to 4·6	..	..	..
V. and J. S. Adriance . .	0·23 to 2·60	5·35 to 7·95	1·31 to 7·61	0·09 to 0·28	9·15 to 15·31	84·69 to 90·85
Guirand . .	0·85 to 1·4	6·7 to 7·7	1·75 to 6·18	0·10 to 0·27	11·2 to 16·3	83·7 to 88·8
Camerer and Söldner . . .	0·82 to 1·85	5·35 to 7·52	1·28 to 5·77	0·11 to 0·36	9·41 to 14·11	80·59 to 85·89
Schlossmann .	0·56 to 3·4	5·2 to 10·9	1·65 to 9·46	..	..	..
Holt . . .	1·00 to 2·00	6·50 to 8·00	3·00 to 5·00	0·18 to 0·25	9·68 to 15·25	84·75 to 90·32

the proteins. These undetermined bodies may account for 17% to 20% of the total nitrogen.

Schlossmann, however, gives the following table to show the total nitrogen in 100 c.c. of human milk at different stages of lactation, and the amount of protein which is represented by these figures, estimating that the total nitrogen figure must be multiplied by the factor 6·25.

[TABLE

TABLE 21

Day	Total Nitrogen Per Cent.	Total Proteins calculated by multiplying by the Factor 6·25
9th to 10th	0·29	1·83
11th to 20th	0·29	1·83
21st to 30th	0·31	1·93
31st to 40th	0·24	1·50
41st to 50th	0·28	1·75
51st to 60th	0·25	1·56
61st to 70th	0·23	1·43
71st to 100th	0·20	1·25
101st to 140th	0·20	1·25
141st to 200th	0·20	1·29
Over 200th	0·21	1·31

The variations shown in the preceding table are not of great significance, for in the same woman the total nitrogen content of the milk will vary slightly from day to day or from hour to hour.

The Character of the Proteins.—Human milk contains two kinds of albuminous bodies: (1) casein, which is insoluble in water; (2) the whey or soluble proteins, lactalbumin and lactoglobulin.

According to Morse and Talbot the total nitrogen of human milk is combined as follows :—

Casein	41%
Lactalbumin, Lactoglobulin	39–44%
Residual Nitrogen	15–20%

We know less about the exact chemical composition of human casein than we do about the casein of cow's milk. We know, however, that they are not identical. The physical properties are different, as shown by the more flocculent curd thrown down by the coagulation of breast milk, while physiologically they can be differentiated from one another by complement fixation and anaphylactic tests.

These differences are certainly due to want of identity in their amido-acid make-up. The amido-acid make-up of cow's-milk casein has been studied by Osborne, and is given in the following table, in which it can be conveniently compared with that of certain other protein bodies. The amido-acid make-up of casein is interesting because it contains representatives of nearly every known variety, while most other proteins lack certain essential amido-acids which are necessary for growth and the maintenance of nutrition, a fact which explains how it is that nutrition can be maintained on an exclusive diet of milk, but on hardly any other single form of protein. It is true that casein contains no glycocoll, and only a very doubtful representation of cystine, but the absence of glycocoll can be compensated for by its synthesis out of glyoxal, which is produced during the metabolism of carbohydrates and ammonia, while the deficiency of cystine is made good by lactalbumin, which contains a sufficiency of this amido-acid. Lactalbumin has a somewhat similar composition to serum albumin, which appears in the following table :—

Table 22

To show the Amido-Acid Make-up of certain Proteins

Amido-Acid	Casein	Egg Albumin	Gliadine	Zein	Edestin	Legumin	Ox Muscle	Serum Albumin
Glycocoll .	..	..	..	..	3·80	0·38	4·0	..
Alanine .	1·50	2·22	2·00	13·39	3·60	2·08	8·1	2·69
Valine .	7·20	2·50	3·34	1·88	6·20	..	2·00	..
Leucine .	9·35	10·71	6·62	19·55	14·50	8·00	14·3	20·00
Proline .	6·70	3·56	3·22	9·04	4·10	3·22	8·0	1·04
Phenylalanine . .	3·20	5·07	2·35	6·55	3·09	3·75	4·5	3·08
Glutaminic acid .	15·55	9·10	43·66	26·17	18·74	13·80	10·6	1·52
Aspartic acid	1·39	2·20	0·58	1·71	4·50	5·30	22·3	3·12
Serine . .	0·50	..	0·13	1·02	0·33	0·53	..	0·60
Tyrosine .	4·50	1·77	1·61	3·55	2·13	1·55	4·4	
Cystine .	..	..	0·45	..	1·00	..	..	2·30
Histidine .	2·50	1·71	1·84	0·82	2·19	2·42	14·5	..
Arginine .	3·81	4·91	2·84	1·55	14·17	10·12	11·55	..
Lysine .	5·95	3·76	0·93	..	1·65	4·29	7·5	..
Tryptophane	1·50	present	1·00	..	present	present	present	a trace
Ammonia .	1·61	1·34	5·22	3·64	3·28	1·99	1·07	..

The lactalbumin and the lactoglobulin of milk agree in all their properties with the proteins of the blood of the mother. This is important from the point of view of anaphylaxis. The lactalbumin of cow's milk, or possibly of a wet nurse's milk, if absorbed into the circulation of a baby may act as a foreign body and cause specific reactions. This is a strong argument in favour of breast feeding on the part of the mother.

The Sugar.—The sugar in breast milk is lactose or milk-sugar; it is the least variable constituent in milk, the amount seldom being more nor less than 7%. It is identical with the lactose of cow's milk.

The Fat.—The fat in human milk exists in a condition of a very fine emulsion. The individual globules measure from 0·001 to 0·02 mm. while those of cow's milk measure 0·001 to 0·01 mm. The percentage of fat varies with the length of time the mother has nursed her baby: it tends to increase towards the end of an individual nursing and to be less at the beginning. The percentage of fat in the milk first drawn varies from 1 to 3%, while in the strippings it varies from 6 to 10%. On an average the percentage of fat is about 3·5%.

The fat of human milk is not identical with that of cow's milk, a fact which should be remembered, but the latter resembles human butter fat much more closely than cod-liver, olive or linseed oil, which are sometimes substituted for it. The following are the properties of human butter fat:—

The melting-point is between 30° and 34° C.

The solidifying point is between 19° and 22·5° C.

The exact chemical composition cannot be stated, for no two samples are identical, but speaking in general terms, it may be said that the percentage of tri-glycerides in human milk and in cow's milk are as follows:—

Table 23

Percentage of Tri-Glycerides in Milk

Cow's Milk		Human Milk	
Oleic	33·9%	Oleic	50·0%
Palmitic	40·5%	Palmitic	33·6%
Myristic	10·4%	Myristic	10·0%
Lauric	2·7%	Lauric	3·0%
Stearic	1·9%	Stearic	2·0%
Butyric	6·2%	Capric, Caprylic, Caproic	1·5%
Capric, Caprylic, Caproic	3·1%		

Lecithin.—I have for many years pointed out the importance of lecithin as an essential factor in nutrition and growth which must be taken into account in the feeding of infants. It would probably be more correct to speak of lecithin bodies, for there are almost certainly several varieties. The lecithins are lipoids or combinations of a phosphorised fat with a nitrogenous basic radicle. Lecithin is present in the brain and nerve tissues, and hence it is to be expected that the milk of those animals in which the development of the brain is most rapid during the early period of life should contain the largest percentage of this substance. To some extent this is true, as has been shown by Professor Starling in the accompanying table :

TABLE 24

	Calf	Puppy	Infant
Relative weight of brain to that of body . . .	1·370	1·30	1·7
Lecithin content of milk in percentage of protein .	1·40	2·11	3·05
Percentage in milk . .	0·048–0·058	. .	0·058

The function of lecithin in the economy of the body is probably not confined to the building up of nerve tissue. It may be concerned also in the development of red-blood corpuscles, as also in the carriage of certain insoluble bodies from the alimentary tract into the circulation.

Lecithin bodies are clearly connected in some way with growth and development, and are so intimately concerned with the maintenance of sound nutrition that they deserve to be included among the accessory food factors and to rank equally with the vitamines.

Salts.—The average amount of ash in human milk is 0·21%. This amount diminishes as lactation proceeds, as is shown in the following table from Camerer and Söldner :—

TABLE 25

Day since Birth	Per Cent. of Ash
8th to 11th day	0·28
29th to 40th day	0·22
60th to 140th day	0·19
120 days and later	0·18

In the following table are given the actual amounts of the mineral elements in 100 parts of ash :—

TABLE 26

Salt	Percentage in 100 Parts of Ash
K_2O	32·14
Na_2O	11·75
CaO	15·67
MgO	3·99
Fe_2O_3	0·27
P_2O_5	21·42
Cl	20·35

The ash varies in amount according as the sample of milk is taken at the end or the beginning of a nursing. There is more total ash at the beginning, but rather less calcium and magnesium. The calcium content falls off also as lactation proceeds, but the amount cannot be restored by giving the mother calcium salts to take with her food.

Iron.—The iron content of the milk appears to be dependent on the general health of the woman. It is higher in those who are in good health, and lower in those who are debilitated. The average amount is 5·09 mg. per litre of milk, but this diminishes towards the end of lactation.

Phosphorus.—Although there is far less phosphorus in human milk than there is in that of the cow, three-quarters of that which is present in human milk is in organic combination, whereas in cow's milk the proportion is one quarter. The total amount of phorphorus, as estimated in P_2O_5, present in milk is on the average 0·1461 grams per litre.

FOREIGN BODIES IN HUMAN MILK

There can be very little doubt that the mammary gland has not got the same power as the placental filter for rejecting substances which are injurious to the health of the child. As has already been mentioned (p. 103), something like 20% of the total nitrogen of breast milk cannot be accounted for in the form of protein bodies. It is highly probable that a considerable proportion of this deficit is represented in toxins, antibodies, antitoxins, agglutinins, hæmolysins, opsonins and bactericidal substances generally, in spite of the fact that we have no absolute proof that this is the case; but circumstantial and collateral evidence is so strongly confirmative of this view that we are probably justified in accepting it.

Drugs excreted in the Milk.—From the fact that so many drugs taken by the mother find their way into the milk, it has been assumed that milk is an excretion as well as a secretion. It would probably be more correct to state that the secreting surface of the mammary gland has little power of rejecting the soluble substances which filter through from the lymphatics.

The following drugs have been found in traces in human milk:—antipyrin, arsenic, aspirin, the bromides, calomel, mercury, potassium iodide, sodium salicylate, urotropin and various iodinised oils. Alcohol has also been found in human and bovine milk after the ingestion of large amounts. It is highly probable that both morphine and atropin are excreted in the milk if the quantity consumed is large, since they have been proved experimentally to be excreted in cow's milk.

Salvarsan certainly is excreted in the milk of women who have been under treatment with intravenous injections of this arsenical preparation; in certain instances syphilitic infants have been reported to benefit greatly from this indirect form of treatment. The fact that one or two infants have died suddenly after salvarsan treatment of the mother does not militate against this method of treatment, for syphilitic infants often die suddenly from no obvious cause.

Poisonous Substances in the Milk of Maternal Origin.—It has already been mentioned (p. 101) that certain poisonous substances, the result of disturbed metabolic processes in the mother, may find their way into the milk and upset the child. Very strong nervous impressions, due to fright, grief, passion, excessive sexual indulgence, epileptic fits, and menstruation, may impart qualities to the milk which make it actually poisonous to the infant who consumes it. In certain cases the secretion of milk may be entirely arrested as the result of violent emotion.

Rotch was of opinion that menstruation noticeably influenced the gross chemical composition of the milk, but Bendix repeating the experiment concluded that such variations as he found in the milk of menstruating women were well within the normal physiological limits. It is probable that disturbances resulting in the infant under such conditions are due to toxic bodies of a character which can only be detected by physiological tests.

THE INFLUENCE ON MILK OF DISEASE IN THE MOTHER

Infective Disease in the Mother.—I cannot think it justifiable on theoretical or practical grounds to wean infants indiscriminately simply for the reason that the mother is suffering from a chronic or an acute infective disorder. The fact that the blood of infants nursed at the breast contains more bactericidal substances than those artificially fed is of itself an argument in favour of the mother continuing to nurse her baby unless by so doing her own condition is imperilled.

I believe it to be of the greatest advantage, indeed the best means of escape, for the infant of a tuberculous mother to be nursed by its mother, and the same is true in the case of syphilis. If a mother has an infectious disorder, acute or chronic, the infant is invariably inoculated; it is practically impossible for it to escape; its only hope of salvation lies in its capacity to resist. If it can derive immunising or bactericidal substances from the mother's milk, and thereby have its powers of resistance reinforced, it must be of benefit to the child.

For these reasons I never order a breast-fed infant to be weaned simply on the grounds of infection in the mother. I consider each case on its own merits.

On the other hand there are certain diseases in the mother connected with perversions of metabolism, such as epilepsy, uræmia, kidney disease and diabetes, in which poisonous substances may find their way into the milk and cause injuries to the child. In such cases it is probably wiser to feed the infant artificially, and, in its defenceless condition, protect it as far as possible from infection of all kinds.

The Diet of the Nursing Woman.—The diet of most nursing mothers is mismanaged, to the detriment of the quality of their milk.

The chief faults are (1) over-feeding, in the hope of increasing the supply of milk and thereby benefiting the baby; (2) depriving the mother of a considerable proportion of the fruit and vegetables she may be accustomed to, under the delusion that green stools and colic in the baby are due to the consumption of these articles of food by the mother.

A nursing mother requires to be more correctly and physiologically fed than an ordinary individual, because she is responsible for the feeding of a second individual, and the quality of her milk is very largely dependent on the food she herself eats, but she does not require a special dietary. She must eat enough, but not in excess, the " balance "—*i.e.* the relative proportions of proteins, fats and carbohydrates—must be adjusted to the physiological requirements. She must not be deprived of any essential accessory factor; the food must be digestible and given at sufficiently long intervals and it must comply with certain psychological requirements, as described in Chapter XIV.

In one well-known text-book the nursing mother is recommended to drink as much milk as is compatible with her digestive capacities. If this advice is put into practice violence will be done to one of the most important of the canons of correct feeding—namely, the maintenance of a physiological balance. This balance cannot be observed if more than 20 to 30 oz. of milk are consumed in the 24 hours, and in any case there is a serious danger of exceeding the caloric requirements if much milk is drunk in addition to the consumption of the ordinary articles of diet.

It must be remembered that certain alkaloids, glucosides, amides, volatile and ethereal oils, as well as organic acids of vegetable origin, may appear in the milk of women who have consumed foods which contain them. It is therefore wise for nursing mothers to select their diet as far as possible from the simplest and most wholesome of foods, and not to make experiments with highly seasoned or bizarre dishes. If a woman has naturally a strong digestion foods are permissible which should be vetoed in the case of those suffering from any form of dyspepsia. Such diets as are recommended for children between 5 and 16 in Table 74 are also suitable for nursing women. The quantity need not be greatly increased.

The caloric requirements of nursing women, over and above those of women otherwise leading the same sort of lives but who have not got to provide milk for another individual, will be represented by the caloric value of the milk they supply. If, for instance, the caloric requirements of a woman are estimated to be 2500 they will rise to 3000 (2500+500) if she provides 25 oz. of milk daily for the nourishment of her offspring. Nursing women often force themselves to take food two or three times in excess of their caloric requirements, but so far from such excess increasing the amount of the mammary secretion it may tend to decrease it, by upsetting the health of the mother.

Alcoholic beverages are not required unless the mother has been accustomed to them and feels their loss. The influence of psychological factors must not be lost sight of in seeking to find an explanation of the paradoxical improvement in the milk supply which sometimes appears to result from the taking of a glass of wine or beer by a nursing mother. The beneficial influence is certainly not due to the food value of the beverage, nor is it likely to be due to any stimulating effect other than that on the spirits and mental condition of the woman.

It is unnecessary to give further particulars on these points, as the matter has already been discussed on the diet of the mother during the puerperium, and will be again discussed in Chapter IV.

The Dietetic Management of Disturbed Lactation.—I have already expressed the view that if a woman is already fed physiologically the quality of her milk will not improve by modifications in her dietary. If, on the other hand, her diet is not physiologically sound, if, for instance, it is excessive or badly balanced, it should immediately be corrected and established on a sound basis, whether her milk appears to suit the baby or not.

For the guidance of those who may be interested in this subject I append certain rules (see p. 113) formulated by the late Dr T. M. Rotch for the modification of breast milk. I give these rules with notes of my own, and with the warning that they must not be expected to hold good under all conditions. Each case must be judged on its own merits and treated accordingly.

The Amount of Milk secreted.—The amount of milk afforded by a nursing mother is certainly very variable, and dependent on a number of different factors, but in the great majority of cases the total is far less than is usually supposed. My own experiences, which now extend over a period of twenty years and include observations made on several thousand cases, do not confirm the individual statements made by various writers whose figures are as a rule derived from a few selected cases, in many instances from single cases. I find that there is a distinct difference in the total amount of milk obtained by the average infant of the class which attends at Infant Welfare Centres and the same class of child living in a well-

TABLE 27

General Principles for Guidance in managing a Disturbed Lactation, from *Pædiatrics* (ROTCH)

To increase the total quantity	Increase proportionately the liquids in the mother's diet and encourage her to believe that she will be able to nurse her infant. (Massage breasts and see that infant stimulates nipples by strong sucking.—E. P.)
To decrease the total quantity	Decrease proportionately the liquids in the mother's diet. (Feed less; take more exercise; leave the infant less long at the breast.—E. P.)
To increase the total solids	Shorten the nursing intervals; decrease exercise; decrease the proportion of liquid in mother's diet. (Draw off fore-milk with breast-pump. Lengthen intervals and encourage infant to empty breast completely.—E.P.)
To decrease the total solids	Prolong nursing intervals; increase exercise; increase the proportion of liquids in the mother's diet. (Limit diet; increase fluids; let infant draw off fore-milk and remove strippings with breast-pump.—E. P.)
To increase the fat	Increase the proportion of meat in the diet and of fats which are in a readily digestible and assimilable form. (Do not attempt this. If the mother's regimen is physiologically founded and fat is still deficient give to the infant supplementary feedings of cod-liver-oil emulsion or other substitute.—E. P.)
To decrease the fat	Decrease the proportion of meat in the diet. (Feed physiologically and insist on exercise.—E. P.)
To increase the proteins	Decrease exercise. (Feed physiologically; do not decrease exercise.—E. P.)

conducted institution, while infants belonging to a better class and living under better hygienic conditions obtain more than either.

These differences depend, I feel convinced, on adaptation of the supply to the requirements more than on any other factor. The stronger and more vigorous the infant, and the better the general hygienic conditions under which he lives, the larger will be the amount of milk he will obtain, for the stimulus which he affords to the breast will be correspondingly greater. This view is, I think, well borne out by the experiences of the late Professor Pierre Budin and recorded in his book, *The Nursling*.

At one of the hospitals—namely, the Maternity—to which Budin was attached, the daily supply of a number of nursing mothers was estimated accurately by means of the "test-feed." Some of these mothers provided milk for three or four other babies in addition to their own, and the total amount thus afforded is given in the accompanying table :

TABLE 28

Daily Quantity of Milk furnished by 7 Wet Nurses at the Maternity Hospital, Paris, on 7 different Days

	Litre	Litre	Litre	Litre	Litre	Litre	Litre
No. 1 Wet Nurse .	1·340	1·340	0·970	1·545	1·070	1·240	1·420
No. 2 ,, ,,	1·590	1·800	1·755	2·210	1·880	1·500	1·590
No. 3 ,, ,,	2·000	2·040	2·330	2·320	1·880	1·470	1·590
No. 4 ,, ,,	1·400	1·990	2·340	2·545	1·800	1·650	1·670
No. 5 ,, ,,	1·895	2·070	2·170	2·840	2·010	1·240	2·030
No. 6 ,, ,,	1·660	2·090	2·120	2·350	1·670	1·540	1·486
No. 7 ,, ,,	1·720	1·750	1·780	1·810	1·530	1·420	1·500
Average Daily Yield	1·657 (58 oz.)	1·868 (65 oz.)	1·952 (68 oz.)	2·230 (78 oz.)	1·691 (59 oz.)	1·431 (50 oz.)	1·612 (56 oz.)

This evidence suggests very strongly that the important factor in determining the quantity of milk furnished is the demand and not the personal index of the mother. It is this fact which largely explains the wide discrepancies in the figures given by different authorities.

In further support of the view that the demand is the real determining factor in the supply I would call attention to the following table, in which the average estimated daily supply afforded to infants attending at my Infant Consultations at the St Marylebone General Dispensary are tabulated, and below these figures are given corresponding records of infants attending Dr Ronald Carter's Consultations in Kensington and also at my outpatient clinic at the Queen's Hospital for Children (see p. 116).

The manner in which these figures have been arrived at is as follows. Every breast-fed infant brought to these three institutions, for a period of time which varied from two to five years, and which therefore in the aggregate amounted to an enormous total, was given a test-feed, generally on three or four occasions, sometimes on two and occasionally on one only. The precaution was always taken to ensure an interval of three hours since the previous feeding. The test-feeds were given sometimes in the morning, sometimes in the afternoon. The total daily supply was calculated by multiplying the total number of feeds by the average yield at the various test-feedings. Reliance cannot be placed on the evidence afforded by one or two test-feeds, for wide variations occur in the measurement of the feeds taken at different times of the day, but when many thousands of estimations are made at different times of the day, and on different mothers, the average is probably very fairly correct.

An examination of these figures shows that the average yield of milk is very much less than the amounts usually stated in English and foreign text-books. It is interesting to note that, while Dr Carter's and my own figures for Marylebone closely agree, those for the Queen's Hospital, which refer to cases which were considered sufficiently ill to be brought to a hospital, indicate that these sick infants obtained a still smaller amount.

Such comparisons invite the question: Do these debilitated infants take less milk because they are more feeble and suck less strongly, or do they owe their infirmities to the fact that the supply itself is deficient? I incline very much to the first alternative, and largely for the reason that when, by individual treatment, these sick infants improve in general health and condition, the test-feeds usually indicate that the breast is giving a better yield.

The figures in the following table give a very fair idea of the total daily supply obtained by slum infants. They obtain little because their needs are small. They need little because their metabolism is low. Their metabolism is low because they lack the health-giving stimuli of fresh air, sunlight, exercise and all the other important hygienic factors which are not denied to the more favourably situated infants of the middle and upper classes. If these same infants are artificially fed the supply is not usually co-ordinated to the demand, and they are overfed with disastrous results.

TABLE 29

Average Daily Yield of Breast Milk afforded by Mothers attending respectively at my Infant Consultations in Marylebone, at Dr Carter's, in Kensington, and at my Outpatient Clinic at the Queen's Hospital for Children

	Age of Infant in Weeks			Age of Infant in Months						
	2	3	4	2	3	4	5	6	7	8
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Marylebone Consultations (Slum Infants) .	18·8	14·77	13·46	16·38	16·02	15·85	13·00	18·25	20·66	12·0
Kensington Consultations (Slum Infants) .	...	16·50	14·50	20·00	14·50	13·20	17·20	21·50	15·40	26·20
Queen's Hospital (Sick Infants) .	8·0	...	9·71	18·15	14·30	11·66	9·16	16·25	12·00	12·0

It may not be without interest to give here the average yield of milk at individual feedings under similar conditions. The great majority of these infants were fed 7 times in the 24 hours, some, however, had fewer feedings, and a small minority only 6 feedings in the 24 hours.

TABLE 30

Average Yield of Milk at Single Feedings afforded by Mothers attending at my Infant Consultations (Marylebone), at Dr Carter's, in Kensington, and at my Outpatient Clinic at the Queen's Hospital for Children

	Age of Infant in Weeks			Age of Infant in Months						
	2	3	4	2	3	4	5	6	7	8
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Marylebone Consultations (Slum Infants) .	1·87	1·62	1·95	2·04	2·26	2·23	3·00	2·81	3·08	2·67
Kensington Consultations (Slum Infants) .	...	1·75	1·85	1·80	2·00	2·15	2·5	2·67	2·72	2·93
Queen's Hospital (Sick Infants) .	...	1·00	1·47	2·00	1·84	1·35	2·18	3·00	2·08	...

These records are based on many thousands of estimations, but at the two extreme ends of the series they are not very reliable, as the number of cases attending at infant consultations under four weeks of age are not very numerous, while after six or seven months of age few infants are fed exclusively on the breast, the great majority having supplementary feeds of artificial food in addition.

In the accompanying tables I give a few figures to show what, in the experience of other observers, is the average secretion of a nursing mother in the 24 hours and at individual feeds. These averages are based on too few observations to make them of any great value. They show, however, that as the infant grows older his daily ration increases, a coincidence which my own observations, based on many hundreds of cases, do not confirm.

Table 31

Name of Observer	Age in Weeks			Age in Months						
	2	3	4	2	3	4	5	6	7	8
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Camerer . . .	19·00	20·00	28·00	28·00	28·25	30·50	33·00	33·50	...	...
Freer . . .	17·00	18·00	20·00	27·50	26·25	27·00	28·00	34·00	30·50	...
Beuthner . . .	13·00	18·00	19·50	27·00	28·50	28·00	...	...	...	...
Peter . . .	16·00	17·00	20·00	21·00	...	...	...	...	...	...
Hachner . . .	15·00	19·00	19·00	28·00	28·00	26·00	30·00	33·00	44·00	...

In the following table (after Czerny and Keller) the average daily yield of milk from the 1st to 26th week is given in oz. and grams.

Table 32

Age of Infant in Weeks	Weight of Infant in Lb., Oz. and Kilogrammes	Daily Supply of Breast Milk in Oz. and Grams
1 .	7 lb. 6 oz. or 3·410 kilos.	10 oz. or 283 gms.
2 .	7 ,, 12 ,, or 3·550 ,,	20 ,, or 577 ,,
3 .	8 ,, 0 ,, or 3·690 ,,	21 ,, or 593 ,,
4 .	8 ,, 11 ,, or 3·980 ,,	23 ,, or 652 ,,
5 .	9 ,, 3 ,, or 4·115 ,,	25 ,, or 687 ,,
6 .	9 ,, 9 ,, or 4·260 ,,	26 ,, or 736 ,,
7 .	10 ,, 1 ,, or 4·496 ,,	27 ,, or 785 ,,
8 .	10 ,, 8 ,, or 4·685 ,,	28 ,, or 804 ,,
9 .	11 ,, 0 ,, or 4·915 ,,	28 ,, or 815 ,,
10 .	11 ,, 5 ,, or 5·055 ,,	28 ,, or 800 ,,
11 .	11 ,, 10 ,, or 5·285 ,,	28 ,, or 808 ,,
12 .	12 ,, 0 ,, or 5·455 ,,	29 ,, or 828 ,,
13 .	12 ,, 5 ,, or 5·615 ,,	30 ,, or 852 ,,
14 .	12 ,, 10 ,, or 5·745 ,,	30 ,, or 870 ,,
15 .	13 ,, 1 ,, or 5·950 ,,	30 ,, or 878 ,,
16 .	13 ,, 5 ,, or 6·150 ,,	31 ,, or 893 ,,
17 .	13 ,, 12 ,, or 6·350 ,,	32 ,, or 902 ,,
18 .	13 ,, 14 ,, or 6·405 ,,	32 ,, or 911 ,,
19 .	14 ,, 4 ,, or 6·570 ,,	33 ,, or 928 ,,
20 .	14 ,, 10 ,, or 6·740 ,,	33 ,, or 947 ,,
21 .	14 ,, 14 ,, or 6·885 ,,	33 ,, or 956 ,,
22 .	15 ,, 0 ,, or 7·000 ,,	33 ,, or 958 ,,
23 .	15 ,, 5 ,, or 7·150 ,,	33 ,, or 970 ,,
24 .	15 ,, 10 ,, or 7·285 ,,	33 ,, or 980 ,,
25 .	15 ,, 14 ,, or 7·405 ,,	34 ,, or 990 ,,
26 .	16 ,, 1 ,, or 7·500 ,,	35 ,, or 1000 ,,

TABLE 33

Average Amounts of Breast Milk obtained at one Feeding by Infants at Different Ages

Name of Observer	Age in Weeks			Age in Months						
	2	3	4	2	3	4	5	6	7	8
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Camerer . . .	2·50	3·50	3·50	3·50	4·50	3·50	...	...	...	...
Freer . . .	2·50	2·80	3·50	4·00	4·50	4·80	4·80	...	...	...
Beuthner . .	2·00	2·25	2·75	3·25	4·50	4·80	5·00	...	...	...
Peter . . .	2·40	2·70	2·87	5·42	...	...	...	...	...	...
Hachner . .	2·50	2·50	3·00	5·25	5·50	5·25	5·5	5·5	7·00	...

In the accompanying tables I give the average supply of milk afforded by nursing mothers in institutions, where each feed has been estimated, and also the same in the case of private patients living at home.

TABLE 34

Table to show the Average Daily Yield of Milk afforded by lower and middle-class mothers in institutions, and of better-class mothers (200 cases) living under good hygienic conditions at home

	Age of Infant in Weeks				Age of Infant in Months										
	1	2	3	4	2	3	4	5	6	7	8	9	10	11	12
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Mothers living in institutions	½-10	12	18	18	20	22	24	26	26	25	25	27?	27?	30?	28?
Better-class mothers living at home under good hygienic conditions .	½-12	14	18	18	22	23	25	28	30	31	33	34	38?	38?	40?

NOTE.—The figures for the 8th, 9th, 10th, 11th and 12th months are not reliable, since only a few mothers, and these giving a good supply, continued to nurse after the 8th month

Although these figures are derived from a very large number of cases, too much reliance must not be placed on them, for the individual amounts obtained by different infants varied within very wide limits.

I find it very difficult to define precisely the exact amount of milk a breast-fed baby should receive in the 24 hours, partly for the reason that no two infants, even though they are exactly of the same age, have the same physiological demands, and partly because the caloric or food value of the milk of no two women is identical, nor of the same woman from hour to hour, or from day to day.

I believe, however, that the figures given in the following table may be taken as a working basis. Very strong and vigorous babies may require rather larger amounts, and very puny, feeble infants will require less.

TABLE 35

To show Average Daily Requirements of Infants at Different Ages for Breast Milk of Average Quality

Age in Weeks				Age in Months										
1	2	3	4	2	3	4	5	6	7	8	9	10	11	12
oz. 10	oz. 12	oz. 16	oz. 18	oz. 21	oz. 27	oz. 30	oz. 32	oz. 35	oz. 37	oz. 39	oz. 41	oz. 43	oz. 46	oz. 48

Factors which may influence the Amount of Breast Milk secreted.—Although there is evidently some physiological co-ordination between the amount of milk supplied by the mother and the demand on the part of the infant, it is by no means safe to assume that every infant will receive his due allowance, and even in those cases in which the total supply in the 24 hours may be regarded as correct it often happens that it is so unequally distributed at the different feeds that at one time the infant may obtain far too much and at another much too little. Such irregularities have a very disconcerting effect on the temper and digestive processes of the infant. It is, therefore, a wise, if not a necessary, precaution to estimate by means of the " test-feed " the exact quantity obtained at each individual feed.

Among the factors, apart from the demands of the infant, which actually may, or have been supposed to, influence the amount secreted must be included (1) the feeding of the mother; (2) the number of feedings; (3) the influence of drugs (galactogogues); (4) psychological influences.

The Feeding of the Mother.—There is no evidence to show that the amount of milk can be augmented by increasing the quantity of food consumed by the mother, provided that she is already receiving enough to satisfy her physiological claims. On the other hand, no woman can secrete a really large quantity of milk, as in those cases in which one woman acts as the wet nurse to several infants, unless she, at the same time, is well fed—*i.e.* obtains enough to fulfil the metabolic requirements.

Without a corresponding stimulus from and demand on the part of the infant, or infants, no increase in the food of the mother will augment the supply. It has been claimed that the total secretion is increased by large potations of water or fluid, but this again is untrue, unless at the same time the demand is increased.

The Number of Feedings.—The number of feedings in the 24 hours certainly has an influence on the yield at individual feeds, as has been shown by Helbrich. If the breast is emptied 3 times in the 24 hours, at 8-hourly intervals, the quantity obtained at each feed is nearly three times as much as when the infant is fed 9 times in the 24 hours, although the total for the 24 hours is practically the same in the two cases.

There is, however, evidence to show that with very infrequent feeds—as, for instance, when the mother goes out to work during the day and only feeds her infant after her return at night—the supply gradually begins to fail, and may ultimately cease altogether.

In my experience the best results, both as regards the quantity secreted and the maintenance of lactation, are secured by 6 feeds in the 24 hours, beginning at six o'clock in the morning and ceasing at nine o'clock at night.

The Use of Drugs.—It is very desirable at the present time, when certain preparations claiming to increase the yield of breast milk are largely advertised and, on the strength of these advertisements, largely used, that it should be clearly stated that there is no evidence to prove that any drug or food preparation has the slightest direct influence on the amount of milk secreted. Animal experiments would seem to suggest that extracts of the posterior lobe of the pituitary gland of the ox, of the corpus luteum of the sheep, of the placenta or fœtus of animals, when injected hypodermically, can either increase the secretion of milk or activate the mammary glands of virgin animals, but these are methods which have no practical application in the case of the human mother.

The Psychological Factor.—As in the case of the establishment of lactation, so in its maintenance, the psychological factor is immense. I have little doubt that the reputation which certain so-called galactogogues have won is due entirely to their influence on the mental state of the mother and that they act rather by suggestion, than by reason of their therapeutic properties. Quite unexpected events may influence the secretion of milk, in favourable or unfavourable directions, through the medium of this psychological factor. I remember one woman who was nursing her baby fairly successfully, and with quite a good yield of milk, although the conditions under which she was living in Marylebone were themselves far from favourable, failing for a time to afford sufficient milk for her child when she was invited on a visit to the country, where all the physical circumstances were apparently absolutely in her favour.

The disturbing factor must have been of a psychological nature —home-sickness, or some such condition of mind, upsetting the physiological equilibrium. On her return to Marylebone a few weeks later the yield of milk immediately resumed normal dimensions.

CHAPTER III

BREAST FEEDING (*continued*)

PRACTICAL DETAILS AND TECHNIQUE

Capacity to nurse—How to hold the Baby—Clothing of the Nursing Mother—Care of the Nipples—Intervals of Feeding—Duration of a Feed—The Amount—The "Test-Feed"—Method of conducting it—Twins—Triplets—Premature Infants

Capacity to nurse.—If a lying-in woman is unable to nurse her baby she is either abnormal or badly managed. In 1914 Professor Pinard stated before the French Academy of Medicine that out of 12,000 cases of confinement which had taken place in the maternity hospitals of Paris during the preceding five months there had been no instance of a mother being unable to nurse her baby. Professor Budin insisted on every woman who was delivered in hospital suckling her baby, and he had few failures. Speaking from my own extremely limited experience, I thoroughly endorse the view that if a woman is capable of performing the extremely difficult task of bringing a living baby into this world she certainly has it within her power to keep it alive afterwards with nutriment from her breast, if only she has the will to succeed and a little elementary knowledge of the physiology of lactation.

Although the majority of the cases with which I deal are those which have previously been failures, I can conscientiously say that during the last fifteen years I have not had personal experience of a single case which has not proved amenable to management.

"In general," say Dr J. L. Morse and Dr F. B. Talbot, in their excellent little book *Diseases of Nutrition and Infant Feeding*, "women are altogether too prone to believe on insufficient grounds that they cannot nurse their babies. It is sad to say that they are often aided and abetted in this belief by physicians and nurses, who should know better. From the point of view of the baby the advantages of breast feeding are so enormous that every effort should be made by all concerned, the mother, the obstetrician and the nurse, to make lactation a success."

In the following pages I propose to deal first with the technique of breast feeding under normal conditions, and then with the difficulties that arise in connection with abnormalities existing in (*a*) the baby, and (*b*) the mother.

BREAST FEEDING UNDER NORMAL CONDITIONS

How to hold the Baby.—Owing to the exigencies of her condition the lying-in woman is compelled to give the breast to the nursling during the first few days of his life in the recumbent position. The nurse or midwife should help to arrange the mother comfortably on her side and support her in that position by means of pillows. The infant should be placed in a position parallel to the body of the mother, and in such a way that the breast as it were drops into his mouth. It is essential that the woman should be in a comfortable and unrestrained position, and that the child's nasal respiration should not be interfered with by having his face smothered in the breast of the mother.

Later, when the mother is allowed to assume the sitting posture in bed, she can hold the child in her lap crosswise with the head slightly turned upwards so that the breast again hangs suspended in such a way that he can grasp the nipple and surrounding areola firmly with his mouth without interference with respiration. The arm of the mother on the same side as the baby's head should be comfortably supported by a pillow so that the hand can hold the breast and arrange its orientation for the convenience of the baby without fatigue. The other arm should rest on the thigh or elevated knee in such a way as to give adequate support to the head of the infant and keep it in position.

After the puerperium, when the mother is again up and about, she should nurse her baby in a low chair, holding it in the same position as described for the sitting posture in bed. The arm which holds the breast may be supported on a cushion or on the arm of the chair.

It is of great importance that the infant should take as much of the breast into his mouth as is possible, and not merely the nipple. Although in the act of sucking the nursling does create a partial vacuum in his mouth, the essential mechanism of sucking is vermicular pressure on the nipple and surrounding areola between the tongue and the roof of the mouth ; an operation which is somewhat analogous to that employed in milking a cow. The exercise thus given to the jaw and its attached muscles is not without influence on the physiological development of these structures as well as on that of the teeth.

The Clothing of the Nursing Mother should be loose and comfortable, and the corsets, if worn at all, should be so cut that the upper rim altogether clears the breasts, especially in the stooping position, while the bones should end short of the actual free margin. Some good support for the abdomen and back is usually required by women who have been recently confined, so that in those cases in which corsets are not worn by nursing women suitable belts should be provided. These should be well shaped, so as to allow expansion of the abdomen after a meal.

It is questionable whether any special pattern for the bodice is necessary for nursing women such as that approved for the wet nurses employed in the Infants' Home at Dresden and in other institutions. No doubt some nursing mothers will be glad to exercise their own ingenuity in designing suitable garments to fulfil special conditions.

The Care of the Nipples.—This subject has already been referred to (p. 92), and will again be dealt with (p. 134). It will be sufficient here to enjoin on the nursing mother the necessity for bathing the nipples before and after each feeding with warm water or boracic lotion and drying them gently but thoroughly with a soft towel or lint. It is wise to protect them between feedings with lint smeared with some simple emollient cream or ointment. If there should happen to be "overflow" in the intervals between nursings, a suitable thickness of absorbent sterile wool should be applied in such a way as to soak up the droppings, so as to avoid soiling the dress. If necessary a layer of oil-silk or jaconet may be interposed between the wool and the vest or combinations.

The Intervals of Feeding.—In order that the mammary glands may have the best opportunity of falling into regular and periodic habits of activity, it is most desirable that the infant should be put to the breast from the very first day of life at the same intervals as will be permanently adopted, and that these intervals should not be changed from day to day during the puerperium.

The best intervals in my experience are those arranged on a three-hour basis during the day, with a long interval at night. The first feed in the morning should be about 6 A.M. and the others continue throughout the day every three hours; the last feed should be at 9 o'clock at night. The long nine-hour rest at night is invaluable for the mother as well as her baby. If the infant is encouraged to sleep the whole of the night from the first day of life, difficulty is very seldom experienced in inducing this priceless habit. If weakness is shown at first and the infant is rewarded by a feed when he wakes at night and becomes importunate for the breast, it is very difficult to eradicate the habit of night-feeds.

It is wise to see that the infant is well awake before he is put to the breast, but nothing must be allowed to interfere with the regularity of the times of feeding; however peacefully the infant may be sleeping when the time arrives to be put to the breast, he must be remorselessly aroused from his slumbers and prepared for his feed. On the other hand, no importunity on the part of the infant for a feed before it is due should be allowed to influence the mother or nurse.

As the infant grows older the intervals between feeds should be prolonged. I do not see any advantage in reducing the 6 feeds a day to 5 before the baby is about five or six months of age. If the breasts then give a good yield 5 feeds may be better than 6, and at eight months of age 4 may be better than 5. I do not think it necessary to lay down hard and fast rules on this matter. I am quite sure that older children, from eighteen months of age onwards, do far better on three, or possibly four, meals than when the latter are more frequent, and to attain this end without disturbing the temper and habits of the child, it is well to accustom it to comparatively infrequent feedings before it is a year old. Sudden changes should be avoided as far as possible.

The Duration of the Feed.—It is quite impossible to lay down hard and fast rules with respect to the time that should be occupied by a feed. Long experience with the "test-feed" proves, however, that the infant draws off most of the milk from one breast in the first five minutes and that hereafter most of his energies are wasted.

It is, however, one of the conditions of successful breast feeding that the gland should be completely emptied, so from this point of view alone it is most desirable that the infant should be allowed time to effect this object; ten to fifteen minutes is generally found long enough. For the purpose of maintaining lactation it is better to allow the infant to have the right and left breasts alternately, than to have both at the same feeding and empty neither completely. Slow feeders can be assisted by massage and manipulation of the breasts to secure the required amount of milk in a reasonable time, while greedy, hungry infants can be restrained from gulping down their feed too quickly by a little judicious compression of the breast between the thumb and first finger.

The Amount of Milk.—This question was dealt with at considerable length in the previous chapter, to which the reader is referred. The amount of milk required by any particular infant in the 24 hours or at a single feed should be estimated partly on a basis of bodyweight, and partly on a basis of age, but chiefly on a basis of the estimated physiological requirements.

The average infant of normal weight, living under normal conditions of temperature, clothing, exercising, airing, etc., requires approximately the following quantities of breast milk in the 24 hours:—

Table 36

Giving the Approximate Quantities of Breast Milk required by Average Infants of Different Ages

Age of Baby	Week				Month										
	1st	2nd	3rd	4th	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Quantity of breast milk in oz.	½-9	9-14	14-18	18-22	22-25	25-28	28-30	30-32	32-34	34-35	34-35	35-36	36-38	38-40	40-42
Quantity of breast milk in grams	15 to 250	250 to 400	400 to 515	515 to 610	610 to 700	700 to 800	800 to 850	850 to 900	900 to 980	980 to 1000	980 to 1000	1000 to 1030	1030 to 1090	1090 to 1150	1150 to 1210

Note.—In this table it is assumed that after the 7th month some supplementary food, such as rusks, cow's milk, etc., is given in addition to breast milk to make up the caloric requirement given in Table 1, page 8.

Unless special precautions are taken infants at the breast do not obtain these amounts; they often obtain half as much, or occasionally much more, and yet they may appear on superficial examination to be doing perfectly well.

It is most unwise to allow ourselves to be deluded into the comforting assurance that things are as they seem. Under such conditions of faulty adaptation to the true requirements the infant is not doing as well as he might, in spite of outward appearances. Infants are very long-suffering and their reserve powers are great, but they do better when they are correctly fed than when they are incorrectly fed, and the nearer the food approaches—both as regards quantity and quality—to the physiological optimum the better will be the final results.

For this reason, if for no others, when an infant is breast fed the amount of milk obtained from the mother each day and at every feed should be measured by means of the "test-feed." I am very familiar with the chorus of derision this demand provokes from superior and experienced persons who have heretofore been satisfied with the mediocre results which are obtainable by the old haphazard method of leaving quantity to the arbitrament of the infant and to the infallible safeguards of nature. Personally I believe in getting the best out of an infant that skill and knowledge can elicit, and I am perfectly certain that you cannot get the best out of a breast-fed infant unless you keep a very accurate watch on the quantity of his daily ration. From thousands of observations I have made I can state very definitely that not one breast-fed infant in ten belonging to the class which attends at Welfare Centres obtains at the fifth month of life and onwards enough milk to fulfil the physiological requirements. When this is the case some impairment in material development or in functional efficiency must result. I am ready to admit that to measure each feed by means of the scales is a counsel of perfection as far as the Welfare child is concerned, but it is not a counsel of perfection to demand that an occasional "test-feed" should be taken when the infant is brought to the Centre, nor is it a counsel of perfection to make the full demand in the case of breast-fed infants of the middle and upper classes.

Personally I find very little difficulty in persuading my own patients to adopt the scientific method, and I find they co-operate very intelligently in my efforts to obtain the best possible results. The cost of the requisite scales is not prohibitive, they can be bought at the present time for about three pounds or they can be hired for a nominal fee.

The Method of conducting the "Test-Feed" is as follows:— The infant, with all his clothes on and with his napkin in position, is placed in the scales and carefully weighed before each feed. After remaining ten minutes or so at the breast he is weighed again, and the increase in weight noted; if he has not obtained his due allowance he is put back to the breast, and if necessary given the other breast also. By the exercise of a little judgment and common sense the capacity of the mother is soon discovered, and the approximate time required by the infant to obtain the estimated amount can be determined in advance.

It is quite unnecessary to be meticulously accurate at each feed. What is required is that the total consumption for the 24 hours should be approximately correct, and that at no single feed the amount should deviate widely from the estimated standard.

At some feeds or on some days the infant may be physiologically entitled to more food than at others; for instance, on cold days more food is indicated than in close weather. When an infant is disturbed by teething he certainly requires less than when there is the usual rebound in his vital activities immediately after the successful cutting of a tooth. If corresponding adjustments can be made to fit in with the prevailing conditions the aims and objects of physiological feeding will be the better attained.

Before leaving the subject of quantity I would like once again to emphasise the supreme importance of estimating the daily quantum of food of any particular infant on a basis of his physiological requirements. It is highly improbable that in any particular case the exact physiological optimum will be arrived at, but unless we get into a habit of making an attempt to solve each problem as it is met with it is extremely unlikely that the average result will be within reasonable distance of the truth. If we accept the figures given on page 126 as a reasonable basis of the requirements of the average baby, it is not difficult to make allowances in an upward or downward direction for particular circumstances. The one factor in the life of the infant which overshadows all others in modifying his caloric requirements is exercise. The caloric requirements of a seamstress living a sedentary life may be well below 2500 calories in the 24 hours, while that of a dock labourer may be from 5000 to 7000. The caloric requirements of a sluggish, inactive baby of eight months may not be half that of an active, energetic baby struggling with the difficulties of learning how to stand or walk. These two distinctive types should not be fed on the same dietetic scale, neither should infants living respectively in very hot or very cold climates, nor infants spending most of their time indoors or out of doors have exactly the same ration.

Speaking quite generally, the more physically active an infant may be, the greater the external cold he is exposed to, the less his clothing, and the more active all his vital processes, the more food does he require.

Sick, feeble, marasmic infants do not require more food, they require less, than healthy ones. If when you place your hand under the clothes of an infant his skin feels cool or cold, you must assume that internal combustion is low and that his capacity for oxidising food elements is correspondingly debased. You inflict the greatest possible injury on such infants if you attempt to fatten them up by liberal allowances of food. Such infants should have a greatly reduced ration. On the other hand, when you feel that the skin is all aglow with warmth, this is clear proof that the metabolic processes are active and that the infant is at least capable of putting the food that is given him to physiological use. Such an infant runs little danger of being overfed.

Breast Feeding in the Case of Twins.—The same general principles apply in the case of twins as in the case of single infants at the breast. The question generally arises, are both infants to be fed at the same hour or should they be fed alternately ? In any event twins make such calls upon the mother's time and energies that I consider all reasonable steps should be taken to spare her ; for this reason I advise that both twins should be fed at the same time, one after the other, the first infant being given one breast and the second the other, the sides being changed at the next feeding so as not to give either any advantage should there be any difference in the functional efficiency of the two mammary glands. The feeding of twins is in my experience no more exhausting to the mother than the feeding of one baby, and as a rule the supply of milk is ample, provided that the infants suck strongly. In the case of twins it is additionally important to check the quantity of milk obtained by means of the " test-feed."

Breast Feeding in the Case of Triplets.—In the case of triplets the difficulties are increased, and although it is possible to feed all three infants at the same hours it is by no means easy. A mother who makes up her mind to give herself up for the time being to this responsible duty must make sacrifices, and can hardly be expected to give much of her time to other household business. The important objects to secure are: firstly, that each infant obtains in the 24 hours enough milk to fulfil the estimated physiological requirements ; secondly, that each infant is fed regularly every three hours ; and thirdly, that no one infant should have any preferential advantage over the others. For instance, one infant should not be allowed on all occasions to get the " strippings " while another has to be content with " fore-milk."

Many complications are avoided if all the infants can be fed at one sitting. If this is not possible they may be put to the breast one after the other at hourly intervals, alternating the breasts. If this method is adopted it is a convenience to extend three-hourly feedings to four-hourly feedings at the earliest opportunity, so as to give a little freedom to the mother. Another method is to feed two of the infants at one nursing, and the remaining baby one hour and a half later, but the regularity of the times of feeding of any one infant must not be sacrificed without due consideration. The supplementary feeds of twins or triplets can be conducted on the lines recommended on page 136.

Breast Feeding in the Case of Premature Infants.—The difficulties of successfully managing breast feeding are at first more than doubled in the case of infants who are premature in any serious degree, for the reasons that the development of the breasts is correspondingly backward and that the infant, owing to feebleness, can only impart weak stimulation to the nipples. It is therefore often necessary to have recourse to the artificial adjutants referred to on page 119. It is, however, even more important for the premature baby to be breast fed than it is for full-time infants. Under these conditions there is a temptation to resort to wet nursing. I do not advise this, because the premature infant more than any other stands in need of the educational advantages of colostrum, and this is entirely lost if the services of a wet nurse in full lactation are requisitioned. There is no disadvantage, but rather the reverse, in the prolongation of the colostrum period which so often occurs when the confinement takes place before it is due.

It must be remembered that the physiological requirements of premature infants are correspondingly less than full-time babies; on page 280 I give a table of their estimated needs when they are artificially fed and this table may be accepted as holding good for breast feeding. If the breast of a woman who has been delivered of an extremely premature infant remains refractory for longer than usual, say for ten days or a fortnight, this is no argument for relinquishing efforts to establish lactation. I have known cases in which efforts have been made for three weeks before the mother reaped the reward of her patience. Meanwhile the infant must be provided with small supplementary feeds of a very completely peptonised mixture of cow's milk modified to breast standard.

For further particulars of the artificial feeding and management of premature infants see page 136.

CHAPTER IV

BREAST FEEDING (*continued*)

Difficulties and Complications arising in connection with Conditions existing in the Infant and in the Mother—

In the Infant.—Difficulties in Sucking—Nervous Excitability—Deformities of the Mouth—Thrush—Cracks in the Lips—Ulcers on the Tongue—Failure to gain in Weight—Symptoms of Indigestion

In the Mother—Depressed Nipples—Fissures and Cracks—Mastitis—Deficient Supply of Milk—Deficiency of Special Elements in the Milk—Excessive Supply of Milk—Excess of Special Elements—Menstruation—Pregnancy—Tuberculosis—Syphilis—Specific Fevers—Weaning—Wet Nursing

COMPLICATIONS IN THE INFANT

Difficulties in Sucking.—Every normal infant has a very strongly ingrained instinct to suck. Such is implicit in the survival of the human race. If an infant does not immediately grasp with its lips any object, such as a nipple or finger-tip, introduced into the mouth there must be something radically wrong with the nervous mechanisms concerned. When inquiring into the history of mentally defective or degenerate infants, I invariably ask the question, "Did the infant suck properly when he was put to the breast for the first time?" If he did not, this is some evidence in favour of the supposition that he is abnormal mentally if not in other respects.

Although the reflex acts of sucking, protruding the tongue or swallowing are innately impressed on the nervous system of all infants, there are degrees in efficiency with which these primitive functions are executed. Infants who cannot suck, protrude the tongue or perform other associated muscular co-ordinations, are often thought to be tongue-tied, and, in consequence of this belief, are submitted to operation for cutting the frænum linguæ. This step is due to a confusion of ideas between cause and effect. An infant who cannot protrude the tongue does not submit the frænum to the strains and tractions which are essential for its normal stretching and development, hence in such an infant the appearance is that the frænum is short and prevents the tongue from being extended. Snipping the frænum with scissors does not, however, improve matters, and the inwardness of the trouble becomes apparent when at a later date the infant finds difficulty in swallowing and executing the fine labial and lingual co-ordinations concerned in speech.

Nervous, Excitable Infants are sometimes difficult to manage at the breast; they become impatient if they do not immediately reap a reward for sucking, and start crying, which interferes with further effort.

Deformities of the Mouth and Palate.—Hare lip and cleft palate both interfere with the normal execution of the acts of sucking and swallowing; neither of these congenital deformities, however, puts the possibility of successful breast feeding out of court: they make it more difficult, that is all. Special nipples are made with a plate which acts as a false roof to the mouth in cases of cleft palate, but I am not sure that any advantage is gained by having recourse to these somewhat cumbrous instruments. Infants as a rule soon learn to suck well with hare lip, and to swallow without regurgitation through the nose even when there is absence of a normal roof to the mouth. It is, to my mind, most desirable to see that these malformations are corrected by mechanical means or plastic operations as soon as possible; the longer they are allowed to remain untreated the more permanent are the injuries inflicted by the faulty methods of sucking and swallowing imposed by the conditions, and the slower are the infants to acquire the new and necessary muscular co-ordinations. Surgeons are rightly disinclined to undertake these delicate operations unless the infants are in a condition of good nutrition: this is an additional argument for breast feeding. Cleft palate operations are better postponed till after the cutting of the temporary canines.

Thrush.—The development of thrush in the mouth of a nursling does not as a rule directly interfere with breast feeding, but it occasionally leads to infection of the mother's nipples, and by making them sore may thus indirectly lead to difficulties. Thrush is generally due to damage inflicted on the mucous membrane of the mouth by too frequent or too violent washing of the buccal cavity after feeds. The fungus of thrush finds a damaged mucous membrane most congenial soil for development. The way to prevent thrush is to prevent the infliction of injuries on the delicate epithelial lining of the mouth by ablutionary efforts, by the sucking of thumbs or dummies, or by the presence of little pools of unswallowed milk in the mouth. It is cured by very gently swabbing out the mouth with cotton-wool soaked in glycerine of boracic acid.

Cracks in the Lips and Ulcers on the Tongue at times lead the infant to refuse the breast. Temporary feedings with the spoon sometimes enable one to overcome the reluctance of the infant to take the breast. If under such conditions the baby is in any way forced against his will he may take a permanent dislike to his mother's milk.

Failure to gain in Weight.—Infants who fail to thrive on the breast are often weaned and relegated to the bottle on most insufficient grounds. It is not wise to assume without supporting evidence that the fault lies in the milk ; it is much more probably due to existing conditions in the infant that certainly will not be improved by a change to artificial feeding.

It is quite impossible to give a complete list here of all the abnormal conditions which may exist in the child and which interfere with his normal progress. The majority of them, however, are connected with infective processes : infections arising in connection with the umbilicus, with the intestinal tract, with the mouth, the nose or the skin. In a few cases there is some congenital malformation of the heart or other important organ, and in quite a considerable number of cases the infant has some inherent defect in his metabolic processes. I think it very important, when young babies fail to thrive on the breast, to make sure by means of a "subnormal" thermometer that the blood temperature of the infant is not unduly low. By means of such thermometers I have often detected a temperature as low as 92° F. in infants who were on the point of being weaned on the grounds of insufficiency or unsuitability of the milk, when the real trouble was in connection with the metabolic processes in the infant himself.

Symptoms of Indigestion in the Infant.—Infants are often weaned owing to the development of symptoms such as vomiting, hiccup, colic, wind or diarrhœa when these symptoms can really be traced to causes unconnected with the quality of the milk, and can quite well be treated successfully by a little resourcefulness or by some change in the details of management. Most of these symptoms continue as habits although they may have started as the direct result of some accidental fault in the feeding—as, for instance, too rapid feeding, too frequent feeding or excessive feeding. Habits thus contracted during the early days of life are apt to persist although the event which has provoked them ceases to be operative.

The successful management of breast feeding demands much patience and ingenuity on the part of the physician and nurse, but to incriminate the milk, or insist on immediate weaning, whenever difficulties and complications arise shows great want of resource and a very narrow purview of the possibilities of treatment.

COMPLICATIONS IN THE MOTHER

Depressed Nipples.—Depressed nipples have already been referred to as a cause of failure of breast feeding (p. 92), and the steps which should be taken during pregnancy to remedy the condition were also mentioned in the same section. Small, flat and undeveloped nipples may be congenital malformations, but more often than not the condition which interferes with breast feeding is retraction of the nipples due, as a rule, to a mild and chronic inflammation of the ducts, leading to fibrosis. It is claimed that this is sometimes due to irritation of the nipples by the free edge of the corsets, but in my experience the cause is to be sought at a much earlier date—namely, immediately after birth—when any injudicious management of the physiologically enlarged and congested breasts, both of male and female infants, may lead to mastitis and subsequent fibrosis. I have had opportunities of watching the development of retraction of the nipple of this kind in quite a considerable number of cases.

Painful Nodules in the Breasts.—It not infrequently happens, both during the establishment of lactation or at a later date, that the breasts become knotted and hard. The condition is due to stasis in some lobule of the gland owing to temporary obstruction of a duct or ducts. In the great majority of cases a little judicious massage along the axis of the duct proves a very successful method of treatment. Hot fomentations also sometimes accelerate the cure. The distinction between simple induration of the breast of this kind and genuine mastitis is fundamental, and should in all cases be made from a general review of the symptoms.

Fissures and Cracks of the Nipples occasionally give the mother such severe pain as to render nursing most distressing, or impossible. These fissures are not always visible to the eye unless a very careful examination is made. Sometimes they are arranged circularly round the nipple, sometimes they radiate in stellate fashion. The best treatment is to paint the cracks as soon as they are discovered with 2% solution of nitrate of silver and to give the injured part an opportunity of recovering by means of rest and the use of the nipple-shield. It is important to keep such damaged nipples dry, and for this reason oozing from the breast should be obviated by emptying the breast at the times of feeding or by manipulation between. The chief complication, apart from the relinquishment of breast feeding, which is likely to result from fissures of the nipple is actual infection of the breasts themselves.

Mastitis.—Mastitis can occur by bacterial invasion of the ducts quite apart from fissures or cracks, although the latter are the usual causes. The breast becomes hard and painful and cannot be emptied by compression. There is almost invariably a rise of temperature and later the skin becomes red and shiny. The glands in the axilla as a rule are enlarged and painful, and if the pus is not evacuated by an incision multiple perforations take place spontaneously.

The treatment should be largely prophylactic, by the early attention to cracks and fissures, also by the dispersal of small areas of induration. It is also wise to apply a little boracic or other simple antiseptic ointment to the nipples as a routine practice. Curative treatment consists in emptying the inflamed breast as far as circumstances allow and applying hot fomentations. The diet of the mother should be reduced to a minimum. She should be mildly purged by means of saline aperients, and the breast should be well supported by bandages. If in spite of this treatment the inflammation goes on to suppuration radial incisions should be made into the abscess and the cavity packed with strips of iodoform or other antiseptic gauze. Good results are also claimed from the use of the Bier suction apparatus.

Mastitis of one breast is no contra-indication to nursing, and even when the inflammation involves both breasts nursing can sometimes be continued throughout the attack, or resumed after a short interval. It is so important that distension of the inflamed breast should be prevented that if the breast can be emptied by the infant himself without the infliction of severe pain to the mother perseverance with breast feeding is justifiable, as long as actual pus is not present in the milk. I have very rarely noticed symptoms in the infant suggestive of direct infection, and this immunity is, I think, explicable on the ground that the milk is probably loaded with anti-bodies. If the infant is temporarily deprived of the use of one breast the need to check the daily supply of milk by means of the "test-feed" becomes the more urgent.

A Deficient Supply of Milk.—A very large number of infants are weaned on this ground alone, and most unjustly. To make sure that there is really a deficient supply the daily yield of milk must be estimated by means of the "test-feed," and if this falls far short of the estimated requirements steps must be taken to increase the daily ration.

It is always possible, and indeed extremely easy, to supplement breast milk with bottle feedings, but, on the other hand, it should never be forgotten that with supplementary feeding there is always a tendency for the mammary secretion to fall off in quantity or to cease altogether. The chief stimulus to secretion is hard sucking, and the most efficacious stimulus to sucking is hunger or thirst on the part of the child. I think a distinction should be drawn between supplementing the natural supply during the establishment of lactation and supplementing it at a later date, when lactation is in full progress. Lactation is at times so difficult to establish that, even at the cost of partially starving the infant for a few days, or even a few weeks, nothing should be done to dull the appetite of the baby or discourage him from affording all the stimulus of which he is capable. For this reason until lactation has been well established only nominal quantities of supplementary food should be given to the infant, afterwards the amount may be regulated in accordance with the physiological indications.

The supplementary feeds may be given at each nursing, so as to supply the shortage made evident by the "test-feed," or they may be given at certain definite feeds at which the shortage is greatest.

It must be remembered in this connection that there is no known method of increasing the breast yield except the demand on the part of the infant.

Feeding the mother up, if she already is adequately fed, is of no avail, neither are there any drugs or special foods which can in any way act as galactogogues. The psychological factor, as stated on page 121, is a most valuable adjunct if it can be rationally employed.

The supplementary food should consist of cow's milk modified to breast standard (see p. 201), and at first it should be peptonised (see p. 472), so as not to upset the digestive functions, and the method of gradual remission in the degree of artificial digestion as described on page 164 should be strictly adhered to, in order to promote the exfoliation of these functions.

Deficiency of Special Elements in the Milk.—I have already stated (p. 101) that chemical analysis of milk which causes serious disturbance in the infant who consumes it affords very little useful information. Reference to page 113 will provide a few hints as to measures which may be tried under special conditions.

There are, however, two respects in which breast milk may be improved when it lacks certain essential constituents. Firstly, when it may be suspected of lacking the so-called anti-scorbutic vitamines owing to symptoms arising in the child, or when, from an examination of the mother's diet, the latter is found to be deficient in fresh fruits and vegetables. When this is the case the mother's dietary should be supervised. Secondly, when the mother is obviously anæmic, from obstetrical or other forms of hæmorrhage, or indeed from any cause, the quality of the milk, as evidenced by a concomitant improvement in the nutrition of the child, is clearly benefited by the administration of Blaud's pills, or some other form of iron; indeed I have often suspected that the fat content of the milk has been by this means improved.

Towards the end of lactation, and occasionally at other times, a nursing woman's milk is poor in fat. If impoverishment of this kind is suspected a sample of milk should be sent [1] for analysis. In obtaining a specimen of milk care must be exercised to secure a mixed sample or the whole contents of a full breast. If a sample of "fore-milk" or strippings is provided very misleading deductions may be drawn.

If a woman, heretofore adequately fed, provides a milk poor in fat there is no known means of improving the quality. Different breeds of cows yield milks of varying fat content, but you cannot convert a Shorthorn into a Jersey by feeding it on oil-cake, neither can you raise the percentage of fat in poor milk of human origin by dosing the woman who supplies it with the advertised nostrums. The best and simplest means of dealing with a deficiency of fat in

[1] To the Clinical Research Association, D., Watergate House, York Buildings, London, W.C.2; or, to the Laboratory of Clinical Pathology, 6 Harley Street, London, W.1.

milk is to supplement the breast feeds by giving independent feeds of cod-liver-oil or butter-fat emulsion to the infant.

An Excessive Supply.—An excessive supply of milk may be suspected if the infant increases unduly in weight—*i.e.* more than 7 oz. in the week—if he passes unusually large and frequent motions, if the amount of the urine is excessive, if he vomits large quantities or if there is a great difference in the size of the breasts before and after feeds. Such suspicions can be verified by the "test-feed." For the want of the "test-feed" many a baby has been done to death and many more reduced to a condition of marasmus. Infants are often believed to obtain a deficient supply of milk from their mothers because they never seem to be satisfied and are constantly crying out to be fed. These are much more probably the symptoms of over-feeding, but in spite of the passing of large motions and copious quantities of urine these overfed infants are often regarded as half-starved. Much more damage is inflicted on young infants by over-feeding than by under-feeding, though both are bad and unnecessary. The physiological requirements of each baby should be estimated on a basis of weight, age and activity, and if the supply is found by the "test-feed" greatly to exceed this amount the quantity must be reduced, gradually rather than suddenly, to reasonable proportions. Infants who are properly managed from the first do not show these symptoms of hunger and dissatisfaction, but mothers and nurses who allow symptoms of this kind to develop through mismanagement are as a rule themselves very difficult to handle: if once they get it into their heads that the infant is being starved even the evidence of the "test-feed" will not shake their belief.

One of the troubles of over-feeding is that when the feeds are reduced to normal proportions the breasts may not be completely emptied. If they are not emptied there is a risk of the secretion failing altogether. In order to avoid this catastrophe the breasts must be completely emptied by the pump if necessary. If the milk appears to be of poor quality the breast-pump should be employed before the infant is put to the breast, if the milk is rich in fat the infant should be given the "fore-milk," while the strippings should be drawn off by the pump.

Excess of Special Elements.—The only two constituents of milk which are likely to be present in excess in breast milk are protein or fat. When the excess of either of these is great, characteristic symptoms are produced (see pp. 360 and 362), but to confirm the diagnosis a sample of milk should be sent for analysis.

Although I am somewhat sceptical of the results which follow efforts to treat these conditions the reader is referred to page 113 for suggestions. As a rule, the "strippings" contain rather less proteins than "fore-milk," and advantage can be taken of this knowledge, in cases in which the percentage of protein is too high without corresponding excess in the fat content, by drawing off the "fore-milk" with the pump before each feed.

The Influence of Menstruation.—It has already been explained (p. 109) that with the re-establishment of the menses toxic substances may be excreted in the milk. If the infant gives no evidence of the presence of such poisons there is no need to take him off the breast even temporarily. On the other hand, if he is sick, has green stools or manifests convulsive symptoms, it is certainly wise to suspend breast feeding until the period is over. The reappearance of menstruation during lactation is clearly an abnormal state of affairs, and calls for treatment. I have found that a course of arsenic and iron often has a most beneficial influence on the condition. During the period of suspension of breast feeding the mammary glands should be kept functionally active by using the breast-pump, while the infant should be fed artificially, with the same precautions as are advised in the case of weaning (see p. 140).

Influence of Pregnancy.—There does not appear to be any general consensus of opinion with regard to the desirability or otherwise of weaning the infant should pregnancy occur, but on the whole I think the argument is in favour of not weaning unless the nutrition of the infant appears to suffer.

On theoretical grounds there does not appear to be any cogent reason why a woman should not be able to nurse an infant after she has become pregnant. As is well known, the usual practice among farmers is to allow cows to become pregnant again soon after calving, for it is found that the milk under such circumstances in no way becomes deteriorated but rather improves.

Influence of Tuberculosis, Syphilis and the Specific Fevers.—For information with respect to these infective conditions see page 110.

WEANING

The term "weaning" is somewhat loosely employed to cover both the process of changing from breast feeding to bottle feeding and to express the transition from a purely milk diet to one which is mixed and partially solid. The subject will be dealt with here in both these aspects.

Weaning from Breast to Bottle.—This change should never be effected suddenly without good and substantial grounds, for the risks involved are considerable. The younger the baby the greater are the risks and the greater the need for a slow and gradual change. If possible one artificial feed only should at first be substituted for a breast feed, and after two or three days, when the infant has grown accustomed to his new food, a second bottle may be tried, until at the end of a fortnight or three weeks the complete change has been effected. In making these changes it is of the greatest importance to know exactly how much breast milk the infant has been in the habit of obtaining from the mother. This information is naturally in our possession when the infant has been accurately fed in accordance with the principles laid down in the preceding pages, but the physician is often called upon to advise with respect to the weaning of infants managed in the old happy-go-lucky manner. I have often met with cases in which weaning has been commenced with artificial feeds three, four and even five times as large as the breast feeds for which they have been substituted. Mistakes of this kind are impossible if the yield of breast milk is estimated by means of the "test-feed."

In making the substitution the first essential condition is to adjust the quantity of the artificial food to the size of the average breast feed previously obtained.

As regards the composition of the substituted food this should be as similar as possible to the breast milk which it replaces; it should be similar in balance and in digestibility. If cow's milk is employed as the basis of the new food it should be modified to breast standard in accordance with the directions given on page 202, and as such a mixture is far more difficult for the infant to digest than the breast milk to which he has been accustomed, his task should be lightened by preliminary predigestion of the food. The extent to which such substitute food should be peptonised will depend to some degree on the age of the infant and the stage of development of the digestive functions. If the baby is under one month of age I allow the process of peptonisation to proceed for 2 to $2\frac{1}{2}$ hours. If the child is three months old $1\frac{1}{2}$ hours' peptonisation is generally enough; at six months 1 hour's predigestion may suffice. As the infant becomes habituated to his new food the degree of peptonisation may be reduced day by day, until at the end of a certain period, which will depend on the age of the child and his learning capacity, this preliminary treatment of the food may be omitted altogether.

Infants who are weaned from the breast to cow's milk after the seventh or eighth month need not be submitted to the indignity of taking their feeds out of a bottle: they may be at once advanced to the cup or cup and spoon stage. Increases in quantity and variations in the quality of the food should be introduced gradually, in accordance with the general principles outlined in the following pages.

Weaning from a Milk to a Mixed Diet.—The very common experience that infants do not do well if they are kept on an exclusive milk diet after the eighth or ninth month has led to the objectionable practice of taking all infants off the breast at this age and substituting for it a diet composed mainly of cow's milk, but partly also of other varieties of solid food. There may indeed be practical reasons of a domestic character for ceasing to breast-feed after the eighth or ninth month, but there is no physiological reason as far as the infant is concerned. The nutrition of the infant does not suffer if he is breast-fed from the eighth month onwards for the next six months or more: he does not become rickety, as many imagine, any more than he would if he were receiving an equivalent of cow's milk. It is not the continuation of the supply of breast milk which does the damage in these cases, but the want of variety and expansion in the dietary which is physiologically called for at or about the time of the cutting of the first teeth.

An infant fourteen months or thereabouts in age should have about one pint of milk, in addition to bread and butter, rusks, vegetables, baked apple, egg and other varieties of easily digested food, and if the mother finds it compatible with her domestic and social duties to provide her infant with this amount of breast milk instead of the equivalent in cow's milk, it should not be for the physician to interfere or interpose learned objections on the score of pathological consequences or the rickets bogey.

When the breast-fed infant reaches the age of about six or seven months he should, if his dietetic education is to be conducted on the best lines, begin to have experiences of new varieties of food. If infants are allowed to have the breast, and nothing but the breast, for too long, it is often found difficult to wean them on to any other kind of food, and sometimes nothing will induce them to take substituted food out of bottle, cup or spoon. For this reason alone I advise at or about the time mentioned above to give to all breast-fed infants a small quantity of additional food, either in a spoon or in a cup. This food should only be regarded as a means of teaching the infant how to deal with varieties of food other than breast milk, and not as supplementary in the quantitative sense.

To begin with, one or two teaspoonfuls of milk and water given once a day are all that is required. After that barley water may be added, to teach the baby to digest starch. This is important, because breast milk, excellent as it is in other respects, contains no form of starch to develop the function of diastatic digestion. An infant habituated in this way to take food out of a spoon or cup, and to digest starchy foods, before the eruption of the milk teeth, will be in a position to deal with rusks or other hard varieties of food as soon as the incisors are cut. This is to my mind of very considerable importance, since nothing promotes the development of the jaws, the palate bone and the teeth so much as hard mastication.

Rusks, biscuits or crusts should be offered to the nursling as soon as he has teeth with which to chew solid articles of food. They should not, however, be given between feeds, but either just before or just after a breast feeding, so as not to introduce irregularities of habit in the digestive functions.

At or about the seventh month the artificial dietary should be amplified, and one meal a day should be set apart for little experiments in the giving of milk puddings, such as semolina or corn flour, mashed potato and gravy, or baked apple and cream. If very small quantities of such foods are given at first there is no danger of the infant becoming upset, and he soon learns to tolerate larger quantities if the daily increments are wisely managed.

It not infrequently happens that after the sixth month the daily yield of breast milk does not satisfy the physiological requirements. When this state of affairs is revealed by the accurate evidence of the "test-feed," even though the infant may continue to gain normally in weight and appear to suffer no impairment of nutrition, it is a good practice to make up the deficiency with supplementary feedings of cow's milk modified to breast standard. The restricted metabolism which necessarily results from underfeeding seems to set the pace of the vital activities at an unduly low level and to inculcate habits of economy which become more or less permanent.

In conclusion I would emphasise the importance of adhering to the rules of physiological feeding during the whole of this transitional period; whilst teaching the infant to digest new forms of food, considerations of balance, quantity, and all the other essentials of correct feeding, must not be lost sight of. The commonest mistake which is made is to deprive the infant of breast milk at an unnecessarily early date and to substitute for it cow's milk, which has a totally different balance. Another frequent error is to provide slops instead of solid dry food which requires mastication, whilst a third serious fault is to delay the provision of vegetables and fruits to too late an age. Vegetables such as Jerusalem artichokes, asparagus, brussels sprouts, onions, and even turnips, can, if well cooked, be safely given in small quantities to normal babies of eleven months old and upwards. Not only are they quite as digestible as the popular potato, but from the point of view of their content in organic salts, very much better suited to the physiological requirements.

Wet Nursing.—Owing to recent improvements in the artificial method and the difficulty of obtaining suitable wet nurses the employment of the latter has largely gone out of vogue. This to my mind is a great calamity, since no artificial method of feeding can afford to the infant the same protection from infectious disease (see p. 96). When it becomes better known that, when controlled by the "test-feed," one woman is capable of nursing one or more additional infants we shall hear less of the cruelty inflicted on the wet nurse's own infant, who is generally supposed to be relegated to the bottle while the privileged child of the rich usurps his birthright. If the services of a wet nurse are called into requisition it is an advantage rather than otherwise that the latter's own child should share and share alike with the adopted baby.

It is sometimes thought necessary to find a wet nurse whose own baby is the same age as the baby who is obtaining the milk. With one reservation this is absolutely unnecessary, for breast milk does not appreciably vary in composition from the time of the establishment of lactation to the time of weaning.

It is only in the case of quite young babies under a fortnight old that the question of the age of the wet nurse's own baby is a matter of import. It cannot be too thoroughly realised that if the new-born baby is deprived of the educational experiences afforded by the colostrum of his own mother he loses the one grand opportunity of learning how to digest human milk.

If a new-born infant is put to the breast of a wet nurse in full lactation he not only runs the almost certain risk of having his stomach overfilled with an excess of milk, and thereby suffering disorganisation of the motor functions, but he also invariably and inevitably obtains food which he is unable to digest.

If it is proposed to wet-nurse a baby from birth, the wet nurse's milk should be drawn off with a breast-pump, and after peptonisation in the manner described (p. 472) should be administered to the baby in a Breck feeder, or by means of a syringe, in the exceedingly small doses in which the baby normally consumes colostrum (see p. 95).

By this means all the troubles and dangers usually associated with wet nursing are avoided. After a few days this method of feeding can be relinquished. The milk should be peptonised for shorter and shorter periods every day, and finally the infant can be put direct to the wet nurse's breast, but each feed must be controlled by the " test-feed " with the same meticulous care that was enjoined in the case of the baby nursed by his own mother. If the wet nurse continues to feed her own baby as well as the foster-child the operation should be conducted on the same lines as described in the case of the management of twins (see p. 129).

The Choice of a Wet Nurse.—Anxiety on the score of tuberculosis or syphilis being imparted to the baby by the wet nurse is less justified now than it was a few years ago. The woman should always be examined by a physician experienced in the diagnosis of these and other diseases. A Wassermann test should be made, since this affords additional, though not conclusive, evidence, but the most important test is the condition of the wet nurse's own baby. For this latter reason it is well not to choose a nurse with too young a baby. If a woman has nursed a baby three or four months, and the latter still remains well nourished and in good health, the milk it has subsisted on cannot be of bad quality. Most authorities insist on the importance of well-shaped breasts, the so-called pear-shaped variety. Personally I think the shape is of minor importance if the yield is good as estimated by the " test-feed," and this method of gauging the capacity of the breasts should never be omitted. A sample of the milk can be submitted to chemical analysis, but here again the evidence afforded compares very unfavourably with that deducible from an examination of the infant himself. This physiological test is to all intents and purposes the only really reliable one.

The Management of the Wet Nurse.—As a rule a wet nurse is not a *persona grata* either to the mother or to the household. It is, however, most important that she should be made happy and comfortable, for if her mind is ill at ease the quality of the milk will greatly suffer. Wet nurses sometimes suffer from a change of food, and the tendency is to overfeed them. They should be fed as has been recommended in the case of a nursing mother, and the same rules hold good with regard to the consumption of alcohol. Regular exercise should be insisted on, and as much fresh air should be afforded as is compatible with the circumstances (see p. 110).

CHAPTER V

THE ARTIFICIAL FEEDING OF INFANTS

General Introduction—The Five Laws for Physiological Feeding—The History of the Evolution of a Scientific Method of Feeding—The Caloric Value—The "Balance"—The Accessory Food Factors—The Digestibility—The Number of Feeds and other Details—Sterilisation

General Introduction.—As far as the artificial feeding of infants is concerned a careful perusal of the principles of physiological feeding and a study of the means by which Nature in her infinite wisdom fulfils these conditions in breast feeding enable us to formulate certain definite rules which must be observed if substitute feeding is to be a success.

There is, however, no primrose path of artificial feeding along which we can confidently travel to the goal which we attempt to reach. The way is beset with difficulties and dangers. The only definite knowledge that we have to guide us is the absolute certainty that we shall never reach this goal unless we obey these fundamental laws in the spirit as well as in the letter. When we say an infant is a law unto himself, we do not mean that he can defy with impunity any of the universal laws of nature; what we mean is that no two infants will evade these laws in exactly the same way and suffer exactly the same penalties. The reserve powers of the human organism are so immense, and its methods of compensation are so diverse, that it is capable of suffering great wrongs without giving evidence of them in any one recognisable way. But evidence there always is of one kind or another if we know where to look for it and how to find it.

Even if we succeed in obeying all the laws of physiological feeding tabulated below, it does not follow that we shall meet with entire success, but what I particularly wish to emphasise is that we shall never succeed if we disobey them.

The physiological laws governing artificial feeding are as follows:—

(1) The energy-value of the food consumed, as measured in

calories, must correspond with the total energy-value of the output in work, heat, growth, etc.

(2) The "balance," or the relative proportions of the three main constituents of the diet—namely, the proteins, the carbohydrates and the fats—must conform to the physiological standard—in other words, to the standard of breast milk.

(3) In addition to the three main constituents there are certain essential accessory factors in a physiological diet which must not be omitted. These include, salts, vitamines, extractives, lecithin bodies, cholesterin, etc.

(4) The food must not only be adjusted to the existing digestive capacities, but it must also be of such a nature as to promote the exfoliation of the still undeveloped digestive functions.

(5) The times and details of feeding must be so arranged as to fit in with the general physiological requirements.

It may be objected that these rules constitute a counsel of perfection and that they are impossible of attainment ; but that is not so. In the following pages I hope to give all the necessary information for putting them into effect. The great majority of the methods of artificial feeding which in the past have proved to be failures, and many of the methods in use to-day which do not give complete satisfaction, owe their ill success to the fact that they do not fulfil all the requirements of these rules: they do some of the things that are required but they leave others undone. If these various methods are submitted to the arbitrament of these five laws, and critically examined in the light of the information which is set out in Part I. of this volume, it is not difficult to recognise the cause of their failure.

The History of the Evolution of a Scientific Method of Artificial Feeding.—One of the oldest and most primitive of all methods was to substitute the milk of any available mammal for the milk of the human mother. The tracks of time are strewn with mythological references to the foster-nursing of the human infant by mammals of different species.

Jupiter is related to have been suckled by a goat, while Romulus and Remus are said to have had the same kindly office afforded by a female wolf. Milk straight from the udder was not confined to ancient or mediæval days. It was not many years ago that the children in a crèche in Alexandria were suckled by goats, and no doubt this method would still be in use had not the scare of Mediterranean fever put a stop to the practice. If at the present time direct suckling is not employed in this country none the less certain optimists still appear to believe that the undiluted and unmodified milk of the cow, the ass, or the goat is a suitable substitute for human milk, and the more direct from the source the better. If the table on page 229 is examined, and the percentage composition of the milks of the above mammals compared with the standard composition of breast milk, the reader will at once notice how fundamentally the second of the above laws is violated, so that apart from other considerations of digestibility we need seek no further to discover causes to explain the unsatisfactory nature of the results obtained by whole-milk feeding. There can be no doubt that from quite early times the Romans followed exactly the same method, using earthenware feeding cups instead of glass bottles—with what ill success can be judged by the number of these cups which are found in their ancient tombs buried side by side with the infants this method of feeding had done to death.

Towards the middle of last century, when artificial feeding came into greater vogue, it was found that the more obvious symptoms of indigestion caused by giving whole cow's milk could be in some degree mitigated by dilution with water, and further, that the more the milk was diluted the less likely were the symptoms to supervene. It thus became a practice to give quite young or newly born infants cow's milk diluted with four parts of water, and as the infant grew older to dilute it less and less, until whole milk could be tolerated. Applying the test of our series of rules to this method of feeding it is perfectly clear that the " balance " is as wrong with much dilution as with little, and that it always departs widely from the physiological standard. Moreover with such dilutions of the original milk other essential constituents besides the three main ones may be reduced in quantity below the border-line of safety. I refer particularly to such substances as the lecithin bodies, the extractives, and possibly the vitamines. The chief objection, however, to this crude method of dilution is that in order to spare the digestive system the caloric requirements of the infant are disregarded.

When at a little later date the chemical properties of milk came to be better understood and the differences between the milk of one animal and another were more fully appreciated, it became evident that one of the most variable elements was the protein constituent, and that it was this substance, and not the sugar or the cream, which caused disturbances of digestion when cow's milk was administered to babies. From this period dated the various methods of milk modification which had as their object the adjustment of the "balance" of the food to breast standard. One of the first of these attempts was made by Dr Meigs. His plan was to allow milk to stand sufficiently long for the cream to rise to the upper levels. He took the upper half of a certain quantity of milk which had stood in this way and, after diluting it with water and lime water, added the required proportion of sugar. The resulting mixture had the following balance :—

Proteins . .	1·3%
Fats . .	3·0%
Sugar . .	6·0%

a percentage composition which does not differ very greatly from that of breast milk.

Biedert, in Germany, a few years later, introduced a somewhat similar method of modification. He took 50 oz. of milk, allowed it to stand one hour, and from it removed the top layer of 8 oz. by means of a special dipper. This top milk was estimated to contain 10% of fat, so that it could be diluted with two parts of water without reducing the fat content below the standard of breast milk. This rich top milk was employed, according to Biedert's method, as a stock mixture which could be more or less diluted according to the age and digestive capacities of the infant; by the addition of varying proportions of sugar a considerable range of percentages could be provided.

The objection to this method, as to that of Meigs and others like it, is that the aim of the modifications is directed to adapt the food to the digestive capacities only, without due regard to the nutritional requirements, while too much attention is centred on the "balance" of the three main constituents and too little on the equally important accessory factors. This method, with certain improvements, has been advocated by Dr Henry Dwight Chapin, of New York, and to his book, *The Theory and Practice of Infant Feeding*, the reader is referred for fuller information.

The next step in the evolution of an accurate method of milk modification was reached when the so-called percentage method came into vogue in America towards the end of the last century. The elaboration of this method we owe largely to the late Dr Thomas Morgan Rotch, of Harvard University. The details of carrying out this exact method of modification were left in the hands of experts at specially equipped milk laboratories. The physician wrote out a prescription for a milk mixture just as he would for one to consist of drugs, and at this point his responsibility ceased, it being left to the laboratory experts to carry out the details.

The following prescription is typical of the kind which were written by the thousand at the beginning of the century when this method was most popular:—

MRS A.'S BABY

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Fat	3·5%	Reaction	Neutral
Milk-sugar	6·5%	Number of feeds	8
Proteins	1·25%	Amount at each feed	3 oz.
Lime water	5·0%	Heated for	40 minutes
		At a temperature of	140° F.

1*st December* 1905. M. D.

Although there was no principle involved which excluded the addition of any or all of the accessory food factors which we now know are quite as important as the three main elements, as a matter of fact this method, by its very exactness, distracted attention from other and equally important requirements, such as caloric values and physiological "balance." Everything was made subservient to the reactions of the digestive system. If the infant vomited, or had so-called curds in the stools, the percentage of protein was reduced, sometimes by decimal places and often far below the level of safety. Quite apart from its intrinsic demerits, this method was doomed from the first on the score of expense. Here, in England, where for a time a Walker-Gordon Milk Laboratory maintained a struggling existence, the cost of feeding an infant on this percentage system amounted to something like £3, 10s. per week. All the same, we owe a great debt of gratitude to Dr Rotch, and others associated with him in the exploitation of this method, for it has taught us the importance of accuracy in "balance" and other details, and the best methods of controlling them.

The next important advance in our knowledge of the food requirements of infants occurred in connection with an appreciation of the respective differences in digestibility of the several proteins present in milk. The proteins of cow's milk, like the proteins of human milk, consist of soluble as well as of insoluble varieties, known respectively as (1) casein and (2) whey albumins.

Casein, or rather caseinogen, for it is in this form that it exists in milk, is soluble in alkaline or neutral media, but insoluble in acid fluids. It is this property that makes milk containing large quantities of this insoluble protein so intolerable to the sensitive stomach of the infant. Human milk contains a very small percentage (0·5%) of caseinogen and a relatively large percentage of the soluble whey proteins which are not precipitated in the stomach, whereas cow's milk contains a very high percentage of caseinogen, about 3·0%, and a low content of the whey proteins. Hence, even when cow's milk is greatly diluted with water, a bulky precipitate or coagulum is thrown down in the stomach of the infant who consumes it, and, owing to the irritation thereby set up, vomiting is apt to occur. Apart from this particular property of coagulability there is no reason to believe that caseinogen is any more difficult to digest than the whey proteins—that is to say, that one can be more easily converted into poly-peptides or peptides than the other—but when an infant vomits any particular class of food attention is immediately drawn to the fact, and as a rule it is changed. Hence, as soon as it was realised that it was the caseinogen of cow's milk, and not other elements, that made it indigestible for infants means were devised for removing this intractable constituent or rendering it incoagulable in the stomach.

The first effort in this direction was the introduction of the so-called "split protein" method. This consisted in removing the casein from the milk by coagulating it with rennet—in other words, by making curds and whey and straining off the clot thus formed. The filtrate contains all the soluble constituents of the milk, including the whey proteins. To the whey thus prepared may be added any desired proportion of fat or casein, by contributing cream or milk in accordance with the details given on page 206. This method has one very decided advantage in that it recognises the teleological significance of the presence of casein in milk as a means of educating the stomach to tolerate solid substances in its interior. If infants are continuously fed over long periods of time on specially prepared foods which do not coagulate in the stomach, they do not acquire the necessary degree of tolerance. On the other hand, it is quite possible to develop the stomach on too robust lines, and to make it a clamouring, tyrannical, hypertrophied organ which is never satisfied without over-feeding.

Another expedient which has been extensively employed in this country is the addition of citrate of sodium to cow's milk for the purpose of delaying or preventing the coagulation of the casein. There are objections to this method in that it does not promote the digestibility of cow's milk: it only delays the coagulation, and thus enables the infant to consume a food which, as regards "balance," is wholely unsuitable. It obscures, in fact, the true issue; it imposes on the later digestive processes in the intestines tasks which without it would be required of the stomach.

There are indeed a great number of other methods now in use which consist of combinations and modifications of the foregoing. Few of them, however, will stand critical examination when submitted to the test of my five essential points, nearly all of them assume the totally unjustifiable and unwarranted suppositions that (1) a food is suitable as long as the digestion is not upset; (2) that an infant requires a "stronger" food as he grows older.

In the following pages I propose to take my five cardinal points one by one, and show how they can be most easily and most effectually observed.

The energy-value of the food consumed, as measured in calories, must correspond with the total energy-value of the output in work, heat, growth, etc.

The student is advised to refer to pages 5-16 before he reads the following paragraphs.

It is quite impossible to make definite statements with respect to the caloric value of the food required by any individual infant of any particular age or weight, each case must be judged on its own merits.

The most that can be said is that average babies of average weight, and living under normal environmental conditions, require food of a certain caloric value. In the chart which appears on page 8 standard figures of this kind are given, and these constitute an excellent basis to work upon.

If by its habits and environmental conditions a baby has an output of energy greater than the normal, it clearly requires a correspondingly larger intake. If, on the other hand, its output is less the intake must be curtailed. Before, therefore, we form an estimate of any infant's food requirements we should ask ourselves: Is this particular baby in need of more or less food than the normal for the purposes of growth? Is it more or less energetic than the average baby? Must it produce more or less heat than the average baby to maintain its normal temperature?

Let me take a concrete case to explain what I mean, and let us suppose that the baby in question is six months old, that he weighs 15 lb., that he is extremely active and strong, and that he is clothed and bathed and housed and generally managed on the most hygienic and up-to-date principles.

By referring to the chart on page 8 we see that the average baby of six months of age requires in the 24 hours food of the value of 708 calories, or about 48 calories for each pound of body weight. The baby whose food requirements we are estimating is clearly entitled to more than the average because of his rate of growth, his muscular activity and healthy environmental conditions. How much more than the average should this baby receive? The one factor on which the answer to this question chiefly turns is that of the output of kinetic energy—to what extent, in fact, the baby makes use of his muscles. The average infant of six months can sit up, but cannot yet stand or dance on his mother's lap. The difference in the output of work in foot-pounds afforded by an infant who merely sits and by another who dances and climbs is immense. If, therefore, our hypothetical baby has already begun to raise himself on to his feet in his bath, and has already begun to dance on his mother's lap and to climb up her body, he clearly deserves a very considerable advance on the average allowance, and we probably should not be wrong in giving him 10 or 20% more than the standard allowance—in other words, food of the value of about 800 calories instead of the normal 708.

Now if this infant were breast fed there would be no difficulty in calculating how much milk he ought to receive in the 24 hours to yield this number of calories, for 1 oz. of human milk has a food value of 20-23 calories in accordance with its richness in cream. Assuming that the milk is of superior quality, and affords 22 calories per ounce, the daily ration should be 800÷22, or 36 oz. In the case of the artificially fed infant difficulties may arise owing to the varying values of the food. If, however, all artificial substitutes for breast milk are so compounded as to be of the same standard as breast milk even these difficulties vanish. Throughout this book I insist over and over again that all substitute foods should be made up to breast standard, not indeed because it makes calculations of caloric values so extremely easy, but chiefly because no other standard so satisfactorily fulfils the nutritional requirements of the average human baby. Since, however, it is improbable that all who refer to this book have adopted this simple method, I give the caloric value of certain of the substitute foods most commonly in use.

TABLE 37

To show the Caloric Value of Certain Foods commonly used in Artificial Feeding

Variety of Food	Caloric Value Per Oz.	Caloric Value Per Gram
Milk—		
Human	20	0·70
Cow	20	0·70
Goat	22	0·78
Sheep	25	0·88
Mare	12	0·40
Ass	13	0·45
Reindeer	61	2·14
Condensed Milk—		
Sweetened, full cream	106	3·7
Unsweetened, full cream	49	1·3
Dried Milk—		
Full cream (25% fat)	141	4·9
Half cream (15% fat)	122	4·0
Separated (2% fat)	100	3·5
Cream—		
Thin (20% fat)	60	2·1
Thick (48% fat)	134	4·3
Whey (0·3% fat)	8	0·28
Buttermilk (0·5% fat)	10	0·3
Allenbury's Infant Food No. 1 (20% fat)	134	4·6
Carbohydrates—		
Starch	116	4·1
Dextrose	110	3·69
Lactose	110	3·87
Saccharose	111	3·95
Gelatine (dry)	106	3·7
Calves' foot jelly	13	0·45
Vegetable broth (p. 476)	13	0·45
Protein, pure and dry, such as casein	116	4·1
Fat and oils	263	9·3
Marylebone Cream (50% fat)	131	4·6
Cod-liver-oil emulsion (33% fat)	88	3·1

A study of the foregoing table[1] will save the reader from making many of the common mistakes with regard to quantity which are made by inexperienced persons when they employ artificial substitutes for breast milk.

Take for instance the case of condensed milk. When this substitute is used the infant is usually greatly underfed, a fact which largely explains the well-known absence of digestive symptoms. Condensed milk has a caloric value almost exactly five times as high as human milk, and therefore if condensed milk is diluted in the proportion of one part of milk to five parts of water, and such mixture is substituted volume for volume for breast milk, the caloric value at any rate will be correct, however poor the balance.

Referring once again to our hypothetical baby, six months old and weighing 15 lb., whose estimated caloric requirements are 800, it will be noted that he will need 800÷106, or about 8 oz., of condensed milk in the 24 hours to satisfy his energy requirements. If this baby has 6 feeds in the 24 hours each feed must consist of $1\frac{1}{3}$ oz. of condensed milk no matter with what volume of water it is diluted. In my experience infants with similar requirements are more often fed on $\frac{1}{2}$ oz. feedings of condensed milk, thus being cheated of more than one half of their just allowance; and so it is with many others of the foods included in this list, notably ass's milk, whey and buttermilk. Buttermilk is rather a favourite substitute for cow's milk in Germany for cases in which there is intolerance of fat and dyspeptic trouble, but from the way in which it is generally recommended to be employed it is very clear that the infants to whom it is supplied must be very seriously underfed. Since its caloric value is less than half that of breast milk, when used as a substitute for the latter, it should be given in more than double amount unless there is some contra-indication.

In deciding whether any particular infant is being physiologically fed or not, the first step to take is to estimate his caloric requirements for the 24 hours, having regard to his age, weight and environmental conditions, and then to compare these estimated requirements with the actual caloric value of the food with which he is being supplied. Such calculations are extremely simple by the aid of Table 1, page 8.

The "balance," or the relative proportions of the three main

[1] For further details of caloric values see page 463.

constituents of the diet—namely, the proteins, the carbohydrates and the fats—must conform to the physiological standard—in other words, to the standard of breast milk.

Considerations of "balance" are usually as much neglected as those relating to quantity, or they are made subservient to the claims of the digestive system. I have already referred at some length (pp. 17-20) to a number of reasons why "balance" is of supreme importance from the point of view of nutrition, and have insisted over and over again that the claims of nutrition must not be sacrificed merely on the grounds that the infant is unable to digest the particular food with which for the time being he is supplied. The claims of nutrition must be satisfied as well as those of digestion, and if the infant cannot digest some particular food which is well adapted for supplying the nutritional requirements, he must have his food changed to one that he can digest, or must receive artificial aids to his digestion. Owing to the inherently indigestible character of cow's milk, when this substitute is employed for infant feeding it is often so diluted down to meet the requirements of digestion that the resulting "balance" infringes rule No. 2, one of the most sacred laws of physiological feeding.

It is necessary that the physician who supervises the feeding of infants should be familiar not only with the chemical composition, or "balance," of the common substitutes for breast feeding, but he should also be an adept at modifying and manipulating such substitutes, so that they may correspond with breast milk or any other required standard.

The most common substitute for breast milk is some form of cow's milk, generally dairy milk, but dried milks are now largely used, and so too are condensed and evaporated milks. I have already explained at the beginning of this chapter that cow's milk as formerly used, and very often as used at the present time, does not conform to breast standard, and that there is a strong tendency to dilute it less and less as the infant grows older, under the totally mistaken idea that such milk is more strengthening than milks which are more diluted. This view is very ridiculous; as an infant grows older he requires proportionately less and less protein and rather more carbohydrate. Hence, if cow's milk is to be rationally modified to meet these requirements, it ought to be diluted rather more, and at the same time to be fortified with a larger proportion of carbohydrate.

Unless there are special indications for doing otherwise, all substitutes for breast milk should be made up to breast standard, and this standard should be strictly adhered to as long as such substitutes remain the exclusive foods of the infants. With the introduction of solid and new varieties of food after weaning, "balance" can be maintained by appropriate combinations of nitrogenous, carbohydrate and fatty foods without exact modification of the staple substitute itself. In the following pages I propose to take *seriatim* some of the more common substitutes for breast milk and explain how they may be modified so as to conform to the required physiological standard.

Cow's Milk.—Although the composition of cow's milk differs very considerably with the breed of cow, with the time of the year and with the period of lactation, an average sample will be found to conform more or less accurately to the following analysis :—

Proteins . .	4·0%
Fats . .	3·5%
Sugar . .	4·5%

If such a sample be diluted with about an equal part of water, or other diluent, and then fortified with additional fat and sugar, it can readily be modified to breast standard. The following is the formula for preparing one pint of the mixture :—

Cow's milk . . .	10 oz.
Cream (50% fat) . .	6 drachms
Sugar	1 oz.
Water to make . . .	20 oz.

Unless cow's milk is diluted the protein content is obviously very excessive, but no degree of dilution will adjust the balance unless cream and sugar are added after such dilution.

Dried Milk.—Dried milk possesses no property which exempts it from the necessity of modification ; if dairy milk must have its balance adjusted, so must dried milk. If the brand of dried milk employed has not already been manipulated by the manufacturer, and consists, as indeed it should, of the desiccated residue of ordinary dairy milk, it is 7½ times as strong as dairy milk—in other words, it should be used exactly as dairy milk is used to make the modification, only for every 7½ parts of dairy milk 1 part of dried milk should be employed—in other words, for every ounce of dairy milk one drachm of dried milk[1] should be substituted. The formula for preparing one pint of dried-milk mixture of breast standard will read as follows :—

Dried milk	$1\frac{1}{4}$ oz.—*i.e.* 10 drachms
Cream (50% fat) . .	6 drachms
Sugar	1 oz.
Water to make . . .	20 oz.

One of the most largely used of all dried milks in this country is Glaxo. This brand is sold in several qualities : (1) full cream ; (2) half cream ; (3) three-quarter cream. They all contain added sugar, so that when they are diluted with water according to the directions the disproportion between the three chief elements is not so great as when unaltered varieties of dried milk are similarly diluted.

I append the following table, as published by the proprietors of Glaxo, to show in what manner and to what extent the " balance " of the resulting mixtures departs from breast standard :—

TABLE 38

	Breast Milk (standard)	Glaxo (full cream) diluted 1 in 8	Glaxo ($\frac{1}{2}$ cream) diluted 1 in 8	Glaxo ($\frac{3}{4}$ cream) diluted 1 in 8
Fats . .	3·5%	3·25%	1·75%	2·55%
Proteins . .	1·5%	2·70%	3·72%	3·37%
Carbohydrates .	7·0%	5·25%	5·80%	5·50%
Mineral matter .	0·2%	0·70%	0·80%	0·73%
Water . .	88·2%	88·10%	87·93%	87·85%

An examination of this table shows that the protein content of every one of these three dilutions is enormously above breast standard. The fat content is, even in the case of the full-cream milk, considerably below breast standard, and the sugar in all cases is too low—in other words, Glaxo does not fulfil the requirements of a correct " balance " in the sense accepted throughout the pages of this book. There is no reason, however, why Glaxo should not be modified to breast standard by the addition of cream and sugar, after the protein content has been reduced to physiological limits by means of the requisite dilution—namely, about 1 in 12.

[1] This only gives an error of one in fifteen—*i.e.* 8 drachms instead of $7\frac{1}{2}$ drachms.

Condensed Milk.—There are certain attractions in the employment of condensed milk for the feeding of infants which obscure the real physiological objections to its prolonged use. One of the chief of these objections is that the "balance" does not correspond with breast standard; a good sample of sweetened condensed milk has the following analysis:—

Proteins . .	9·7%
Carbohydrates .	52·2%
Fats . .	13·7%

If a condensed milk of this composition is diluted with five parts of water the resulting mixture will have a balance of—

Proteins . .	1·9%
Carbohydrates .	10·4%
Fats . .	2·7%

In this the sugar is 33% too high and the fat about 33% too low. To a certain extent these discrepancies could be adjusted by the addition of supplementary fat. In those cases in which, owing to digestive difficulties, a high percentage of sugar is indicated and a low fat, condensed-milk dilutions have undoubted advantages. As a matter of fact I make great use of condensed milks in my hospital practice in the treatment of sick babies, but always keeping in view the necessity for adjusting the "balance" as soon as the infant's digestive capacities allow.

Unsweetened condensed milks are less open to criticism on the score of unsuitability of "balance," or rather their "balance" is more amenable to modification.

The chemical composition of a good brand of unsweetened condensed milk is as follows:—

Proteins . .	8·3%
Sugar . .	16·0%
Fats . .	12·4%

If such a condensed milk is diluted with five parts of water the resulting mixture has the following composition:—

Proteins . .	1·6%
Sugar . .	3·0%
Fats . .	2·5%

In this dilution the protein percentage is of breast standard, but the sugar and fat content are both too low. Such a mixture can be made to conform to breast standard by the addition of 4% of sugar and 1% of fat.

Ass's Milk, Whey, Buttermilk, etc.—It was pointed out in the last section, which dealt with the question of caloric values, that grave injustice was often done to babies who were fed on whey mixtures, buttermilk or ass's milk, on the score of insufficiency of total quantity of food. It may here be pointed out that the defects in " balance " are equally great.

TABLE 39

Food	Protein	Carbohydrate	Fat
Ass's milk . .	1·85%	6·19%	1·37%
Whey . . .	0·9%	5·6%	0·34%
Buttermilk . .	3·0%	4·8%	0·5%

Substitute foods of this nature may be very valuable as temporary alternatives to foods which contain an excess of fat and upset the infant's digestive functions, but their defects in balance must be borne in mind and not allowed permanently to jeopardise the prospects of nutrition.

Methods of adjusting " Balance."—It is quite easy to rectify an incorrect " balance " in any variety of food which is otherwise suitable by the addition of the particular element which may be deficient in amount. For instance, ass's milk is often well indicated as an alternative to cow's milk for delicate infants with sensitive stomachs owing to the low protein content and the lightness of the curd thrown down in the stomach ; its low percentage in fat renders it an unsuitable food for the exclusive and permanent nourishment of the infant. The fat deficiency can be made good by the addition of some supplementary fat, such as butter fat, cod-liver oil or nut oil made up into a suitable emulsion so that it can mix well with the milk. It is convenient to have such emulsions made of standard strengths of 50% or 33% fat. If this is done the correction in " balance " is easily carried out by adding twice or three times as much emulsion as pure fat is required.

If, as in the case of whey mixtures, it is found necessary to bring up the protein content to the standard of breast milk, it is quite easy to effect this correction by the addition of pure whey proteins (albulactin) or white of egg. White of egg contains 10·7% of albumin.

In the case of carbohydrates, adjustments of "balance" are very simple, since pure sugars and starches are easily procurable. The question often arises, Is it better to supplement a deficient percentage of carbohydrate with milk-sugar, cane-sugar, maltose or starch? With very young infants milk-sugar has advantages, but it is expensive, while later on, after the third month of life or thereabouts, it may be of educational value to habituate the infant to different varieties of carbohydrate, including malt-sugar and small quantities of starch. Personally I make a practice of combining different kinds of carbohydrate, and especially small quantities of insoluble varieties (starches), from quite an early date.

In addition to the three main constituents there are certain accessory factors which are essential in a physiological diet which must not be omitted. These include salts, vitamines, extractives, lecithin bodies, cholesterin, etc.

The part which many of these unconsidered trifles play in the maintenance of nutrition and in the building-up of the human edifice can be compared to the share which such essential details as nails, screws, bolts, rivets, windows, hinges, locks, handles, bells, etc., take in the construction of the modern house.

The proteins, the carbohydrates and the fats compare with the bricks, the mortar and the wood, which constitute the main staples of the builder's requirements, but no house and no animal body can be considered complete or finished without benefit of these accessory factors. I feel very well convinced that it is for want of these that artificial feeding mainly fails. At the present day quantity and "balance" are fairly well understood; the need for vitamines is also beginning to be recognised, but few methods of feeding embrace within their purview provision for salts in organic combination—lecithin bodies, cholesterin and animal extractives. It has been maintained that young animals develop better and are more vigorous if they are occasionally supplied with soups or hashes of all the organs of some other animal, because in this way all the essential elements for building up their own organs will be provided. This statement must not be accepted too literally, but I must admit that I have had much better success in the feeding of infants since I have made it a rule to provide in the artificial food a small daily ration of soup[1] made from vegetables and bones containing red marrow. In this way a large number of vegetable salts and animal extractives are provided which otherwise might be omitted. All the accessory food factors are required in small amount only, but the total omission of any one of them is fatal to perfect nutrition, and may even be fatal to life. I am not aware that excess of any one of them is harmful, except perhaps lecithin, so that no evil result is likely to accrue from giving a little too much. It is obvious that at the present time we have no means of providing bactericidal and immunising bodies such as undoubtedly exist in small quantities both in colostrum and in breast milk, and on these grounds may quite possibly be explained the greater resistance of breast-fed babies to infective disease; but all the same, there is no reason to despair of being able to do so at some future date.

From a practical point of view I would make the following suggestions with regard to the provision of accessory food factors in artificial feeding :—

(1) In all cases of artificial feeding provide fresh fruit juice—one or two teaspoonfuls of orange juice, grape juice or apple scrapings, or as an alternative, the raw juice of turnip, tomato or carrot. In this way will be provided a sufficiency of the anti-scorbutic accessory food factor.

(2) Ensure that every artificially fed baby has a fair proportion of fat from animal sources. Vegetable fats must not be employed to the exclusion of fats of animal origin, for these alone contain the fat soluble vitamine which is in some way essential for growth. It is believed that cod-liver oil, beef suet, and especially that form of it which is known commercially as oleo fat, and which is a fat expressed from kidney suet, contain the largest proportions of this vitamine.

(3) If starchy and farinaceous foods constitute any considerable proportion of the total carbohydrate intake, as in the case of the use of proprietary foods, see that an adequate supply of the anti-neuritic vitamine is afforded. Yeast preparations serve this purpose well. Marmite, which is an extract of yeast, is a convenient preparation to employ. A quarter of a teaspoonful, or less, added to the day's

[1] See p. 476.

supply of food provides more than enough of this food factor, and further, it imparts an agreeable flavour to the milk.

(4) By giving 3 or 4 oz. of vegetable and bone soup in the 24 hours, especially if a small piece of liver is also boiled with it, a number of vegetable salts and animal extractives, as well as lecithin and cholesterin, are provided in appreciable quantity. These may be of great value as additions to milk dilutions.

Lecithin may be provided also in yolk of egg. In the pure form one grain in the 24 hours is sufficient. One teaspoonful of yolk of egg added to the day's supply of milk contributes extractives and nucleo-albumins which may be of value to nutrition.

The food must not only be adjusted to the existing digestive capacities, but it must also be of such a nature as to promote the exfoliation of the still undeveloped digestive functions.

It is very difficult to predict on theoretical grounds whether a food will prove digestible or not. Many factors complicate the issue. Incapacity to digest is evidenced by vomiting, so-called wind or colic, and by diarrhœa or an abnormal condition of the bowels. But these symptoms may equally well be the result of some other disturbance, such as an infection, entirely disconnected with any special unsuitability in the food itself. It is, however, of very great practical importance to have a good knowledge of the relative digestibility of different varieties of food in normal and average circumstances, so that if one kind of food produces symptoms of indigestion it may not be replaced by one which is still more difficult to deal with. It is a very common experience to find that when breast milk, which is relatively digestible, disagrees the infant is condemned to bottle feedings of cow's milk, which is enormously more resistant to the digestive processes. I hesitate very much to attempt to classify different foods in any particular order of digestibility, but, with a warning not to accept the following statements as applicable under all conditions, I venture to submit the following comparative table of digestibility :—

(1) Colostrum ; (2) completely predigested foods (pancreatised for two or more hours) ; (3) partially predigested foods (pancreatised for two hours or less), Allenbury No. 1., Horlick's Malted Milk, Savory and Moore's food ; (4) breast milk ; condensed milks ; (6) dried milks in the following order :—Glaxo, Cow and Gate,

Ambrosia, Trumilk; (7) citrated milk dilutions; (8) citrated whole milk; (9) milk dilutions; (10) whole milk.

An examination of this table suggests how very irrational it is to jump from breast milk, when this is supposed to disagree on the grounds of indigestibility, to ordinary milk dilutions, which occupy almost the last position in the scale. It would be a far more rational proceeding to try, in the first instance, some more digestible food, such as Allenbury No. 1 or pancreatised milk dilutions, and after these have proved successful to advance to foods which tax the digestive functions to a greater extent.

The great value of predigestion has not in my opinion been sufficiently appreciated, and partly for the reason that it is not universally recognised that the digestion of food "in vitro" cannot be accomplished with the lightning speed which is suggested by the printed directions which appear on the labels of the various artificial digestants. The digestion of cow's milk in the alimentary tract of a baby occupies from 5 to 7 hours. It is hardly to be expected that the same result can be accomplished in a jug in a few minutes. As a matter of fact, it has been proved that it takes some 20 hours or more to completely digest cow's milk artificially—that is to say, to reduce it completely to a condition of disintegration in which all the component constituents are fit for absorption. From the practical, as opposed to the theoretical, point of view it is not found necessary to push predigestion as far as this. If liquor pancreaticus, or some other efficient digestive, is allowed to act upon cow's milk for two to three hours at a suitable temperature it will be found that the process has been carried sufficiently far for all practical purposes. The method that I recommend is to begin on the lowest rung of the ladder and to mount up by gradual stages, making quite sure of one step before attempting a second—in other words, to predigest very thoroughly at first and then to reduce the time of pancreatisation by 5, 10 or 15 minutes every day, until the infant gives evidence of digestive independence. For the practical details of peptonisation see page 472.

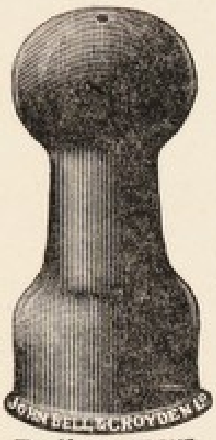
It has already been explained in the chapter which deals with breast feeding that under normal circumstances the infant has no opportunity of learning how to digest starchy and farinaceous foods until he is weaned, for the simple reason that milk does not contain any representatives of this class of food. With artificial feeding the case is different, and there is no valid reason why the infant's education with respect to starch digestion should be neglected until the time of the eruption of the teeth. Infants feel better satisfied with food which contains starch than with milk, which contains an equivalent of sugar, for the reason that it gives the digestive functions more work to do. Under normal corcumstances starch is first hydrolysed to a condition of maltose and the maltose is then inverted to dextrose. The way is prepared for this double process by giving the artificially fed infant a small quantity of maltose or dextrinised flour at quite an early age, or by providing it with a small quantity of weak barley water. An infant's powers of amylolytic digestion can be developed at almost any age if the educational process be applied gradually. It is of advantage to the infant to be able to digest starch well by the time the teeth arrive, for the gnawing of crusts and rusks promotes the development of the jaws as well as the teeth.

The times of feeding and other details must be made to conform to the physiological requirements.

The Times of Feeding.—These should be arranged, as in the case of breast feeding, at three-hourly intervals from the first day of life, with a long interval at night. The best times are 6 A.M., 9 A.M., 12 noon, 3 P.M., 6 P.M., 9 P.M. After the fifth or sixth month the number of feeds may be reduced to 5, and after the eighth or ninth month to 4. The infant should always be awakened at feeding-times, and any temptation to feed the child at irregular times should be strenuously resisted. If the infant has previously been in the habit of receiving night-feedings it is usually very difficult to break him of this unfortunate practice. Every effort should, however, be made. It is sometimes a good plan to make the night-feeds smaller and smaller, or weaker and weaker, until finally they become reduced to a small drink of water, which is no great encouragement to the infant to wake.

Time occupied in a Feed.—This should not be too protracted, from 10 to 20 minutes is quite long enough. Much will depend on the size of the hole in the nipple, and, indeed, on the character of the nipple itself. Some infants, especially wind-suckers and those with inco-ordination of the movements of the tongue, do better when they are spoon-fed. Although the small amount of jaw work involved in sucking helps to encourage the development of the teeth, there need be no hesitation in substituting the spoon for the bottle if there are compensatory advantages.

The Nipple.—As has already been mentioned (p. 123), the naturally fed infant when taking the breast does not produce a genuine vacuum in his mouth, but rather causes a flow of milk by compression of the nipple and surrounding areola between the tongue and roof of the mouth, in fact, largely by jaw work. It is wise to select a nipple which encourages the same kind of muscular movements. The nipple, of which an illustration is here given, to a certain extent fulfils these objects. If such a nipple is fitted to a feeding-bottle and turned upside down little spurts of milk can be ejected by intermittent pressure between the thumb and finger, in a manner somewhat resembling the process of milking. This form of nipple certainly encourages jaw work more than any other with which I am acquainted, but it does not compel it.



THE MARYLEBONE TEAT

FIG. 40.

It is difficult to say what should be the size of the hole in the nipple, as different infants have varying powers of suction, but as a rough guide it will be found large enough if, when the bottle is turned upside down, the drops that issue from it are separated by intervals of about one second.

Sterilisation, Pasteurisation, Boiling and Scalding of Milk.—All these methods are employed to render milk consumed by infants free of bacteria, but the terms used to describe them are often very loosely employed.

Strictly speaking, the term "sterilisation" should be reserved for any process which, by means of heat or other agent, renders milk or other matter absolutely germ-free. Milk so treated will, theoretically at least, remain sweet for an indefinite period as long as it is preserved in hermetically closed vessels. It is, however, very difficult to kill all the bacteria and their spores by heat alone, for some of the bacteria, and most of their spores, are very resistant to this form of lethal agent. Milk is very often spoken of as "sterilised" when it has been raised to the temperature of boiling water, and a great deal of the milk which is sold commercially as "sterilised," in special sealed bottles, is by no means sterile—that is to say, free from germs. Indeed it is in my experience the most dangerous variety of milk which can be used for infant consumption, because it gives a false sense of security and encourages the belief that it can be kept indefinitely without undergoing deterioration or losing its sterility. A certain proportion of such milk is really germ-free, but this does not lessen the danger which attaches to that which is not. Moreover the danger is enhanced owing to the fact that such milk often does not reveal its poisonous properties by sour taste or objectionable odours.

To render milk really sterile—that is to say, free of spores as well as of fully developed bacteria—it is necessary to submit it to a much higher temperature than that at which, under normal circumstances, milk boils—that is to say, just over 100° C. or 212° F. If milk is heated under pressure in an autoclave or other suitable vessel it can be kept from boiling until the temperature reaches any required degree—110° C. is the temperature commonly employed in the commercial sterilisation of milk, and this temperature is maintained for 30 minutes or longer. Milk thus treated may be relied upon as quite sterile.

Another method, which is known as "fractional sterilisation," achieves the same object by more expensive and tedious means. This method requires that the milk should be raised to a temperature high enough to kill fully developed bacteria—say 140-170° F.—for some 30 minutes. The milk is then allowed to cool, and is then kept for 24 hours at a temperature favourable for the development of spores into mature bacteria. At the end of this period these bacteria are themselves killed by a second cooking of the milk at 140-170° F. This fractional sterilisation can be repeated indefinitely, but three cookings are usually found sufficient to clear the fluid of the most refractory of spores.

The object of fractional sterilisation is to avoid the alteration in the taste of the milk which results when the latter is raised to a high temperature and part of the milk-sugar is caramelised. This characteristic flavour of boiled milk is objectionable to adults or children who have acquired a taste for raw milk, but it need not stand in the way of its employment in infant feeding if this is the only argument against its use.

Objections have, however, been raised to the boiling or sterilisation of milk on the ground that such treatment impairs its nutritive qualities. Inasmuch as this belief is very widely spread, it may be of advantage to make the position quite clear.

The boiling or heating of milk does not impair the nutritive qualities of the contained proteins, carbohydrates or fats. The effect of heat on some of the accessory food factors is not quite so clear. It is possible that either heat, or the oxidation to which heat disposes, may cause some deterioration in the properties of the anti-scorbutic vitamine and certain others of the biological elements present in milk, the significance of which little is at present known. There can, however, be no possible doubt that the nutrition of infants fed on sterilised milk can remain first-rate provided that the anti-scorbutic element is afforded independently in the form of fresh fruit juice, nor can there be any doubt that the dangers attaching to raw milk are very serious from the point of view of infection with the germs of tubercle, summer diarrhœa, gastro-enteritis, diphtheria, scarlet fever, etc.

The practical question, in my opinion, is not so much whether milk should be rendered germ-free, or relatively germ-free, before it is allowed to be consumed by infants, as by what means the germs can be most conveniently killed.

However carefully cow's milk may be handled, it seldom contains less than 5000 bacteria per cubic centimetre, the standard fixed for certified milk in America. Average samples of milk in this country commonly contain 3,370,000 living germs per cubic centimetre, and in hot weather sometimes as many as 9,000,000.

The majority of germs present in milk are non-pathogenic—that is to say, they do not provoke definite disease in the baby or individual who consumes it, but all the same the presence of a great excess of even the most harmless of bacteria must be prejudicial to the health of the infant and the nutritive value of the milk. The exponents of the raw-milk fad claim that it is an advantage rather than otherwise that bacteria belonging to the milk-souring group—*i.e.* the bacillus acidi lactici, the bacillus lactis aërogenes and the streptococcus lacticus—should be present in milk in good quantity in order that the growth of pathogenic varieties should be inhibited by the lactic acid produced by their growth and activities. As this milk-souring group is killed by comparatively low degrees of temperature, while some of the more dangerous bacteria are more resistant to heat, there is evidently some risk of killing the benign varieties and leaving the malign to survive unless the degree of heat applied is sufficient to kill both. The argument is that it is better not to make any attempt to sterilise the milk, but to leave it with a probable predominance of the benign varieties of bacteria.

An examination of the accompanying table will show that the majority of the pathogenic bacteria which are found in milk are killed at comparatively low temperatures.

TABLE 41

Name of Bacillus	Lethal Temperature	Time occupied
Bacillus diphtheriæ	55° C. (136° F.)	10 minutes
Bacillus typhosus	56° C. (136° F.)	,,
Pneumococcus	52° C. (125° F.)	,,
Bacillus coli communis	60° C. (140° F.)	,,
Bacillus acidi lactici	56° C. (136° F.)	,,
Staphylococcus pyogenes aureus	58° C. (136° F.)	,,
Staphylococcus pyogenes albus	62° C. (144° F.)	,,
Bacillus tuberculosis	80° C. (170° F.) ?	?

At first sight, therefore, it would appear that if milk is heated to 62° C. for 10 minutes it ought to be quite safe from the most common of the pathogenic organisms; but this is not actually the case, for among the most dangerous parasites of milk are those which produce proteolytic changes and lead to the formation of toxic bodies of the character of ptomaines. Many of these bacteria are spore-forming and highly resistant to heat. Some of them survive exposure to a temperature of 100° C. for quite a long time.

Opinions seem to differ with respect to the temperature at which the tubercle bacillus perishes. It is, however, known to be killed if exposed to a temperature of 80° C. (170° F.) for 10 minutes, or to that of boiling water, 100° C. (212° F.), for 1 minute.

Taking these facts into consideration, I cannot recommend the pasteurisation of milk—*i.e.* exposure to a temperature of 140°-170° F. for 30 or more minutes—as a safe method of sterilising milk intended for infant consumption. I am, however, quite convinced that if milk is brought to the temperature of boiling water, 100° C. (212° F.), and maintained at that temperature for 3 minutes, such milk is perfectly safe either for infants or for children. This does not mean that the milk is actually boiled, for the boiling-point of milk is above 100° F.: in fact, milk cannot be boiled in a double-chambered saucepan, it can only be raised to a temperature of 100° F. This is a very great advantage, for it cannot be burned, neither can it be wasted by boiling over. If milk is heated in an ordinary saucepan, when it reaches a temperature slightly above

100° C. it boils over and is apt to be burned. Milk which has been boiled in this way it is called " scalded " milk.

It is sometimes objected that if cow's milk is boiled, or indeed raised to the temperature of boiling water, the whey albumins are coagulated and form as a skin on the top of the milk. It is quite true that the whey albumins coagulate at a temperature of about 160° F., but they are not necessarily lost to the consumer. On the other hand if the milk is stirred during the process of heating no such skin forms, and the coagulated whey proteins remain in fine division in the milk, and thereby lose nothing of their food value.

Taking all these facts into consideration, the advantages appear to me to be strongly in favour of heating milk to a temperature of 100° C. without allowing oneself to be deluded into the belief that by so doing the milk is rendered " sterile " in the strict meaning of the term. It is only relatively sterile, but quite safe for infant consumption provided it is not kept too long nor at too high a temperature afterwards. Milk " sterilised " by this method should be cooled down quickly, and kept subsequently as cold as possible, so as not to give any surviving spores an opportunity of developing and multiplying in a favourable medium. Spores will not, as a rule, develop unless the temperature of the medium in which they exist rises above 40° F., and only very slowly if below 50° F.

Sterilising Apparatus.—For many reasons it is better to employ a regular sterilising apparatus than merely to boil the milk in a saucepan. There are several convenient forms of sterilisers on the market, most of them modifications of the original " Soxhlet."

Messrs W. H. Bailey & Son, 38 Oxford Street, W. 1 ; Messrs Bell & Croyden, 50 Wigmore Street, W. 1, and Messrs Arnold & Sons, 5 Giltspur Street, E.C. 1, all supply convenient forms of the apparatus.

A complete set consists of the following details :—

(1) Oak rack stand for bottles, with drawer (12).
(2) Boiler or saucepan for holding 6-8 bottles (1).
(3) Spirit-lamp.
(4) Heater for one bottle (3).
(5) A set of bottles (6).
(6) Rubber discs and caps for retaining the same in position (10 and 9).
(7) One large graduated measure to hold 40 oz. (4).

(8) One 6 oz. conical glass measure (5).
(9) Glass funnel (13).
(10) Special brush for cleaning bottles (11).
(11) One packet of shot for cleaning bottles.

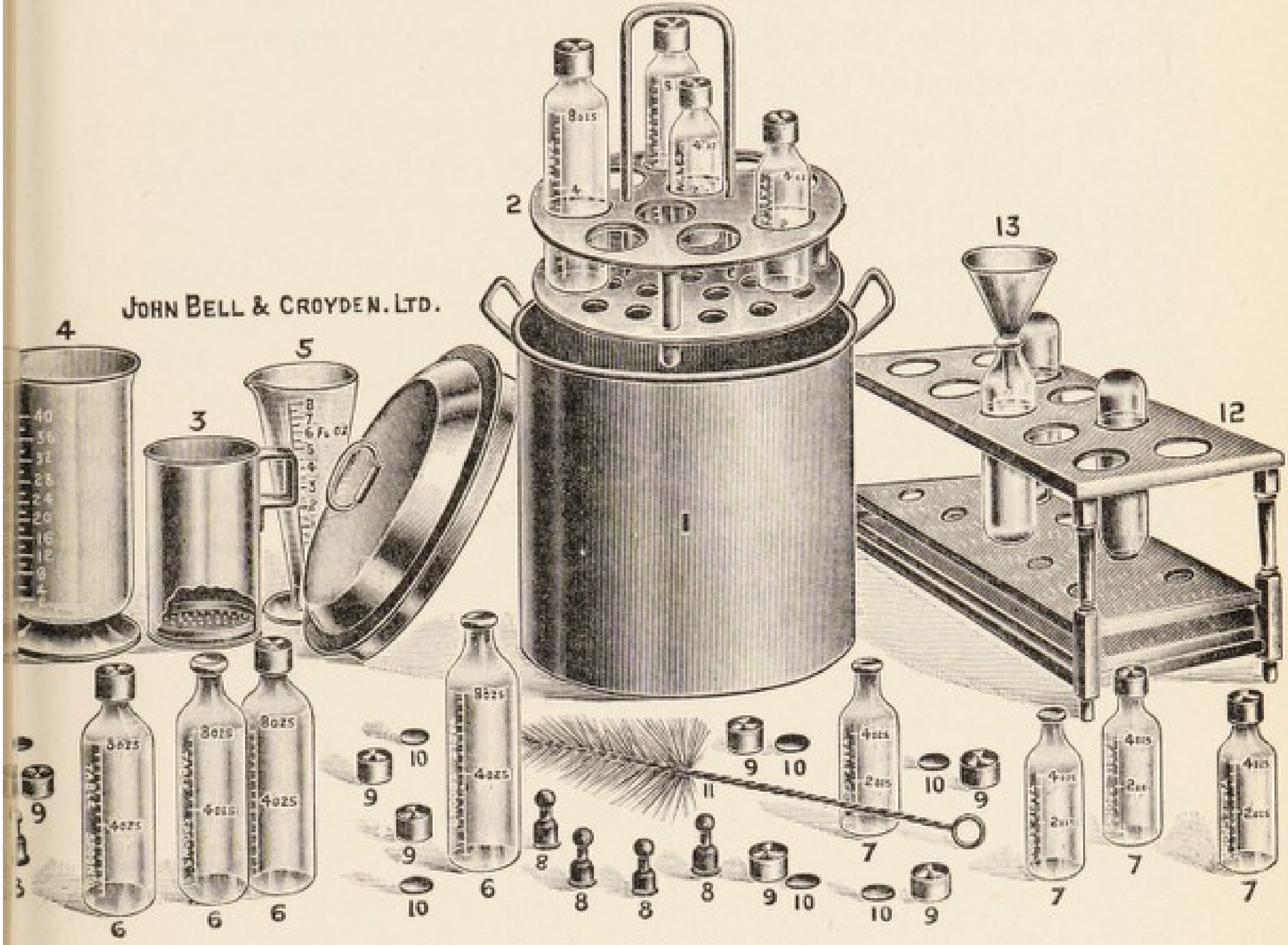


FIG. 42.—Sterilising Apparatus

The method of using such an apparatus is as follows :—

The total supply of food for the 24 hours should be prepared in the 40 oz. graduated measure. The exact amount required for one feed should then be measured in the six-ounce glass and poured into one of the bottles by means of the glass funnel. If the remaining bottles required in the 24 hours are filled up to the same level there is no need to waste time and energy in measuring each individual portion. It is wise, in case of accidents, to have one additional bottle. The indiarubber discs must then be accurately adjusted and held in position by means of the metal caps.

The bottles thus securely corked should be fitted into their appropriate compartments in the tray and placed in the saucepan.

The saucepan, containing sufficient water (at about the temperature of 115° F.) to reach to the level of the milk in the bottles, should be placed on a gas-ring or spirit-lamp and allowed to remain there until the water has boiled for three or four minutes. The bottles should be cooled down as quickly as circumstances allow and then returned to the saucepan, which may be packed with ice or kept in the coolest available place.

As a feeding-time comes round a bottle should be taken from stock, heated in the warmer to 100° F. and fitted with a nipple after the removal of the disc and cap.

The advantages of this method are (1) accuracy ; (2) saving of time and trouble ; (3) safety from injurious micro-organisms.

CHAPTER VI

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

COW'S MILK

Production and Distribution—Composition—Total Solids—Nitrogenous Constituents—Extractives—Ferments and Enzymes—Immunising Substances—Fat, Sugar, Salts—Specific Gravity—Reaction—Coagulability—Influence of Rennin—Foreign Matter and Dirt in Milk—Bacteria—Conditions which affect the Composition—Breed of Cow—Period of Lactation—Influence of Diet—The Stage of Milking—Influence of Intervals between Milkings—Examination of Cow's Milk

Production and Distribution.—There may be differences of opinion with respect to the advantages of raw milk as compared with those of cooked milk, but all are agreed that clean milk is preferable to dirty milk. Following the example of America, great efforts have been made in this country to improve dairy methods and provide reasonably clean milk, and the public owe a great debt of gratitude to The National Clean Milk Society [1] for many reforms, both in the methods of production and distribution of milk, introduced during recent years, as also for its exposure of the indescribably filthy condition of much of the milk we consume at table or buy for the nourishment of our babies.

The number of bacteria present in milk is usually accepted as the most reliable index of its degree of cleanliness. High-grade milk at the time of delivery to the consumer should not contain more than 5000 bacteria to the cubic centimetre. Second-class milk should not contain more than 100,000. To attain to the standard of 5000 bacteria—or even 10,000 bacteria—to the cubic centimetre requires the employment of very cleanly methods in every department of the dairy; moreover, it entails a greatly increased cost of production. All our efforts should be directed to the introduction of improved methods which, if they do not actually effect economies in the production, at least do not greatly add to the cost.

It is very expensive to produce milk with a bacterial count of

[1] 3 Bedford Square, W.C.1.

less than 10,000 per c.c., whereas it would add very little to the present cost of production to supply milk that is reasonably clean and free from stable contamination with a bacterial count of some 100,000 bacteria per c.c.

I believe the public interest would be better studied if reasonably clean milk could be sold at 8d. a quart than if high-grade milk with a bacterial count of only 5000 per c.c. were sold at 1s. a quart. From the point of view of safety from bacterial infection, there is far less risk in feeding a baby on such reasonably clean milk, which has been boiled in the home, than there is in feeding it on the highest grade certified milk which is raw; and from the point of view of nutrition I do not believe there is one iota of difference if ordinary precautions with respect to the independent supply of accessory food factors are taken.

Opinion is distinctly inclining at the present time in favour of the pasteurisation of milk on a commercial scale before it is delivered to the householder. Personally, I do not see any objection to this practice, provided that the consumer is informed of what has taken place, and the procedure does not become a cloak for dirty production and careless distribution.

Readers who are interested in the question of clean milk are advised to read *Milk and its Hygienic Relations*,[1] or to inquire of The National Clean Milk Society.

The Composition of Cow's Milk.—Although for the general purposes of this book it is assumed that the average composition of cow's milk is :

Proteins . .	4·0%
Fats . .	3·5%
Sugar . .	4·5%

it must be remembered that milk is an "assemble" of a very large number of different constituents in addition to these three main elements, some of which are definitely known to possess properties of nutritive value, while others are strongly suspected of having important relationships with the normal metabolic processes.

In the accompanying table a comprehensive list of the better recognised constituents of cow's milk is supplied, and side by side with them, for purposes of comparison, a similar list of the same constituents with their percentages in human, goat's and ass's milk.

[1] J. Lane Claypon. Longmans, Green & Co.

TABLE 43

The Composition and Properties of Different Kinds of Milk

Name of Constituents	Human Milk Per Cent.	Cow's Milk Per Cent.	Goat's Milk Per Cent.	Ass's Milk Per Cent.
Water	86·4	88·0	85·5	91·0
Total solids	13·6	12·0	14·5	9·0
Caloric value per oz.	20·0	20·0	20·0	13·0
Fat				
Total content	3·5	3·5	4·0	1·0
Volatile fatty acids (Percentage in total fat)	1·4	6·8	..	..
Insoluble fatty acids (Percentage in total fat)	49·0	54–60	..	..
Oleic acid (Percentage in total fat)	50·0	34–38	..	..
Nitrogenous bodies—				
Total nitrogen	0·15–0·25	0·55	..	..
Extractive nitrogen (creatin, creatinin, hypozanthin, etc.)	0·03	0·05	..	..
Casein	0·6–1·0	3·00	3·6	0·6–1·8
Whey proteins (lactalbumin, lactoglobulin)	0·5–1·0	0·3–0·8	1·2	0·3–0·7
Urea	0·02	0·01	..	..
Protective bodies (antitoxins, precipitins, agglutinins, alexins, opsonins, etc.)	Indefinite quantity	Indefinite quantity	Indefinite quantity	Indefinite quantity
Ammonia (?)	0·018	0·02	..	..
Sugar (lactose)	6–7	4–5	2–5	5–6
Citric acid	0·037	0·12–0·2	0·1–0·15	..
Total ash	0·14–0·28	0·7	0·77–1·0	0·4–0·5
K_2O	0·08	0·17	0·13	0·08
Na_2O	0·02	0·05	0·06	0·03
CaO	0·03	0·2	0·19	0·1
MgO	0·006	0·02	0·015	0·013
Fe_2O_3	0·0005	0·001	0·003	0·001
P_2O_5	0·046	0·24	0·28	0·15
Organic phosphorus in complete solution	0·009	0·06	0·07	0·026
Inorganic phosphorus in complete solution	0·037	0·08	0·21	0·24
Cl.	0·043	0·095	0·1	0·03
Ferments (catalase, reductase, aldehydase, amylase, glycolytic, lipase, proteolytic, etc.)	Traces	Traces	Traces	Traces
Specific gravity at 15° C.	1·032	1·032	1·026-1·038	1·025-1·034

[1] After Professor R. M. Raudnitz. See *Diseases of Children* (Pfaundler and Schlossmann), vol. i., p. 321. American Edition.

The Total Solids.—Although the total solids in cow's milk are given in the above table as 12%, this figure only holds approximately true of mixed milks in which the total is made up from a number of different cows of different breeds and in different periods of lactation. The total solids in the milk of Jersey cows are more usually 15·93% while that of shorthorns may be about 13·3%.

Nitrogenous Constituents.—The total nitrogenous compounds in cow's milk are computed by Van Slyke to be 3·2% and by Babcock as 3·8%, the greater proportion of which consists of casein, on an average about 3%. The soluble proteins, the so-called whey proteins, are present in cow's milk in variable proportion from 0·3% to 1·0%. Of these lactalbumin is the chief representative, while lactoglobulin contributes only a small share. Lactoglobulin is similar to, or identical with, the serum globulin of the blood.

Extractives.—Traces of extractives are found in cow's milk. For the most part these consist of urea, creatin, creatinin, hypozanthin and cholesterin.

Ferments or Enzymes.—A great number of ferments of different kinds have been identified in cow's milk, but, on the whole, opinion does not incline to the belief that they are capable of aiding, to any appreciable extent, the digestion of any of the food elements contained in milk itself. The influence of peroxidase on nutrition is negligible, as also is that of the reductases and amylases. Many of these enzymes appear to originate from or to be produced by bacteria present in the milk. They are, in fact, contaminations and not natural constituents. Since all of these enzymes are destroyed at temperatures above 150° F. it is naturally important to know whether they have any physiological influence either on digestion or on the metabolic processes, for if so it would be detrimental to the nutrition of the infant if he be fed on milk which has been boiled. The belief in the superiority of unboiled milk on such grounds is based on the very flimsiest of evidence.

Substances concerned in the Production of Immunity.—There can be no possible doubt that all milks, including that of the cow, contain the same substances—alexins, antitoxins, agglutinins, etc., as are contained in the blood of the animal which produces it, and which protect it from infection; but to what extent the protective substances present in cow's milk are of value to the human infant is quite another matter. Moreover, after the establishment of the functions of digestion, such protective substances will be destroyed and disintegrated in the stomach or intestines before they have an opportunity of being absorbed, and for this reason no great value can attach to these bodies after the early days of life.

Fat.—The fat content of mixed milks ranges between 3·5% and 4%, but the individual milk of some particular cows may be very much richer—for instance, the milk of Alderney and Jersey cows may contain as much as 5% or 6%. The milk of a Holstein cow may be very poor in fat—even as low as 2·88%, while that of a shorthorn is on an average 3·73%. The combination of fatty acids in the butter fat of cow's milk is quite different from that in human milk. This fact may have physiological significance (see p. 106).

The Sugar is one of the least variable of the constituents of cow's milk. Throughout this book the average of 4·5% is accepted as the standard. The percentage may, however, vary between the two extremes of 2·11% and 6·1%.

Salts.—The total ash in cow's milk ranges in quantity between 0·6% and 1·0%. In the accompanying table is given the percentage of the individual constituents of the total ash according to various authorities:

TABLE 44

Percentage of Salts in Cow's Milk in 100 parts of Ash

Mineral Element	Bunge	Abderhalden	Schloss	Söldner	Pelka	Richmond
K_2O . . .	22·14	22·40	24·74	24·96	23·75	28·71
Na_2O . . .	13·91	12·25	10·79	6·16	15·36	6·67
CaO . . .	20·05	21·07	21·35	22·25	20·37	20·27
MgO . . .	2·63	2·91	2·71	2·71	..	2·80
Fe_2O_3 . . .	0·04	..	..	..	..	0·40
P_2O_5 . . .	24·75	24·10	29·54	32·27	27·13	29·33
Cl . . .	21·27	17·25	13·63	10·86	14·67	14·00

Specific Gravity.—The specific gravity of whole milk lies between 1·028 and 1·035 at 15° C. (59° F.).

These differences depend to a considerable extent on the cream content, but the specific gravity of the fat itself in the milk of different breeds of cattle varies also, owing to differences in the composition—*i.e.* in the balance of the constituent fatty acids.

The Reaction.—The reaction is amphoteric to litmus paper when the milk is perfectly fresh; on keeping, it becomes acid, due to the splitting of lactose into lactic acid under the influence of bacterial activity. The reaction of fresh milk as observed with different indicators is as follows:—100 c.c. has the same alkaline reaction, with litmus as indicator, as 41 c.c. of decinormal caustic soda, and the same acid reaction towards phenolphthalein as 19·5 c.c. of decinormal sulphuric acid.

COAGULABILITY

The Influence of Heat.—Perfectly fresh milk does not coagulate on boiling, although a pellicle of coagulated casein and lime salts forms on the surface.

The Influence of Acids.—Cow's milk coagulates spontaneously when the degree of acidity due to the presence of lactic acid is sufficiently high—*i.e.* 0·711%. Such coagulation is facilitated by heat. Richmond states that it will coagulate on boiling when the lactic acid reaches 0·29%. Hydrochloric acid will precipitate casein; 50 to 70 c.c. of decinormal hydrochloric will precipitate the casein in 100 c.c. of milk, while 60 to 80 c.c. of decinormal acetic acid will have the same effect.

The Influence of Rennin.—Rennin will coagulate the casein of cow's milk when the reaction is neutral or acid, but not when it is alkaline. The addition of calcium chloride or free acid hastens the advent of coagulation and increases the amount of clot. The addition of inert material, such as starch or sawdust, hastens the action of rennin, but lime water when added to milk in sufficient quantity to render it alkaline, entirely prevents the formation of a curd. In lesser amount it delays coagulation in the stomach by staving off the point at which the acidity of the gastric juice neutralises the milk or renders it acid. The temperature influences the action of rennin, 106° to 108° F. appears to be the optimum temperature; above or below this point rennin acts less efficiently. The temperature also affects the character of the coagulum. At 60° F. the curd is flocculent, spongy and soft. At 77-113° F. it is more or less firm and solid. At 122° F. and above it is very soft, loose and gelatinous.

Boiled or condensed milk is not under normal conditions coagulated at all by rennin. Barley water and other cereal decoctions hinder the formation of heavy casein curds by acting as protective colloid. The percentage of starch which has a maximum effect of this kind is 0·75%. Citrate of sodium is of great value in the prevention of the formation of large tough curds in the stomach. The citrate of sodium combines with the calcium caseinate of the milk to form sodium caseinate and calcium citrate. The rennin splits the sodium caseinate into sodium paracaseinate, which is very soluble. Two grains of citrate of sodium to the ounce of milk delays coagulation in the stomach of the infant sufficiently long for all practical purposes.

FOREIGN MATTER AND DIRT IN MILK

Bacteria.—From the moment of milking to the time of consumption milk is continuously exposed to sources of contamination: from the cow itself, from the milker, from the pail, from the cowshed, from the churn, from dairy utensils, and from utensils in the home. Each source of infection contributes its quota of bacteria, and when it is remembered that, under favourable conditions of temperature, multiplication proceeds with incredible rapidity, it is scarcely surprising that, by the time an average sample of milk is swallowed by the human being, it is teeming with countless numbers of living organisms. As an indication of the dangers to which milk is exposed, unless it is handled with the most meticulous cleanliness and care, it may be mentioned that a single hair from the cow, falling into the milking pail, may contribute 27,000 bacteria, while a gram of barnyard manure contains something like 13,050,200,000 living organisms. The importance of the temperature to which milk is exposed after milking is explained by the following facts. If high-grade milk, containing only 3000 bacteria per c.c., is kept at a room temperature of 68° F. for 24 hours the bacterial count may rise to 450,000 per c.c.; if it is kept for 48 hours the number may amount to 25,000,000 per c.c.; while less clean milk, with an initial content of 30,000 per c.c., may possess 4,000,000 bacteria per c.c. at the end of 24 hours, and 25,000,000,000 at the end of 48 hours under similar conditions of temperature. These facts reveal the futility of spending large sums of money in producing initially clean milk unless similar pains are taken to maintain it afterwards at a sufficiently low temperature to inhibit bacterial multiplication.

The bacteriology of milk is such a large subject that it is not proposed to enter upon it here, further than to repeat what has already been said—namely, that the dangers to infant life are so great from possible infection due to bacterial contaminations that the only safe course is to sterilise all milk by heat before allowing it to be used as a food.

Dirt in Milk.—Most of the dirt found in milk is derived from extraneous sources, but there is also a large amount of slime derived from the mammary gland of the cow which can be removed by centrifugalising the milk, and which is so unpleasant in appearance that an inspection of it can give one quite a distaste for milk. A few years ago the late Professor Delépine estimated that the average amount of slime and dirt in milk was 106 lb. in 40,000 gallons of milk. This large quantity was reduced to 78 lb. by quite simple precautions.

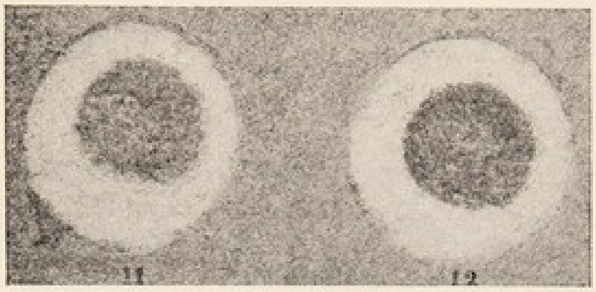


Fig. 45.—Milk purchased from well-known London Dairies

A very striking method of demonstrating the relative cleanliness of different samples of milk is to filter a given quantity of each through little discs of cotton-wool and compare the results. The accompanying illustration shows the quantity of dirt, mainly originating from the barnyard, in two samples of milk delivered to houses in well-to-do parts of London, and the illustration below it represents the result of filtering a similar quantity of milk which had been carefully handled by improved dairy methods.

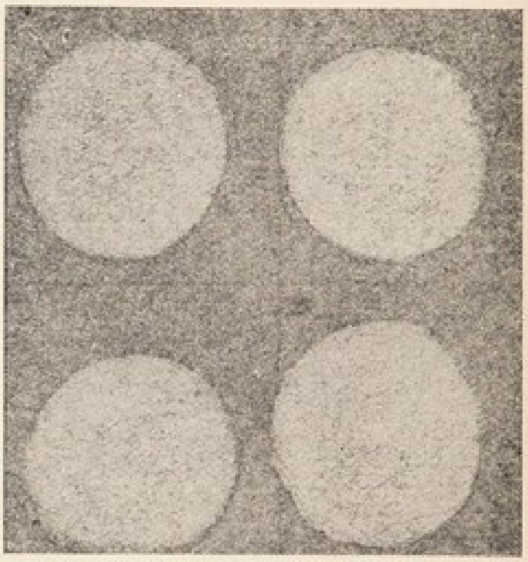


Fig. 46.—Nursery Milk

The dirt represented in the first series of discs is chiefly dung, earth, hair and vegetable fibre, not necessarily detrimental to health even in the uncooked condition, and certainly quite wholesome after boiling, but it is, in part at least, dirt of a character which offends the senses.

CONDITIONS WHICH AFFECT THE COMPOSITION OF COW'S MILK

The Breed of the Cow.—Even under similar conditions of feeding and general management, the milk of different breeds of cows shows distinctive variations, chiefly as regards cream content. Some of these are shown in the accompanying table :

Table 47

	Durham	Ayrshire	Holstein	Jersey	American Grade	Shorthorn
Fat . . .	4·04%	3·89%	2·88%	4·95%	4·01%	3·73%
Sugar . . .	4·34%	4·41%	4·33%	4·87%	4·36%	4·99%
Proteins . .	4·17%	4·01%	3·99%	3·99%	4·06%	4·01%
Ash . . .	0·73%	0·73%	0·74%	0·71%	0·74%	0·71%
Water . . .	86·72%	86·96%	88·06%	85·57%	86·83%	87·17%

Period of Lactation.—Towards the end of lactation there is a drop in the total amount of milk supplied, but there is a concomitant rise in the total nitrogen content, which is quite contrary to what occurs in the case of the nursing mother. The comparison, however, is vitiated by the complication of pregnancy which usually occurs in the case of the cow after a few months of milking.

The Influence of Diet.—The composition of milk appears to be almost entirely independent of the composition of the food consumed by the cow, but the total amount can, within limits, be increased by increments in the food supply. To increase the yield by increasing the food supply over a certain limit is not a profitable proposition ; a more practical alternative is to keep cows with better individual capacities for secreting milk. Attempts have recently been made in America to determine the optimum diets for obtaining the maximum yield of milk of any required standard. Although such experiments must necessarily add to our knowledge of scientific dairying, it cannot be claimed that so far the results have proved particularly practical. The personal index of the cow is almost as important as the same factor in the nursing mother. In the case of the nursing woman the yield, and to some extent the quality, is dependent on the variable factor of the baby's demands and capacity to suck ; in the case of the cow there is little variation in the milking factor.

The Stage of Milking.—The fat content of the milk increases towards the end of milking—the "strippings" are the richest of all. The "fore-milk" is often very poor in fat. In the following table after Jensen are given the figures of some experiments undertaken by him.

TABLE 48

	First Experiment	Second Experiment	Third Experiment
Fore-milk	0·55% of fat	1·5% of fat	1·70% of fat
Middle milk	2·70% ,,	3·40% ,,	3·35% ,,
Strippings	8·30% ,,	7·80% ,,	6·40% ,,

The Composition in relation to Total Yield.—The relative proportions of the various constituents in milk—*i.e.* the balance—appear to be practically independent of the total quantity secreted in the 24 hours.

The Influence of the Intervals between Milkings.—With two milkings a day the milk is richer in both total nitrogen and in fat than when there are three or more milkings. The total quantity is greater the more frequent the milkings.

THE EXAMINATION OF COW'S MILK

When any doubts are held with regard to the quality of cow's milk the Medical Officer of Health for the district should be informed. The latter will always be glad to give advice without disclosing the name of the informant. It must, however, be remembered that the public are peculiarly ignorant on the subject of the quality of milk; they pass hasty judgments on most unconvincing evidence. For instance, they are very apt to judge by colour. A rich yellow is regarded as equivalent to a good fat content although, as a matter of fact, such coloration may be entirely due to independent causes.

The most valuable criterion of the quality of any milk is the percentage content of fat. As far as London milk is concerned the fat content is remarkably constant, and for the following reasons. Fat is far the most valuable element in milk, and in accordance with Government regulations no milk is allowed to be sold in which the percentage of fat falls below 3·0%. On the other hand, the vendors of milk obtain no advantage in selling milk with a higher content. They therefore take very good care to remove any excess, if such exists, and on the other hand, they rarely run the risk of falling into the clutches of the law by selling milk below the standard. In the country, and in small provincial towns where the milk supply is not controlled with the same zeal, variations in the fat content are more liable to occur.

The Cream Test.—A rough but very useful means of estimating the fat content of any sample of milk is as follows. Take a 6 oz. medicine bottle graduated with $\frac{1}{2}$ oz. (tablespoonful) doses, fill it up to the level of the tenth marking (5 oz.) and let it stand for 24 hours. If at the end of this time the layer of cream does not occupy at least three-quarters of the space between the ninth and tenth marking, it certainly contains less than the statutory quantum of cream, and may be referred to the analyst for further examination.

The Sourness Test.—Take a small test-tube and fill it with milk up to the middle, adding an equal quantity of 70% alcohol. Close the tube with the thumb and shake thoroughly. If after waiting two minutes there is no curdling, the milk is not unduly sour.

The Dirt Test.—Reference has already been made to the method of testing the cleanliness of milk by its filtration through discs of cotton-wool (p. 180), but a more feasible test is to take a conical measure or specimen glass capable of holding 10 oz. and to fill it with milk and allow it to stand for a few hours. Reasonably clean milk will not give evidence of a sediment of dirt at the bottom of the vessel.

The Specific Gravity Test.—This is taken by means of the lactometer.[1] The average specific gravity of milk is about 1·032. The result of this test, considered in relationship to the result of the cream test, will serve to indicate whether the milk has been watered or no. There are two conditions which lower the specific gravity of milk: (1) the addition of water; (2) exceptional richness in cream. If, therefore, the fat content as estimated by the fat test is low, and the specific gravity as estimated by the lactometer test is also low, watering of the milk may be suspected.

[1] This can be obtained from Messrs Townson & Mercer, 34 Camomile Street, London, E.C.

CHAPTER VII

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

DRIED MILK

Historical Account—Physical Properties—Taste—Solubility—Coagulability—Keeping Properties — Bacteriology — Digestibility — Composition and Chemical Properties—Ferments—Protective Bodies—Vitamines—Value of Dried Milk in the Feeding of Infants

Historical Account.—Those who are interested in the subject of dried milk are referred to one or other of the publications [1] mentioned in the note at the foot of this page.

Although partially dried or condensed milk has been a practical proposition since about the middle of the last century, all efforts to desiccate it on a commercial scale proved to be complete failures until the beginning of the present century, when the Ekenberg process (1902 and 1903) was introduced. The Just Hatmaker process (1903 and 1906), an improvement on the foregoing method, depends on the drying of milk, which has previously been concentrated "in vacuo," on rapidly rotating cylinders heated internally by superheated steam. As the milk dries on the surface of the cylinders it is scraped off in the form of a thin film or pellicle and subsequently granulated.

Further improvements were incorporated in the Merrell-Soule process (1906), by which milk after concentration "in vacuo" is sprayed in the form of an exceedingly fine "nebula" into a drying chamber. As the "nebula" is carried across this chamber in a current of dry hot air it falls as a snow-like powder on to the floor, where it is swept up and removed. Although there are numerous modifications of both the cylinder and spray processes, all the dried milks on the market in this country are desiccated by one or other of these methods, and in the following

[1] Reports to Local Government Board. *Dried Milk.* New Series, 116. 1918. *Le Lait desséché,* by Prof. Porcher. Lyons, 1912. *Economic Uses of Dried Milk,* by Eric Pritchard. Report, English-speaking Conferences on Infant Mortality, 1913. *Le Lait desséché,* by Xavier Cazalas. Asselin & Houzeau. Paris, 1912.

pages they will be described as cylinder-dried and spray-dried[1] respectively.

The Physical Properties of Dried Milk.—The physical properties with regard to taste, solubility, coagulability, and so on, differ very considerably according to the particular method by which the milk has been desiccated.

Taste.—The taste of cylinder-dried milk, of which Glaxo is the best-known example, is agreeable and biscuity, but not the least like that of raw milk. Babies and children like it well, especially when they have not acquired tastes for other varieties of milk. On the other hand it completely spoils tea and is not nice even in coffee. For milk puddings and confectionery it is excellent.

The taste of spray-dried milk can be almost indistinguishable from that of raw milk, but it must be absolutely fresh. Owing to the exceedingly fine division of the fat, and the large surface exposure to the air which consequently results, the fatty acids soon become oxidised and impart a cheesy, and by no means pleasant, odour to the milk. When or if this objection to spray-dried milk can be overcome, I have very little doubt that it will be the only variety of milk employed for domestic purposes. Attempts have been made to prevent the development of this disagreeable odour by packing in hermetically sealed tins containing no air, but nitrogen gas only, but so far without practical results.

Solubility.—Cylinder-dried milk varies in solubility in accordance with special modifications in the manufacture, and according as chemical substances—alkaline phosphates, for instance—have or have not been added for the purpose of promoting solubility.

Strictly speaking, the degree of solubility is fairly high, about 90%, in cylinder-dried milk; but Glaxo certainly, and the same is more or less true of other brands of this nature, separates into distinct layers if it is allowed to stand undisturbed for a short time after reconstruction. The fat soon separates as a yellow layer of unemulsified oil on the surface.

According to Dr G. W. Monier-Williams the whole of the whey proteins are not coagulated in the process of drying, as one might imagine; some portions of them remain soluble. In fresh milk the percentage of soluble whey proteins is about 0·5%; in reconstituted dried milk the amount is about 0·21%.

In spray-dried milk the solubility is much higher. In some

[1] Sometimes described as the air-dried process.

samples it reaches 100% and the whey proteins remain completely unchanged. In appearance Trumilk and other milks dried by the Merrell-Soule process are, after reconstitution, exactly like fresh milk. The cream rises slowly in the ordinary way, and not in an oily layer, as in Glaxo and other cylinder-dried milks.

Coagulability.—In cylinder-dried milk the curd produced by rennin is quite unlike that produced in fresh milk. It is more flocculent and more finely divided. The curd produced in spray-dried milk is practically identical with that of fresh milk.

The greater digestibility of Glaxo and similar brands of dried milk is due to this physical property. Whether such easy digestibility is, in the final issue, a virtue or a fault depends on the manner in which the milk is used.

Keeping Properties.—Owing to the relative absence of water (see p. 189) dried milks can be kept a long time without their protein content undergoing decomposition, although, as already stated, the fat, especially in the spray-dried varieties, is apt to become rancid or tallowy in odour, owing to oxidation processes. The milk as a whole becomes less soluble, sometimes it becomes caked, but I have had milk which has been dried by the cylinder process in my possession for seven years without it becoming seriously insoluble, and without it acquiring any unpleasant odour. But such results can only occur when the packing has been exceptionally good.

The Bacteriology.—Dried milks are not bacteria-free, but the cylinder-dried milks are less contaminated than the spray-dried varieties. Since most of the bacteria are killed outright by the Hatmaker process, and a considerable proportion of them by the Merrell-Soule process, it is clear that if no subsequent contamination were to occur dried milks would remain relatively sterile. In practice it is found that the milk becomes reinfected in the concluding stages of powdering and packing. According to the late Professor Delépine one sample of dried milk shortly after drying grew 4900 bacteria per c.c. of reconstituted milk on aerobic gelatine plates. After the same milk had been kept for 112 days the colonies were reduced to 4180 under similar conditions of examination, thus proving that there is no development of bacteria, but rather the reverse, in dried milk on keeping.

From the point of view of infant feeding dried milks may be regarded as incapable of infecting infants with tubercle or other forms of pathogenic bacteria, and from this point of view they have obvious advantages over raw milk.

Digestibility.—Clinical experience very clearly proves that milks dried by the Just Hatmaker process do not cause the same obvious disturbances of digestion that we are familiar with when cow's milk, modified or undiluted, forms the basis of an infant's diet. This is largely owing to the property, already referred to, of such milks curdling with rennin in a finely divided and flocculent clot. Hence with cylinder-dried milk there are no violent gastric reactions to detract from its popularity. We are very apt to classify foods as good or bad for infants according as they do not or do provoke gastric symptoms. But gastric symptoms, although very obvious and insistent, are not the only evil results produced by unsuitable foods. There are often other effects less obvious at first, and longer delayed.

Hence before jumping to the conclusion that cylinder-dried milk is superior to other forms of milk as a food for infants, we ought to inquire carefully into its influences on intestinal digestion, which is really much more important than gastric digestion, and on nutrition generally. I am not aware of any investigations carried out on these lines, but from long clinical experience my impression is that infants fed on cylinder-dried milks do no better, and no worse, than infants fed on milks dried by other processes, provided that all the rules for physiological feeding are strictly observed. On the other hand, since there are fewer gastric symptoms with cylinder-dried milks, they are safer in the hands of those who do not know how to fulfil the requirements of physiological feeding—safer, that is, in the hands of ignorant persons. For my part, I always used to employ spray-dried milks when I could obtain them at a reasonable price. At the present time, for some reason, I cannot procure them,[1] and so have to use milks dried by the Just Hatmaker process, which I do not like so well.

Composition and Chemical Properties.—If all varieties of dried milk were simply milk powders made from fresh milk, to which nothing has been added and nothing extracted except water, their employment in infant feeding would be greatly simplified. The problem is, however, complicated by manipulations of the fat content. To a few brands fat is said to be added, but more often

[1] It is more expensive to dry milk by hot air than by the cylinder process. But now, April 1922, air-dried milks are procurable.

fat is taken away—in some cases admittedly, in other cases presumably—so that the actual percentage of fat is a somewhat variable and unreliable quantity. According to Sir James Dobbie's [1] analytical report the fat content of twenty-six samples of full-cream milk powders examined in the Government laboratory ranged from 22·58% to 31·28%. The figures for milk powders made from impoverished milks were 4·73% to 21·29%, and for skimmed or separated milks 0·67% to 3·4%. The percentage of sugar is also most variable; even the quantity of milk-sugar is not constant, varying in full-cream samples from 33% to 41%; in impoverished milks from 39% to 49% and in skimmed milks from 45% to 52%. The real trouble, however, in connection with the sugar content is that in certain cases cane-sugar has also been added. Such additions complicate the problem of correct physiological feeding enormously, for while they raise the sugar percentage they do not raise it to the standard of breast milk, and the user is thus left in doubt as to whether the milk powder is to be employed simply with the addition of water, in accordance with the very misleading directions usually supplied with the tin or package, or whether it should be modified to breast standard on the assumption that such powder represents nothing more nor less than the desiccated residuum of ordinary dairy milk to which no supplementary sugar has been added.

Preservatives, such as boron preparations, boric acid or salicylic acid, are rare contaminants, but occasionally found in French and Dutch dried milks. Alkalies, such as bicarbonate of soda, added for the purpose of neutralising acidity, and alkaline phosphates, for the purpose of increasing the solubility, are much more commonly detected.

In the accompanying table (p. 189) is given the percentage composition of various dried milks according to analyses supplied by the makers or from independent sources.

Ferments.—In fresh milk the following ferments are present —catalase, peroxidase, formaldehydase and amylase. Although others have been described they are probably bacterial in origin. All these ferments are destroyed in the process of drying by the cylinder method. They are not necessarily destroyed when milk is dried by the Merrell-Soule process, for this can be conducted

[1] Report to the Local Government Board. New Series, No. 116. Food Reports, No. 24. Published by his Majesty's Stationery Office, 1918.

TABLE 49

Percentage Composition of Various Samples of Dried Milk

Brand and Authority of Analysis	Water Per Cent.	Fat Per Cent.	Protein Per Cent.	Sugar Per Cent.	Ash Per Cent.	Remarks
Full cream— Extremes of 26 samples— Sir James Dobbie's Report	1·85 to 6·10	22·58 to 31·28	22·27 to 27·75	33·26 to 41·39	5·44 to 7·58	
Impoverished milks (half-cream, etc.)— Sir James Dobbie's Report	5·00 to 6·50	4·73 to 21·92	25·01 to 32·25	39·28 to 49·51	6·40 to 7·80	
Skimmed or separated milks— Sir James Dobbie's Report .	2·29 to 10·87	0·67 to 3·4	30·69 to 37·23	45·65 to 52·58	7·00 to 9·66	
Glaxo (full cream)— Manufacturer's analysis .	3·20	26·00	22·90	42·30	5·60	Contains added sugar
Glaxo (half-cream, No. 1)— Manufacturer's analysis .	3·20	14·00	29·80	46·50	6·50	Contains added sugar
Glaxo (three-quarter cream)— Manufacturer's analysis .	3·20	20·00	26·90	44·00	5·90	Contains added sugar
Ambrosia— *Lancet* analysis . . .	1·60	29·29	28·71	35·20	5·20	
Trumilk— *Lancet* analysis, 1911 . .	2·00	26·9	27·8	37·4	5·9	Air-dried
Cow and Gate (full cream)— Garratt and Stewart, 1912 .	3·35	25·00	27·5	37·82	6·32	
Cow and Gate (half-cream)— Garratt and Stewart, 1912 .	4·56	16·00	30·9	41·54	6·98	

at quite a low temperature—*i.e.* below that at which ferments are destroyed. It does not, however, appear to be a matter of importance from the point of view of digestion or nutrition in the infant whether these ferments are destroyed or not.

Protective Bodies of the nature of antitoxins, precipitins, agglutinins and alexins are present in fresh cow's milk. Whatever may be the value of these to the calf, it is improbable that they are of great value to the baby, so that even if such bodies are destroyed or damaged by the process of drying the consequences would not be serious; but as a matter of fact, as far as is known, their properties are not affected by the degree of heat to which milk is usually subjected in process of drying.

Vitamines.—The value of vitamines as factors in nutrition has recently been exalted to such a pinnacle of importance that if there is reasonable ground for believing that they can be destroyed or damaged in the process of drying milk, it is quite clear that such milks will be used with the greatest circumspection. Although we know very little about the identity and physical properties of the whole group of vitamines, it appears that the so-called antiscorbutic vitamine suffers depreciation in efficiency when it is submitted to high degrees of heat. Although there is clear evidence to show that at least most varieties of dried milk contain this accessory factor, I am very distinctly of the opinion that if infants are fed exclusively and for prolonged periods on even the very best varieties of dried milk their nutrition and resisting power is adversely affected unless at the same time fresh fruit juices are given as supplementary foods. For many years past I have invariably given orange juice or grape juice to babies who are fed on dried milks, and I am quite sure their general condition is also better when a small quantum of broth made from fresh vegetables and bones is also added to the dietary (p. 476).

The Value of Dried Milk in Infant Feeding.—A very excellent summary of the opinions of various authorities in this country and abroad who have used dried milk on a large scale is given in the Local Government Report [1] to which reference has already been made. The writer of this report sums up very distinctly in favour of the use of dried milk in those cases in which breast feeding is impossible or when reliable cow's milk cannot be obtained. What I shall have to say on the relative values of dried and fresh

[1] New Series, No. 116. 1918.

milks in infant feeding will be entirely based on my own personal experiences. I attach no value at all to the great majority of the reports made by medical officers of Welfare Centres at which great doles of dried milks of various brands have been sold at a reduced price or given free to the mothers attending, for the very good and sufficient reason that I do not believe it is possible to get good and reliable results when dried milk is employed in the way it almost invariably is employed at these centres—that is to say, by simple dilution with water.

To one who, like myself, believes in a correct physiological "balance" it seems monstrous to expect an infant to thrive on any dietary, of dried milk or otherwise, in which all regard to "balance" is thrown to the winds, and when the child, with all its human metabolic individualities, is forced into a metabolic groove which is peculiar to the calf.

As I have stated over and over again in these pages, the physiological "balance" for the human baby is:

Proteins . .	1·5%
Fats . .	3·5%
Sugar . .	7·0%

This is the ratio of the three main constituents which natural selection has determined to be the best for the average infant. The further we depart from this standard the worse, in the long run, are the results. When dried milks are employed without any attempt at modification, as they usually are at our Welfare Centres and often in private practice, the "balance" will vary with the brand of dried milk employed. Let me take a few examples, assuming that in all cases these milks are diluted with water in the proportion of 8 to 1—that is to say, one drachm of dried milk to the ounce of water.

If Glaxo full cream is employed the balance works out at:

Proteins . .	2·86%
Fats . .	3·2%
Sugar . .	5·2%

If Cow and Gate full cream is used the "balance" is:

Proteins . .	3·43%
Fats . .	3·1%
Sugar . .	4·7%

If Cow and Gate half-cream is used the " balance " is :

Proteins . .	3·6%
Fats . .	2·0%
Sugar . .	5·1%

It seems to me to be asking too much of any human infant to juggle thus with its metabolic processes. I quite admit that infants will survive on a diet of this kind, just as they will survive on a diet of whole milk fresh from the cow, but I deny altogether that they ever do really well. I therefore think it most unfair on dried milk to judge it on the criterion of the results achieved by using it in this completely unscientific and irrational manner. If a group of independent observers would take a series of infants and would feed them on dried milk modified to breast standard, and comply with all the other physiological conditions, I am perfectly certain that they would come to the same general conclusion that I have come to after fifteen years' experience in the management of nearly 3000 infants fed exclusively on dried milk—namely, that if this method does not give as good results as any other method it is not the fault of the milk, but of the manner in which it is used.

CHAPTER VIII

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

CONDENSED MILKS

Unsweetened Condensed Milk—Sweetened Condensed Milks—Condensed Milks as Foods for Infants—Digestibility—Bacterial Content

CONDENSED milks differ from dried milks in the amount of water that is removed by evaporation, otherwise their composition is very similar. A very excellent account of the history and properties of condensed milks will be found in Dr F. J. H. Coutt's Report [1] to the Local Government Board, 1911.

Since these milks are very largely used in infant feeding it is essential that certain particulars with respect to their composition and properties should be known by all those who employ them.

Speaking quite generally there are two classes of condensed milks: (1) the unsweetened; (2) the sweetened. To the latter varying quantities of cane-sugar are added.

Unsweetened Condensed Milk.—The following may be regarded as the average composition of unsweetened condensed milks:—

Proteins . .	8·3%
Fats . .	12·4%
Lactose . .	16·0%
Ash . . .	2·0%
Caloric value .	60 calories per oz.

—and the brand most usually employed is the "Ideal."

The great advantage of unsweetened condensed milk as a food for infants is that in its dilutions the actual amount of sugar can be controlled. The disadvantages, as compared to the sweetened variety, are that it does not keep so well and that it has been submitted to a higher temperature in manufacture.

In order that the protein content may be reduced to the standard of breast milk—*i.e.* 1·5% to 2%—it is necessary to dilute the condensed milk 4 times—in other words, to 1 part of the milk 3 parts of water must be added.

[1] Local Government Board's Reports. New Series, No. 56. Food Reports, No. 15. 1911.

The percentage composition of such a dilution will be as follows :—

Protein . .	2·0%
Fat . .	3·1%
Sugar . .	4·0%

If 3% of sugar and a little supplementary cream are added to this mixture the balance will closely approximate to that of breast milk.

Sweetened Condensed Milks.—A good sample of sweetened condensed milk is of the following composition :—

Proteins . .	9·7%
Fats . .	12·0%
Lactose . .	12·0%
Cane-sugar .	40·0%
Ash . . .	2·0%
Caloric value .	100 per oz.

It will be noted that if a food of this percentage composition is diluted sufficiently to reduce the protein content to the standard of breast milk, the percentages of the remaining constituents will be very different from those of breast milk. If sweetened condensed milk be diluted with 4 parts of water the " balance " will be as follows :—

Protein . .	2·0%
Fat . .	2·4%
Sugar . .	10·2%

In such a dilution the sugar is much too high and the fat is too low, but no method of dilution can alter this ratio or improve the balance.

Condensed Milks as Foods for Infants.—Examining the suitability of condensed milks for the purposes of infant feeding on the criterion of the essential physiological requirements, it may be stated that, as regards caloric value, condensed milk of the sweetened variety is almost exactly 5 times as great as breast milk, and consequently should be substituted in the proportion of 1 oz. of condensed milk for every 5 oz. of breast milk.

As regards balance this is quite incorrect, at least as far as sweetened condensed milk is concerned, and cannot be adjusted without infinite trouble. On this ground alone it deserves to be condemned as a permanent food for infants.

As regards accessory factors condensed milks can be classed with sterilised cow's milk or with dried milks—that is to say, they cannot be given with safety for any lengthened period without the supplementary addition of some anti-scorbutic element, such as grape juice or orange juice, and owing to the degree of dilution usually necessary the quantity of certain other accessory factors, such as organic salts, lecithin bodies, extractives, etc., may be reduced in quantity below the physiological requirements. For this reason I strongly advise a small addition of the vegetable and bone soups described on page 476.

As regards Digestibility condensed milks show up exceedingly well as compared with fresh cow's milk, or even with most varieties of dried milk. This is partly due to its large content of easily digestible sugar and partly due to the change in the molecular constitution of the casein which the prolonged cooking brings about. This property of condensed milk is one of its dangers, as it is one of its attractions. Infants who have been tortured with wind and colic due to the consumption of cow's milk or other indigestible form of food often experience the greatest relief when they are put upon a diet of sweetened condensed milk. Peace and calm in the digestive system is thus apt to obscure wrongs inflicted on general nutrition, wrongs which remain veiled or latent until the mischief has been done and it is too late to repair the damage. Partly owing to the excess of sugar, and partly also to other faults in "balance," the condensed-milk-fed infant is peculiarly susceptible to infective disorders and shows little resistance in fighting them.

As regards Bacterial Contamination.—Investigations which have been undertaken with regard to the bacteriology of condensed milks prove that, although most of the bacteria originally present in the milk in the raw state are destroyed by the prolonged heating process to which the milk is subjected, nevertheless condensed milk is by no means sterile even when a tin is freshly opened. Tubercle bacilli and other pathogenic varieties if present and alive are so attenuated in virulence that no fears need be entertained in consequence of their presence. Condensed milk in the undiluted state is a bad culture medium for bacteria owing to its high sugar content, but after dilution with water, and especially warm or hot water, it is a highly favourable medium for bacterial growth.

Taking it all round, condensed milk is a very attractive and agreeable food for infants, but even with the greatest precautions it cannot be made to fulfil the physiological requirements for sound and good nutrition. It is, however, a most convenient food for temporary use in sickness or during transitional periods—as, for instance, in weaning from the breast to artificial food. It must, however, be used only with a full knowledge of its limitations and weaknesses.

CHAPTER IX

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

PROPRIETARY INFANTS' FOODS

General Review—Nature and Composition—Varieties—Table of Percentage Composition and Caloric Values

IGNORANCE with respect to food values and the principles of physiological feeding has led to the widespread exploitation of the public by the manufacturers of these goods. As is the case with dried milks, so also with these so-called patent foods for infants—if they prove failures the fault lies with the method of use and not with the foods themselves. The usual method of use is as follows. An infant becomes ill, it may be from unsound feeding, it may be from some infective disease, or it may be from some absolutely independent cause, but no matter what be the origin of the illness the first, and often the only, idea that presents itself to the mother or nurse is to change the food. My note-books are full of cases in which breast-fed infants who have not been faring well have been taken off the breast and put on to cow's milk, and when this has failed on to Glaxo, condensed milk, Horlick's Malted Milk and the Allenbury foods in rapid succession, without any regard to the various properties of these foods or to the probable cause of the symptoms.

Inasmuch as all the different classes of infants' foods have their different properties and different effects upon the human organism, and inasmuch as many of the special foods have their special properties, it is clear that they should be employed with direct regard to these properties and not indiscriminately.

Infants who have been fed on an excess of fat improve when they are given a fat-poor food ; infants who have been overfed with carbohydrates recover when they are supplied with a food which is deficient in this element, and similarly when proteins have been overdone benefit follows from the use of foods in which these constituents are subnormal in amount, while infants in whom the digestive functions are undeveloped thrive better, for a time at least, on predigested foods. The range of proprietary foods is so great, and their properties so different, that it is not difficult to find for particular infants one or more which fulfils the required indications. The mistake is to draw a bow at a venture and try one food after another without any considered plan or policy. Before settling one's course of action, and the particular food which is to be tried, it is absolutely necessary to discover the cause, or the causes, of the symptoms which have to be treated. We must, for instance, come to some decision as to whether the symptoms are primarily due to disturbance of the digestive functions or whether they are referable to nutritional failures or to infective disorders. If it is suspected that the trouble is really due to food causes the whole method of past feeding must be reviewed and submitted to the test of our cardinal rules of physiological feeding (p. 146). If it is found that there has been any serious breach of any of these—if, for instance, the caloric value of the food has been excessive, if the balance has been wrong, or the supply of any necessary factor neglected—the question must be fully considered whether this particular fault may not have been directly or indirectly responsible for the existing state of affairs.

When the fault has been detected, it must be dealt with on rational lines. If the method of feeding, when examined critically, suggests no error in the food, there is no need for any drastic change in the diet, and any existing disability of digestion or nutrition should be treated symptomatically.

I frequently find that, when an infant becomes seriously ill and is treated for his special complaint, he subsequently develops symptoms which are actually due to some want of balance or other fault in the food which is supposed to be indicated for his primary condition. For instance, an infant suffering from indigestion may be given Horlick's Food, for the reason that it is a predigested food. If such a line of treatment meets with success, and is pursued too long, the infant is almost certain to develop some form of malnutrition owing to the excess of carbohydrate in the food, or to some other defect in "balance," or an infant may have an attack of looseness of the bowels and in consequence be ordered off all orange juice or similar anti-scorbutic. If, when the symptoms subside, the orange is still discontinued, symptoms of scurvy may easily supervene.

If therefore these proprietary foods for infants are used without regard to their special properties and failings they may lead to

TABLE 50

Table of Percentage Composition of certain Proprietary Infants' Foods. With Notes

Name of Food	Albuminoids Per Cent.	Fat Per Cent.	Carbo-hydrates: Soluble Sugars, etc. Per Cent.	Carbo-hydrates: Insoluble Starches, etc. Per Cent.	Ash Per Cent.	Water Per Cent.	Caloric Value Per oz.	Notes
Breast milk desiccated	12·0	26·0	52·0	..	2·0	8·0	141	This is accepted as the required standard for all desiccated foods which fulfil the condition of correct balance.
Allenburys' Foods—No. 1	9·7	20·0	60·85	..	3·75	5·7	134	One of the best of the proprietary foods for very young or delicate infants. Should be diluted with 7 parts of water. Slight excess of sugar and slight deficiency of proteins and fats. Very easily digested. Addition of anti-scorbutic and other accessory factors required. Should not be used too long.
No. 2	9·2	15·0	69·1	..	3·5	3·9	121	This is also a complete food. A little more difficult to digest than No. 1. Otherwise has same properties. Fat insufficient.
No. 3	9·2	1·0	82·8 soluble and insoluble		0·5	6·5	110	This is not a complete food. It is to be used as an addition to cow's milk. It contains starch, and therefore should be given with caution to infants under six months of age.
Benger's Food	10·2	1·2	79·5	..	0·8	8·3	107	This is not an entire food. It should be prepared and added to cow's milk, according to the directions, in which case the contained starch is malted and converted into sugar (maltose). Must be used with caution in cases of young infants.
Chapman's Entire Wheat Food	9·4	2·0	79·3 soluble and insoluble		0·9	8·4	108	Contains much unaltered starch. May be added to the milk dilutions of infants over six months. To be used with caution.
Frame Food Diet	13·4	1·2	79·4 soluble and insoluble		1·0	5·0	109	To be used as an addition to milk dilutions when infant can digest starch, therefore not before sixth month. Useful for certain classes of marasmic infants.
Horlick's Malted Milk	13·8	9·0	70·8	..	2·7	3·7	120	A very digestible malted food for delicate infants. For temporary use only. Great excess of sugar. Vitamines deficient.
Hovis Babies' Food—No. 1	7·7	0·2	86·6	..	1·82	3·7	110	Practically a malted cereal. To be used instead of lactose or other sugar as an addition to milk mixtures.
No. 2	5·7	0·10	82·6	7·5	1·7	2·4	105	Same as No. 1, except for a small content of starch.
Mellin's Food	7·9	0·18	82·6	..	3·8	6·3	105	Practically a malted cereal. To be used as a substitute for lactose or other sugar at any age.
Milo Food	11·03	3·92	62·0	19·0	2·11	1·56	117	Contains starch. To be used as addition to milk dilutions when infant is beginning to digest starch.
Neave's Food	9·2	1·0	3·0	78·2	0·7	7·9	106	Almost unaltered flour. To be used with caution.
Nestlé's Food	11·0	4·25	40·91	36·86	1·70	5·0	116	Contains unaltered starch. To be used as an addition to cow's-milk dilutions when starch is indicated.
Nutroa Food	15·9	10·3	66·0 soluble and insoluble		1·0	6·8	119	A complete food. Deficient in fat. Contains starch.
Ridge's Food	9·24	0·63	5·18	77·96	0·60	9·23	108	A starch food. To be added to cow's-milk dilutions after six months. To be used with caution.
Robinson's Patent Barley	5·13	0·97	..	82·0	1·93	10·10	103	Useful for making barley water. Must be used with caution before sixth month, as it is almost a pure starch preparation.
Savory & Moore's Food	9·63	0·40	44·83	36·36	0·89	8·34	106	As an addition to milk dilutions, and if carefully prepared as directed, is a useful food after sixth month.

[*To face page* 198

serious trouble. If, on the other hand, their chemical and physical properties are studied and understood they may be extremely useful.

Those who are interested in the subject of these proprietary foods are advised to read the Local Government Board's Report [1] on their use and analysis.

Nature and Composition.—Leaving out of account condensed milks, dried milks, and the various modifications of cow's milk which are sold as infants' food, the proprietary foods may be classified in the following categories :—

(1) Foods consisting mainly of dried milk, but with the addition of sugar or malted cereal (maltose)—that is to say, foods without any starch. Allenbury No. 1.

(2) Foods consisting mainly of malted cereals, but without any starch, such foods being intended to be used as an addition to milk, but which do not profess to be complete foods. Mellin's Food.

(3) Foods which consist partly of malted and partly of unmalted cereal flours—that is to say, which contain starch as well as malt-sugar. Allenbury No. 3, Savory & Moore's and Benger's foods.

(4) Foods which consist mainly of flour which has been baked or partially dextrinised. Chapman's Entire Wheat Food.

(5) Foods which consist exclusively of starch. Robinson's Patent Barley.

In Table 50 I have given a few examples of some of the better-known proprietary foods, with their percentage compositions, their caloric values, and a few notes in explanation of their uses. The great majority of these foods are recommended to be given in the proportion of 1 part of food in 7 parts of water—in other words, if the percentage composition is divided by eight the resulting figures will give the percentage composition of the food as consumed by the infant. If these figures are compared with those of breast milk, the correctness or the reverse of the balance can be seen at a glance. Take for instance the case of Horlick's Milk, which has a composition of :

Protein . . .	13·8%
Fat . . .	9·0%
Carbohydrate . .	70·8%

[1] Food Report No. 20. New Series, 80. Issued by the Local Government Board, 1914.

Divide this by 8 : the resulting figures give the composition of Horlick's Food dissolved in 7 parts of water—*i.e.*

Protein	1·7%
Fat	1·1%
Carbohydrate	8·8%

Compare this with the composition of breast milk :

Protein	1·5%
Fat	3·5%
Carbohydrate	7·0%

Such a food, therefore, when examined from the point of view of "balance," is shown to be very deficient in fat. It may be excellent as a temporary food in illness, or when the baby has previously been fed on an excess of fat, but it does not fulfil the requirements of physiological feeding as regards "balance," and consequently must not be given for too long a period.

When examined from the point of view of caloric value it will be noticed that in the case of Horlick's Malted Food the value is 120 per oz. So that if any particular infant is to be correctly fed from the point of view of caloric value he must be given a sufficient number of ounces in the 24 hours to supply the whole amount. Say, for instance, he requires food of the value of 500 calories in the 24 hours, he must be given $\frac{500}{120}=4{\cdot}1$ oz.

Examined from the point of view of accessory factors it may be stated that the anti-scorbutic vitamine is practically absent. The fat-soluble vitamine must be present in very limited amount. It cannot, therefore, be used for more than a very short period with safety without the addition of these and other accessory factors which are absent or deficient in amount. Examined from the point of view of digestibility Horlick's Food, being practically a predigested food, fulfils the requirements of an infant in whom the digestive functions are undeveloped or impaired, but on the other hand it will not promote the development of these functions when they do not exist, or it may lead to the atrophy of those already developed.

In this way, and in the light of our cardinal rules, the properties of all proprietary foods should be examined, and if they do not fulfil all the physiological requirements they are unsuitable for long-continued use unless their defects are compensated for by supplementary additions. On the other hand, the very defects which make them inappropriate for long-continued use may make them of the greatest value in special conditions.

CHAPTER X

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

PRACTICAL DETAILS

Introductory Remarks—"Half-and-Half" Method—"Split-Protein" Method—"Top-Milk" Method—"Protein-Milk" ("Eiweissmilch") Method

Introductory Remarks.—I have already explained that there are a number of means whereby cow's milk, which, in its natural and unaltered condition, is quite unsuitable for the feeding of infants on the grounds of digestibility and balance, can be rendered suitable, or at least less unsuitable, for this purpose. Some of these means come within the compass of home resources, others do not. For the most part I shall confine myself in this chapter to descriptions of home modification, but I shall also allude to the uses of proprietary and manufactured foods.

First, as regards methods of home modification. The number of these is legion, some good, some bad, some indifferent, some suitable under certain conditions, some under others. It is perhaps unsafe to generalise or attempt to arrange them in order of merit, but on the whole I think the simple method of diluting milk with an equal part of water and fortifying it with additional sugar and cream is the most convenient and practical method for general use. This method I have ventured to call the "half-and-half" method, and it will be the first one to be described, but I shall refer in detail also to the "split-protein" method, the so-called "top-milk" method, the "protein milk" ("Eiweissmilch") method, and to the uses of dried, condensed and other varieties of milk.

In each case I shall give directions for making 1 pint of mixture, since it is easy then to prepare feeds of 2, 4, 5 or 6 oz. by taking an easily calculated proportion of the various constituents, or to prepare larger quantities for the whole day's supply by multiplying by equally simple factors.

I shall mention in each case the shortcomings or the advantages of the method under review, and the steps which are necessary for making it fall in with the principles of physiological feeding.

THE HALF-AND-HALF METHOD

To prepare 1 pint of the mixture. Take:

Milk . . .	10 oz.
Cream (33% fat) .	1 oz.
Sugar . . .	1 oz.
Water to make . .	1 pint

Prepared in this way the resulting mixture has the following percentage composition:—

Proteins . .	2·0%
Fat . .	3·5%
Sugar . .	7·0%

—that is to say, it very closely approximates to the standard of breast milk.

The fat content will obviously vary with the richness of the milk and the strength of the cream. It is, however, assumed that the milk is of average richness—*i.e.* about 3·5-4·0%—and that the cream contains about 33% of fat. If either the milk or the cream contains more or less than this average amount of fat, less or more than 1 oz. of cream will be required for this mixture in proportion to their respective richness.

A mixture of this kind is an excellent basis to work on, but it does not fulfil all the requirements of physiological feeding, although the "balance" is approximately correct.

As regards accessory factors, it is probably deficient in the anti-scorbutic vitamine, therefore orange juice or grape juice must be given in addition. It may lack a sufficiency of extractives and organic salts, hence in making a pint of this mixture some 4 oz. of vegetable broth (p. 476) should be added. The lecithin content may be too small, therefore 1 grain of this substance should be added to each pint of the mixture.

As for digestibility, it is not suitable for young babies or those recently weaned from the breast. It can be rendered more digestible by peptonisation in accordance with the method described on page 472. At first the mixture should be thoroughly predigested, say for 2-3 hours, and then less and less as the infant's digestive capacity develops.

Further Details.—Since this mixture is of breast standard the *quantity* to be given in any case is the same as when breast milk is supplied (see p. 8).

This food should always be sterilised after compounding by being brought to the boil. It should then be cooled down rapidly and kept in a clean jug or bottle in a cold place until required.

For training the baby to digest starch it is a good plan to substitute barley water for plain water in the preparation of mixtures for babies over three months of age. After six months a starchy food, or dextrinised food, may be substituted for the sugar, ounce for ounce or drachm for drachm, so as not to increase the total percentage of carbohydrate and upset the balance. I mention this because I notice that farinaceous or dextrinised foods are often added to milk mixtures without a corresponding decrease in the sugar, a mistake which leads to carbohydrate over-feeding. There are very substantial advantages (p. 164) in replacing soluble carbohydrates by insoluble carbohydrates as soon as the infant's digestive functions are sufficiently developed to enable him to digest starch.

The Modification of Half-and-Half Mixtures.—Although in the great majority of instances modifications in the percentage composition of the food prepared in accordance with this method are uncalled for, in certain instances in which there are food idiosyncrasies or intolerances, departures from breast standard may be required. It may be necessary to increase or decrease the protein, the carbohydrate or the fat content of the food, in which case approximate accuracy can be ensured by quite simple manipulations, as follows :—

To alter the Protein Content increase or decrease the quantity of milk. Every 5 oz. of milk added to the mixture makes a difference of 1 per cent in the protein content. If 5 oz. instead of 10 oz. are employed in preparing the mixture the percentage of protein will be reduced from 2 to 1 ; if 15 oz. are employed the percentage will be raised to 3%, and so on in proportion. It must be remembered, however, that alterations in the quantity of milk affect also alterations in other elements besides the protein, so that corresponding alterations must also be made in the supplementary additions of cream and sugar.

To alter the Fat Content.—This can easily be accomplished by increasing or decreasing the amount of cream used in making a pint of the mixture. If the cream contains 33% of fat every ounce of cream added to the pint of mixture raises the percentage of fat by 1·5%, so that every half-ounce added raises it by 0·75%, every quarter ounce by 0·37%, and so on, and of course decreases may be effected in the same way, by reducing the quantity of cream in corresponding proportions.

To alter the Sugar or Carbohydrate Content.—This is a very simple matter. Every ounce of sugar added to the pint of mixture raises the percentage by 5%. Consequently every half-ounce added raises the percentage 2·5%, and so on.

Formulæ for preparing Milk Mixtures of Definite Percentage Composition. A more accurate method of varying the percentage composition of milk mixtures prepared on the half-and-half basis is by the use of the accompanying table. In this table the protein percentages range between 1·0% and 2·5%; the fat percentages between 1·5% and 3·5%, and the sugar percentage can be varied at will, but in this table is fixed at 5%. The use of this table is very simple if a milk mixture is required of a percentage which comes within its range. The formula for its preparation will be found in the following manner.

If, for instance, we require to prepare a mixture of the following percentage composition:—protein, 2·0%, fat, 2·5%, sugar, 5·0%, we employ this table in the following manner. We notice that all mixtures with 2·0% protein are contained in the horizontal compartments lettered C., and that all mixtures with 2·5% fat are contained in the third vertical column, so that compartment C3 will contain the required formula.

The instructions here given are to take 10 oz. of milk, 3½ drachms of cream (33%) and 5 drachms of sugar, and to add sufficient water to make the total up to 20 oz., or 1 pint. The sugar percentage can be varied at will by adding more or less sugar, remembering that 1½ drachms of sugar make a difference of 1%. If, therefore, we wish to prepare a mixture containing 7% of sugar instead of 5%, as required in the original formula, we must add 3 more drachms of sugar—in other words, we must add 1 oz. of sugar instead of 5 drachms.

The caloric value of these mixtures is stated in each case. I have thought it desirable to give these figures because I notice that when, owing to digestive incapacity, the milk mixtures are made very dilute the total caloric value of the food is sometimes reduced to a dangerous level. For instance, supposing a baby is ordered a mixture of the formula A1—*i.e.* protein, 1·0%, fat, 1·5%, sugar, 5·0%. The caloric value is 11½ per ounce—almost exactly

TABLE 51.—Formulæ for preparing Milk Mixtures of various Percentage Compositions. In each case the ingredients given are for making 1 pint (20 oz.) of mixture, and the necessary water to make this amount must be added in each case. In the preparation of this table it is assumed that the cream contains 33% of fat and that the milk is of the following composition:—protein, 4%, fat, 3·5% and sugar, 4%

The Protein Percentage		The Fat Percentage 1·5%	2·0%	2·5%	3·0%	3·5%	The Sugar Percentage
1·0%	The Percentage Composition { Protein . Fat . Sugar . The Ingredients .	A1. 1·0% 1·5% 5·0% Milk, 5 oz. Cream, 3 dr. Sugar, 6½ dr. Caloric value, 11½	A2. 1·0% 2·0% 5·0% Milk, 4½ oz. Cream, 6 dr. Sugar, 6½ dr. Caloric value, 12½	A3. 1·0% 2·5% 5·0% Milk, 4 oz. Cream, 1 oz. Sugar, 6½ dr. Caloric value, 13½	A4. 1·0% 3·0% 5·0% Milk, 3¾ oz. Cream, 1¼ oz. Sugar, 6½ dr. Caloric value, 14½	A5. 1·0% 3·5% 5·0% Milk, 3¼ oz. Cream, 1¾ oz. Sugar, 6½ dr. Caloric value, 15½	5·0%
1·5%	The Percentage Composition { Protein . Fat . Sugar . The Ingredients .	B1. 1·5% 1·5% 5·0% Milk, 7½ oz Cream, 1 dr. Sugar, 5½ dr. Caloric value, 12½	B2. 1·5% 2·0% 5·0% Milk, 7½ oz Cream, 3½ dr. Sugar, 5½ dr. Caloric value, 14	B3. 1·5% 2·5% 5·0% Milk, 7 oz. Cream, 6 dr. Sugar, 5½ dr. Caloric value, 15	B4. 1·5% 3·0% 5·0% Milk, 6½ oz. Cream, 1 oz. Sugar, 5½ dr. Caloric value, 16	B5. 1·5% 3·5% 5·0% Milk, 6 oz. Cream, 1½ oz. Sugar, 5½ dr. Caloric value, 18	5·0%
2·0%	The Percentage Composition { Protein . Fat . Sugar . The Ingredients .	C1. 2·0% 1·5% 5·0% Impossible	C2. 2·0% 2·0% 5·0% Milk, 10 oz. Cream, 1 dr. Sugar, 5 dr. Caloric value, 15½	C3. 2·0% 2·5% 5·0% Milk, 10 oz. Cream, 3½ dr. Sugar, 5 dr. Caloric value, 16½	C4. 2·0% 3·0% 5·0% Milk, 9 oz. Cream, 7 dr. Sugar, 5 dr. Caloric value, 17	C5. 2·0% 3·5% 5·0% Milk, 8¾ oz. Cream, 1¼ oz. Sugar, 5 dr. Caloric value, 18½	5·0%
2·5%	The Percentage Composition { Protein . Fat . Sugar . The Ingredients .	D1. 2·5% 1·5% 5·0% Impossible	D2. 2·5% 2·0% 5·0% Milk, 12½ oz. No cream Sugar, ½ oz. Caloric value, 16½	D3. 2·5% 2·5% 5·0% Milk, 12½ oz. Cream, 1½ dr. Sugar, ½ oz. Caloric value, 17½	D4. 2·5% 3·0% 5·0% Milk, 12 oz. Cream, 5 dr. Sugar, ½ oz. Caloric value, 18½	D5. 2·5% 3·5% 5·0% Milk, 11½ oz. Cream, 1 oz. Sugar, ½ oz. Caloric value, 19½	5·0%

half that of breast milk. Unless an infant fed on this food is to be starved he should receive twice as large a volume as he would were he to be breast fed. This is usually impossible, but the knowledge that the child is being starved will prevent the starvation being continued too long, and will be an incentive to lead the infant on to stronger mixtures.

The Fat Percentage.—Since the chief advantage of the foregoing table is the accuracy with which the variations in the different constituents can be controlled, it is obvious that the percentage composition of the constituents of which the mixtures are compounded should themselves be accurately known. It is assumed in all these mixtures that the milk is of average standard—*i.e.* protein, 4%, fat, 3·5%, sugar, 4·5%—so that accuracy would immediately be vitiated if specially rich or specially poor milks were employed; but the chief source of inaccuracy is obviously the cream. The fat content of cream differs within wide limits. Some creams contain only 16% of fat, others contain no less than 50%. In all the formulæ given in this table it is assumed that the cream is of 33% strength. Such cream can be obtained from most dairies on application; if it cannot, the fat content of the cream supplied should be ascertained and the necessary milk added to reduce the fat percentage to 33%. I say to reduce, because it is only in rare instances that creams of so low a percentage as 33% are sold by reputable dairies. As a rule the percentage is over 40%. No difficult calculation is necessary to ascertain how much milk with a 3·5% of fat must be added to a cream of any given degree of richness to reduce it to 33%.

To take an example, on inquiry it is ascertained that the cream supplied contains 48% of fat. To reduce cream of this strength to 33% all that it is necessary to do is to add 54% of milk. For instance, to make 1 pint of cream of this strength take 13 oz. of 48% cream and add 7 oz. of milk, or to make smaller quantities take correspondingly smaller quantities both of the cream and of the milk (see p. 483).

THE "SPLIT-PROTEIN" METHOD

Before I describe the home method of employing the "split-protein" on a percentage basis let me once again explain what is meant by this term.

Human milk contains 1·5% of total proteins, consisting of:

Caseinogen	0·5%
Whey proteins (lactalbumin, lactoglobulin) .	1·0%

These proteins have different physical properties, which evoke different reactions on the part of the digestive system. The caseinogen coagulates in the stomach and causes some delay in the emptying of the viscus, whereas the whey proteins are soluble and can pass out of the stomach without any preliminary change. No doubt the particular combination of soluble and insoluble proteins in the milks of different animals has both a teleological and a physiological significance, and it is in consequence of the large proportion of insoluble caseinogen and the small proportion of whey proteins in cow's milk that the latter excites such exaggerated reactions in the infant's stomach. To avoid this the so-called "split-protein" method has been devised. This method aims at securing the correct "balance" by modifying cow's milk in such a way that the required protein content is afforded by the same proportions of soluble and insoluble proteins as are present in breast milk.

To carry out this method it is necessary to remove the great excess of caseinogen which exists in cow's milk by coagulating the casein with rennin and removing it by filtration. The filtrate will consist of the milk minus all the caseinogen and some of the fat. The actual composition of this whey is as follows:—

Proteins (lactalbumin, lactoglobulin) . .	0·9%
Fat	0·34%
Sugar	4·7%

Using this whey as a basis, the deficiency in fat and sugar can be made up by the addition of an emulsion of butter fat and sugar in the required proportions, or by the addition of cream, but if the latter is used it must be remembered that it also contains caseinogen, which it may be undesirable to add except in very small quantity.

If, however, we wish to prepare a milk mixture of breast standard in accordance with the "split-protein" method, it is quite convenient to use cream, since caseinogen to the extent of 0·5% is required to fulfil the required conditions.

The problem consequently resolves itself into the following. How are we to secure a percentage composition of :

Protein	caseinogen	0·5%
	whey proteins	1·0%
Fat		3·5%
Sugar		7·0%

—by a combination of whey which has the following percentage composition :—

Whey proteins	0·9%
Fat	0·34%
Sugar	4·7%

—and cream (20% fat)[1] which has the following percentage composition :—

Caseinogen	3·0%
Whey proteins	1·0%
Fat	20·0%
Sugar	4·0%

It can be made in the following way :—

Take 16⅔ oz. of whey and 3⅓ oz. of 20% cream. This gives a composition of :

Caseinogen	0·5%
Whey proteins	1·0%
Fat	3·5%
Sugar	4·0%

—which very closely approximates to breast standard, except that the sugar content is 4% instead of 7%. This discrepancy can be adjusted by the addition of 3% of sugar—in other words, by adding 5 drachms of sugar to 1 pint of mixture.

It is quite possible to vary the fat percentage by employing creams of different degrees of richness ; a difference of 2·5% in the strength of the cream makes a difference of 0·5% in the strength of the fat in the resulting mixture. To make this quite clear I give the formulæ for mixtures containing 2·5%, 3·0% and 3·5% fat. They are as follows :—

(1)	Caseinogen	0·5%	Take 16⅔ oz. whey
	Whey proteins	1·0%	3⅓ oz. 20% cream[1]
	Fat	3·5%	5 drachms sugar
	Sugar	7·0%	Caloric value, 20 per oz.

[1] To prepare cream containing this percentage of fat (see p. 483).

(2)	Caseinogen . .	0·5%	Take $16\frac{2}{3}$ oz. whey
	Whey proteins .	1·0%	$3\frac{1}{3}$ oz. $17\frac{1}{2}$% cream [1]
	Fat . . .	3·0%	5 drachms sugar
	Sugar . . .	7·0%	Caloric value, 18 per oz.

(3)	Caseinogen . .	0·5%	Take $16\frac{2}{3}$ oz. whey
	Whey proteins .	1·0%	$3\frac{1}{3}$ oz. 15% cream [1]
	Fat . . .	2·5%	5 drachms sugar
	Sugar . . .	7·0%	Caloric value, 16 per oz.

Useful as this method is for providing milk mixtures in which the relative proportions of the caseinogen and whey proteins are the same as those of breast milk, nevertheless it becomes complicated and troublesome when it is necessary to alter the ratio of the proteins or the percentage of the fat. Under such conditions I advise the reader to use dried whey powder, which in combination with cream or milk is readily manipulated so as to afford almost any percentage combination (see pp. 217 and 470).

Personally I do not recommend the use of this "split-protein" method except in certain cases in which only small percentages of caseinogen are tolerated. It is an expensive and a troublesome method, and from the point of view of digestibility it has few advantages over the method of predigestion (see p. 164).

THE "TOP-MILK" METHOD

The term "top-milk" is applied to the upper portion of milk which has been left standing. "Top-milk" is in fact cream, of a strength which varies in accordance with the level at which it is drawn off.

To obtain "top-milk" a pint or a quart of fresh milk should be placed in a bottle of corresponding size and allowed to stand for a certain time until the cream has risen into the upper layers. These upper layers can be obtained separately from the lower layers and drawn off to any required level by (1) siphoning off the lower portions and leaving the rich cream in the bottle; (2) pouring off the upper part; or (3) by skimming off the upper portion with a ladle or "dipper."

The first method is the only reliable and safe one; a siphon tube can easily be improvised by bending a piece of glass-tubing which has been softened by holding it over a candle or gas jet, but

[1] To prepare cream containing this percentage of fat see page 483.

the best plan of all is to purchase one of the special humanisers illustrated on this page.

Maw's milk humaniser[1] is made in two sizes, one to contain a quart and a smaller size to contain a pint. The bottles are graduated so that $\frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$ of the contents can be siphoned off, leaving the "top-milk" in the bottle.

The percentage of fat will differ with the time of standing, the level at which the bottom milk is drawn off and the initial richness of the milk. Very complete and complicated tables have been drawn up by American authors who advise this method. Unfortunately their tables are not applicable in this country, for the bottles which they use are American quart bottles, which contain 32 oz., and not, according to our system of measures, 40 oz.

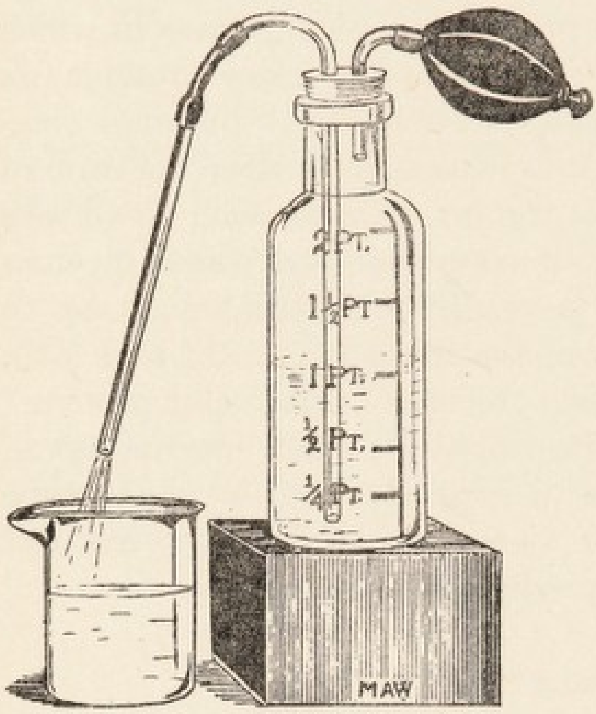


FIG. 52—Maw's Milk Humaniser

The following simple table suffices for general use, in which correctness to a decimal point is not necessary nor desirable.

It may be accepted that ordinary good milk (not nursery milk), as sold by reputable dealers in London and other large towns, contains from 3·4% to 3·8% of cream. If such milk is allowed to stand in the pint bottle for 4 hours the top 5 oz. will be found to contain about 5·50% of fat and the top 10 oz. about 4·8% of fat.

If the milk stands for 6 instead of 4 hours the top 5 oz. contain about 8·10% and the top 10 oz. about 5·40%.

In modifying cow's milk to breast standard by this method we require to have a top milk of 7% standard. Such top milk will have an approximate percentage composition as follows :—

Protein . .	4%
Fat . .	7%
Sugar . .	4%

[1] S. Maw, Son & Sons Ltd., 7-12 Aldersgate Street, E.C.1.

If such milk is then diluted with an equal part of water the percentage composition will be:

Protein . .	2·0%
Fat . .	3·5%
Sugar . .	2·0%

If 5% of sugar—*i.e.* 1 oz. to the pint—be then added we obtain a mixture which is approximately of breast standard.

A top milk containing 7% fat can be obtained by allowing milk to stand for 5 hours in the humaniser and by siphoning off the bottom three-quarters. The upper quarter will contain the required percentage of fat.

If it is required to make more than half-a-pint of humanised milk since the pint bottle is not large enough, the quart bottle must be used.

It is perhaps unnecessary to say that the bottom milk which is siphoned off need not be wasted, it can be used for cooking or other purpose. I would again emphasise that nursery milk, so called, is not required in the preparation of top-milk mixtures. Many of these are so fortified with cream that they upset all calculations. An ordinary average milk containing 3·4% to 3·8% of fat is of the required strength.

The advantage of this method is that dairy cream is not required for preparing the mixtures, so that the addition of preservatives and the dangers attaching to cream of uncertain age are thereby avoided.

The chief objections to the method are, firstly, the delay caused by the rising of the cream; and, secondly, the bacterial contamination, which is apt to grow the longer the milk stands. This, however, can be avoided by standing the milk in ice or in a refrigerator.

THE "PROTEIN-MILK" METHOD

Protein milk, alternatively called casein milk, albumin milk or Eiweissmilch, is a creation of a German school of pædiatrics, with Professor Finkelstein at its head. The principle on which the method is founded is that most of the troubles connected with intestinal fermentation, summer diarrhœa and the like, are due to sugar decompositions, which are themselves dependent on two main factors: the concentration of the whey and the relative proportions of casein and sugar in the mixture. The argument is that such fermentations can be prevented by a diminution in the quantity of milk-sugar and salts, and an increase in the quantity of the casein, and Professor Finkelstein's Eiweissmilch represents an attempt to embody these principles in the material form of a specially prepared milk mixture which fulfils the required conditions.

Personally, I agree with no part of the argument and I regard Eiweissmilch as a very clumsy and complicated method of providing a mixture of the desired properties. The same end can be arrived at by much simpler means, but since the method has certain adherents in this country I supply the necessary details for carrying it out.

Details of Preparation.—Take 1 quart of milk, heat to 100° F., add 4 teaspoonfuls of rennet, and stir. When the curd has formed strain through muslin, rub this curd through fine sieve, and work it up into a smooth and thin paste with 1 pint of water. To this add 1 pint of buttermilk (see p. 471).

The resulting mixture has the following composition :—

Protein . . .	3·0%
Fat	2·5%
Sugar	1·5%
Salts	0·5%

The caloric value of this mixture is about 14 calories per oz.

Such a mixture, if given in the small quantities usually recommended, provides a semi-starvation diet which is obviously indicated during the acute or subacute stage of intestinal disturbances. It also contains a large number of lactic-acid bacilli, which help to restrain the activities of proteolytic bacteria. The same ends, however, can in my opinion be better secured by more drastic starvation, by the hypodermic injection of normal saline, and if necessary by the independent administration of a pure culture of lactic bacilli.

Certain enthusiastic followers of the method go a good deal further than Professor Finkelstein himself, and give Eiweissmilch for a great number of conditions apart from those for which it was primarily intended, and even in certain cases to healthy infants. For the reasons already given (pp. 19 and 156) I strongly deprecate the violation of the fundamental principles of " balance " which is implicit in the use of such a mixture for healthy infants.

If an infant has been fed on an excess of carbohydrate an improvement usually results from a drastic curtailment of this particular element in the food, and under such circumstances Eiweissmilch may be highly suitable as a temporary food, but for cases in which there has already been an excessive supply of protein such a food can only add to the trouble.

CHAPTER XI

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

DRIED MILKS

Practical Details—Modification to Breast Standard—"Split Protein" Method with Dried Whey and Dairy Cream—"Split-Protein" Method with Dried Whey and Fat Emulsions

As I have already stated (p. 192), dried milks are invaluable in infant feeding provided that in using them all the principles of physiological feeding with respect to quantity, "balance," accessory factors, and so on, are strictly observed, but they possess no magic properties which render unnecessary the observation of the same precautions that are essential in employing dairy milk or other substitute foods.

In order to secure the correct "balance" and to modify dried milks to breast standard the actual chemical composition of the particular variety of milk used must be known. The chemical analysis of various brands is given on page 189, and this will be seen to vary to some extent with the maker and methods of manufacture. Taking "Cow and Gate" full-cream as a representative type, it will be observed that the percentage composition is as follows :—

Protein . . .	27·5%
Fat	25·0%
Sugar	37·82%

To reduce the protein percentage to the statutory 2% it is necessary to dilute the milk with 13½ parts of water. This will reduce the fat and sugar content in the same proportions, giving a resultant composition as follows :—

Protein . . .	2·0%
Fat	1·8%
Sugar	2·7%

To bring the fat percentage up to the standard of breast milk—*i.e.* 3·5%—additional fat to the extent of 1·7% must be added, and to bring the sugar percentage up to the standard of breast milk—*i.e.* 7%—sugar must be added to the extent of 4·3%.

Now to make 1 pint of dried milk mixture of breast standard the following quantities must be taken :—

Dried milk (Cow and Gate)	$1\frac{1}{2}$ oz.
Cream (33% fat)	1 oz.
Sugar	$6\frac{1}{2}$ drachms
Water to make	20 oz.

Such a mixture is correct as regards balance, but it is not quite correct as regards the accessory factors. It is probably deficient in the anti-scorbutic vitamine, so that this must be given independently in the form of orange or grape juice.

In employing dried milks I invariably give a small quantity, usually about 4 oz., of vegetable soup (p. 476) in the 24 hours, in order that organic salts, extractives, etc., may be provided in addition to such as may be contained in the dried milk itself.

One grain of lecithin in each pint of mixture is in my opinion a valuable addition, to make up for the possible deficiency in the milk.

As for digestibility (see p. 187), dried milk coagulates in the stomach in the form of a less heavy clot than is the case with fresh cow's milk, and to this extent may be said to be more digestible. I should not dream of giving a dried-milk mixture to a new-born baby, nor to one recently weaned, without some previous artificial digestion. Some infants can tolerate such a liberty, but the majority cannot, and there is no need to take the risk.

It is quite easy to modify the percentage composition of dried-milk mixtures, in the same way that dairy milk has been shown to be capable of being manipulated (see p. 204). In Table 53 will be found the formulæ for preparing 1 pint of mixture of various percentage compositions, the protein varying from 1·0% to 2·5%; the cream from 1·5% to 3·5%, while the sugar remains at the constant figure of 5%. This table may be used in the following manner. Let us suppose we require to prepare 1 pint of a mixture of the following composition :—

Protein . . .	1·5%
Fat	3·0%
Sugar	5·0%

All mixtures containing 1·5% of protein will be found in the horizontal compartments lettered B, and all mixtures containing 3·0% of fat in the vertical column numbered 4.

TABLE 53.—Formulæ for preparing Milk Mixtures of various Percentage Compositions. In each case the ingredients given are for making 1 pint (20 oz.) of mixture and the quantity of water required for making this amount must be added. It is assumed that the dried milk is of the following composition:—protein, 27·5%, fat, 25%, sugar, 37·82%, and that the cream contains 33% of fat

The Protein Percentage		The Fat Percentage 1·5%	2·0%	2·5%	3·0%	3·5%	The Sugar Percentage
1·0%	The Percentage Composition { Protein Fat . Sugar . The Ingredients .	A1. 1·0% 1·5% 5·0% Dried Milk, 6 dr. Cream, 3 dr. Sugar, 6 dr. Caloric value, 11½	A2. 1·0% 2·0% 5·0% Dried Milk, 5 dr. Cream, 6 dr. Sugar, 6 dr. Caloric value, 12½	A3. 1·0% 2·5% 5·0% Dried Milk, ½ oz. Cream, 1 oz. Sugar, 6 dr. Caloric value, 13½	A4. 1·0% 3·0% 5·0% Dried Milk, 3 dr. Cream, 1⅓ oz. Sugar, 6½ dr. Caloric value, 14½	A5. 1·0% 3·5% 5·0% Dried Milk, 3 dr. Cream, 1¾ oz. Sugar, 6 dr. Caloric value, 15½	5·0%
1·5%	The Percentage Composition { Protein Fat . Sugar . The Ingredients .	B1. 1·5% 1·5% 5·0% Dried Milk, 1 oz. Cream, 1 dr. Sugar, ½ oz. Caloric value, 12½	B2. 1·5% 2·0% 5·0% Dried Milk, 1 oz. Cream, 3½ dr. Sugar, ½ oz. Caloric value, 14	B3. 1·5% 2·5% 5·0% Dried Milk, 1 oz. Cream, 6 dr. Sugar, ½ oz. Caloric value, 15	B4. 1·5% 3·0% 5·0% Dried Milk, 1 oz. Cream, 1 oz. Sugar, ½ oz. Caloric value, 16	B5. 1·5% 3·5% 5·0% Dried Milk, 1 oz. Cream, 1½ oz. Sugar, ½ oz. Caloric value, 18	5·0%
2·0%	The Percentage Composition { Protein Fat . Sugar . The Ingredients .	C1. 2·0% 1·5% 5·0% Not possible	C2. 2·0% 2·0% 5·0% Dried Milk, 1½ oz. Cream, 1 dr. Sugar, 3½ dr. Caloric value, 15½	C3. 2·0% 2·5% 5·0% Dried Milk, 1½ oz. Cream, 3½ dr. Sugar, 3½ dr. Caloric value, 16½	C4. 2·0% 3·0% 5·0% Dried Milk, 1¼ oz. Cream, 7 dr. Sugar, 3½ dr. Caloric value, 17	C5. 2·0% 3·5% 5·0% Dried Milk, 1½ oz. Cream, 1 oz. Sugar, 3½ dr. Caloric value, 18½	5·0%
2·5%	The Percentage Composition { Protein Fat . Sugar . The Ingredients .	D1. 2·5% 1·5% 5·0% Not possible	D2. 2·5% 2·0% 5·0% Dried Milk, 1¾ oz. No Cream Sugar, 2½ dr. Caloric value, 16½	D3. 2·5% 2·5% 5·0% Dried Milk, 1¾ oz. Cream, 1½ dr. Sugar, 2½ dr. Caloric value, 17½	D4. 2·5% 3·0% 5·0% Dried Milk, 1¾ oz. Cream, 5 dr. Sugar, 2½ dr. Caloric value, 18½	D5. 2·5% 3·5% 5·0% Dried Milk, 1¾ oz. Cream, 1 oz. Sugar, 2½ dr. Caloric value, 19½	5·0%

The required formula will therefore be found in the compartment B4. It runs as follows :—

Take of dried milk	. . . .	1 oz.
,,	cream (33% of fat) . .	1 oz.
,,	sugar	½ oz.

and add sufficient water to make 1 pint of mixture.

To alter the Sugar Content in these mixtures all that it is necessary to do is to add or omit 1½ drachms of sugar for every 1% of sugar required. For instance, in the above mixture we can raise the percentage of sugar from 5% to 7% by adding 3 drachms of sugar to the ½ oz. already required in the original formula.

The Use of Fat Emulsions in Place of Cream.—It may be objected that in using cream, which is practically never germ-free and may be actually dangerous, we nullify one of the great advantages of dried milk—*i.e.* its comparative freedom from pathological germs. This objection can be obviated by substituting some sterile fat emulsion of the required percentage (p. 480).

For many years past I have used in my Infant Consultation Department various oil emulsions which provide the required quantity of fat in a bacteria-free form, and with the most excellent results. Emulsions of olive, linseed, cod-liver, nut and other oils can be used for this purpose ; for the sake of uniformity and ease of preparation it is well to make these emulsions up to the same standard as the cream used in the two tables—*i.e.* so that they contain 33% of fat. If such 33% fat emulsions are used instead of cream of corresponding strength it must not be forgotten that by omitting the cream the resulting mixture will be deprived of the small quantity of protein and sugar contained in cream itself, and hence will be of slightly lower percentage composition as regards these two elements than it otherwise would have been. To correct this trifling error a shade more dried milk may be used in the preparation than is stated in the table.

THE "SPLIT-PROTEIN" METHOD

The "split-protein" method can be carried out in the making of dried-milk mixtures by the employment of that exceedingly useful preparation called Sec-Wa, which is a desiccated whey powder manufactured by the spray method (see p. 184).

The chemical composition of dried whey is as follows :—

Whey proteins	14·25%
Fat	0·27%
Milk-sugar	74·45%
Mineral matter	9·80%
Water	1·20%

If 1 part of this powder be dissolved in 14 parts of water we reconstruct a fluid whey of the following composition :—

Whey proteins	1·0%
Fat	0·01%
Milk-sugar	5·3%
Mineral matter	0·7%
Water	93·0%

It will be observed that this whey has almost exactly the same composition as whey prepared from separated milk (p. 470), and very nearly the same as that used in the preparation of the "split-protein" mixtures described on page 207, and which is prepared from whole milk.

To make this whey mixture conform to the standard of breast milk it is necessary to add 0·5% of caseinogen, 3·5% of fat and 1·7% of sugar. This can very easily be done by fortifying the whey solution with 3⅓ oz. of cream which contains 20% fat, and with ½ oz. of milk-sugar. The formula will thus read as follows :—

To prepare 20 oz. of a "split-protein" mixture of breast standard take—

Dried whey (Sec-Wa)	1½ oz.
Cream (20% fat)	3⅓ oz.
Sugar of milk	½ oz.
And water to make	20 oz.

The approximate percentage composition of this mixture is :

Proteins {caseinogen, 0·5%; whey proteins, 1·0%}	1·5%
Fat	3·5%
Sugar	7·0%
Mineral matter	0·7%

This composition corresponds very closely to breast milk, but it is comparatively easy to ring the changes in the protein and fat content by employing creams of different percentage strengths. In the following tables are given a few typical examples. In certain cases it may be thought desirable to give the full protein percentage (1·5%) entirely in the form of whey proteins, with the omission altogether of caseinogen. Under such circumstances cream cannot be employed for supplying the required proportion of fat, since it contains a small proportion of caseinogen, and therefore a 33% emulsion of butter fat must be employed in its place. For the preparation of a butter-fat emulsion of this strength see formula (5), page 481.

In Table 54 are given the formulæ for making such caseinogen-free mixtures; the fat percentages range from 3·5% to 1·5%; the sugar percentage is 8%.

In Table 55 are given the formulæ for preparing "split-protein" mixtures of breast standard as far as the proteins are concerned—*i.e.* whey proteins 1·0%; caseinogen 0·5%, and with fat percentages varying from 3·5% to 1·5%, the sugar in each case being that of breast standard—*i.e.* 7%.

In Table 56 are given the formulæ for preparing "split-protein" mixtures with a higher caseinogen content—*i.e.* 1%. This necessitates the use of creams with a low fat content. These creams can easily be prepared from richer creams by diluting with milk in the required proportion. To do this accurately the fat percentage of the cream must be ascertained. It is assumed that the fat content of the added milk is 3·5%. (See page 480 for further details.)

Table 54

Formulæ for preparing Whey Mixtures from Dried Whey Powder which contain 1·5% of whey proteins, no caseinogen, 3·5%, 3%, 2·5%, 2% and 1·5% of fat respectively, and 8% of sugar. In using these formulæ it is necessary to use a 33% emulsion of butter fat, formula (6), page 481

Percentage Composition—					
Whey proteins	1·5%	1·5%	1·5%	1·5%	1·5%
Fat	3·5%	3·0%	2·5%	2·0%	1·5%
Sugar	8·0%	8·0%	8·0%	8·0%	8·0%
Ingredients—					
Whey powder	2¼ oz.	2¼ oz.	2¼ oz.	2¼ oz.	2¼ oz.
Butter-fat emulsion (33% fat)	2 oz.	1¾ oz.	1 oz. 3 dr.	1 oz.	6 dr.
Water to	20 oz.	20 oz.	20 oz.	20 oz.	20 oz.
Caloric value per oz.	23½	22½	21½	20½	19½

Table 55

Formulæ for preparing Whey Mixtures from Dried Whey Powder so as to contain 1% of whey proteins, 0·5% of caseinogen, 3·5%, 3·0%, 2·5%, 2% and 1·5% of fat respectively, and 7% of sugar. To prepare these mixtures creams with varying fat percentages must be employed (see p. 484)

Percentage Composition—					
Whey proteins	1·0%	1·0%	1·0%	1·0%	1·0%
Caseinogen	0·5%	0·5%	0·5%	0·5%	0·5%
Fat	3·5%	3·0%	2·5%	2·0%	1·5%
Sugar	7·0%	7·0%	7·0%	7·0%	7·0%
Ingredients—					
Whey powder	1½ oz.	1½ oz.	1½ oz.	1½ oz.	1½ oz.
Cream	(20% fat) 3⅓ oz.	(17% fat) 3⅓ oz.	(14% fat) 3⅓ oz.	(11% fat) 3⅓ oz.	(8% fat) 3⅓ oz.
Sugar	½ oz.	½ oz.	½ oz.	½ oz.	½ oz.
Water to	20 oz.	20 oz.	20 oz.	20 oz.	20 oz.
Caloric value per oz.	22½	21½	20½	19½	18½

Table 56

Formulæ for preparing Whey Mixtures from Dried Whey so as to contain 1% whey proteins, 1% caseinogen, 3·5%, 3·0%, 2·5%, 2·0% and 1·5% of fat respectively, and 7% of sugar. To prepare these mixtures creams with varying percentages of fat must be employed (see p. 484)

Percentage Composition—					
Whey proteins	1·0%	1·0%	1·0%	1·0%	1·0%
Caseinogen	1·0%	1·0%	1·0%	1·0%	1·0%
Fat	3·5%	3·0%	2·5%	2·0%	1·5%
Sugar	7·0%	7·0%	7·0%	7·0%	7·0%
Ingredients—					
Whey powder	1½ oz.	1½ oz.	1½ oz.	1½ oz.	1½ oz.
Cream	(10% fat) 6⅔ oz.	(8% fat) 6⅔ oz.	(7% fat) 6⅔ oz.	(6% fat) 6⅔ oz.	(5% fat) 6⅔ oz.
Sugar	3½ dr.	3½ dr.	3½ dr.	3½ dr.	3½ dr.
Water to	20 oz.	20 oz.	20 oz.	20 oz.	20 oz.
Caloric value per oz.	22½	21½	21	20	19

By the use of these formulæ any required "balance" within reasonable limits can be secured. The quantity which will be required will depend on the estimated caloric requirements of the baby for whom it is intended and the caloric value of the particular mixture employed. This is clearly stated in each case. As a rule, when whey mixtures are given, the infants who consume them are partly starved, because of the low caloric value of the food.

Whey mixtures should be supplemented by grape juice or other fruit juices, which contain the anti-scorbutic vitamine, and further I advise a daily ration of vegetable broth (see p. 476) to the extent of 4 oz., to make good any possible deficiency in organic salts, extractives and other accessory factors.

Precaution.—Whey mixtures must not be heated above 150 F. for sterilisation or other purposes, since by so doing the whey proteins would be coagulated. If it is thought necessary to sterilise these mixtures they should be heated for 40 minutes at 150° F.

"SPLIT-PROTEIN" MIXTURES WITHOUT THE USE OF DAIRY CREAM

There is no difficulty in preparing "split-protein" mixtures out of milk powders and dried whey, without the use of cream at all, provided that the required quantum of fat can be supplied in the form of an emulsion. I have for many years past been in the habit of employing this method in the case of babies attending at my Marylebone Centre. As a rule I have used an emulsion of linseed oil, since in this way fat is provided in the cheapest possible form, but in private cases I usually employ emulsions of butter fat, since these can be prepared at home without difficulty.

In the following tables a few formulæ are given for preparing such mixtures. Their range can be extended to any degree with the exercise of a little ingenuity, but for ordinary purposes they cover all the required combinations.

For the preparation of 33% fat emulsions see formulæ (3) and (6), page 481.

Table 57

Formulæ for preparing Mixtures on the "Split-Protein" Basis from Dried Milk, Whey Powder and Fat Emulsions (33% fat). The range of fat percentages is from 3·5% to 1·5%. The whey protein percentage is 1·0%, the caseinogen, 0·5% and the sugar, 7%

Percentage Composition—					
Proteins {whey proteins .	1·0%	1·0%	1·0%	1·0%	1·0%
Proteins {caseinogen .	0·5%	0·5%	0·5%	0·5%	0·5%
Fat	3·5%	3·0%	2·5%	2·0%	1·5%
Sugar	7·0%	7·0%	7·0%	7·0%	7·0%
Ingredients—					
Whey powder . .	1½ oz.	1½ oz.	1½ oz.	1½ oz.	1½ oz.
Dried milk (Cow and Gate)	3 dr.	3 dr.	3 dr.	3 dr.	3 dr.
Fat emulsion (33% fat) .	2 oz.	1¾ oz.	1½ oz.	1¼ oz.	1 oz.
Sugar	½ oz.	½ oz.	½ oz.	½ oz.	½ oz.
Water to . . .	20 oz.	20 oz.	20 oz.	20 oz.	20 oz.
Caloric value per oz. .	22½	21½	20½	19½	18½

TABLE 58

Formulæ for preparing Mixtures on the "Split-Protein" Basis from Dried Milk, Whey Powder and Fat Emulsions (33% fat). The range of fat percentages is from 3·5% to 1·5%. The whey protein percentage is 1·0%, the caseinogen, 1·0% and the sugar, 7·%

Percentage Composition—					
Proteins {whey proteins .	1·0%	1·0%	1·0%	1·0%	1·0%
Proteins {caseinogen .	1·0%	1·0%	1·0%	1·0%	1·0%
Fat	3·5%	3·0%	2·5%	2·0%	1·5%
Sugar	7·0%	7·0%	7·0%	7·0%	7·0%
Ingredients—					
Whey powder . .	1½ oz.	1½ oz.	1½ oz.	1½ oz.	1½ oz.
Dried milk (Cow and Gate)	6 dr.	6 dr.	6 dr.	6 dr.	6 dr.
Fat emulsion (33% fat)	2 oz.	1¾ oz.	1½ oz.	1¼ oz.	1 oz.
Sugar	½ oz.	½ oz.	½ oz.	½ oz.	½ oz.
Water to	20 oz.	20 oz.	20 oz.	20 oz.	20 oz.
Caloric value per oz. .	22½	21½	21	20	19

CHAPTER XII

THE ARTIFICIAL FEEDING OF INFANTS (*continued*)

CONDENSED MILKS

Condensed Milks—Practical Details—Proprietary Foods—The Milk of Goats and other Animals

Unsweetened Condensed Milk.—This section should be read in conjunction with Chapter VIII., page 193.

A mixture may easily be prepared of breast standard by dilution with water and fortification with cream and sugar according to the following formula :—

Unsweetened condensed milk . .	4 oz.
Cream or fat emulsion (33% fat) .	¾ oz.
Sugar	6 drachms
Water to make	20 oz.
Caloric value	20 calories per oz.

It is to be noted that condensed-milk mixtures can be used in very considerable degrees of concentration without untoward results as far as digestion is concerned ; for instance, in making up the above formula half the amount of water might be used ; or, more accurately speaking, the mixture might be made up to 10 oz., in which case the percentage composition would be twice that of breast milk—namely,

Proteins	3·2%
Fat	7·0%
Sugar	14·0%
Caloric value . .	40 per oz.

Such mixtures are well tolerated in still greater degrees of concentration. I have often given condensed milks straight out of the tin without any dilution and without any bad results. In using concentrated mixtures of this kind the high caloric value must be taken into account, and correspondingly small quantities should be supplied.

In using condensed-milk mixtures for any prolonged period of time, I think it most advisable to give fruit juice regularly, to make up the probable deficit in the anti-scorbutic vitamine and also to provide a daily ration of about 4 oz. of vegetable soup (p. 476) which can replace part of the water in preparing the mixture.

Sweetened Condensed Milk.—As regards these varieties of condensed milk, they can be made to approximate to breast standard by dilution with water and by the addition of cream in accordance with the following formula :—

Sweetened condensed milk . .	$3\frac{1}{4}$ oz.
Cream or fat emulsion (33% fat) .	1 oz.
Water to make	20 oz.

This gives a percentage composition of :

Proteins . .	1·6%
Fat . . .	3·5%
Sugar . .	8·6%

—which is slightly higher than breast-milk standard as regards the proteins and the sugar, and with a caloric value of 23 per oz.

The same reservations with regard to the use of sweetened condensed milk hold good as in the case of the unsweetened varieties —that is to say, they are not recommended for permanent or prolonged use, and they require to be supplemented by the same accessory factors. I use condensed milk thus modified, with or without additional fat, very largely in the case of sick infants as a stepping-stone to cow's-milk modifications.

The high percentage of sugar and the relatively low percentage of fat make condensed milk a very useful food in those cases in which the infant has heretofore been fed on an excess of fat, but for the normal infant this defect in balance may affect nutrition most prejudicially, and therefore additional fat must be supplied.

PATENT OR PROPRIETARY FOODS

This subject has already been somewhat fully discussed (pp. 197-200), so that little remains to be said with regard to the practical details.

It may, however, be repeated here that a distinction should be drawn between infants' foods which claim to be complete foods, requiring nothing beyond the addition of water to make them ready for use, and those which are only intended to serve as supplementary foods to be added to milk mixtures.

Complete foods such as Allenbury No. 1 or Horlick's Malted

Milk are in a sense complete foods, since they contain representatives of all the essential elements, but they must be employed with caution, and not continued too long, since the balance of the main food constituents in them is not the same as in breast milk. Owing to the ease with which they can be digested they are often very useful as stepping-stones which can lead up to the use of more indigestible milk mixtures. The way in which I employ them myself is as follows. I give them in quantities, and in such degrees of dilution as are indicated by the physiological conditions. I calculate as nearly as I can the caloric requirements of the baby—say, for a delicate baby, 1 month old, and weighing 7 lb., $7 \times 50 = 350$ calories for the 24 hours.

Since the caloric value of Allenbury No. 1 is 141 calories per oz., the total requirements for the 24 hours will be $\frac{350}{141} = 2{\cdot}48$ oz., or roughly $2\frac{1}{2}$ oz.

Taking this amount as a basis to start with, I divide this amount of food among the individual feeds given in the 24 hours. If these number 6 the amount for each feed will be $\frac{2\frac{1}{2}}{6} = 3\frac{1}{3}$ drachms.

This amount of the food can be diluted with such a quantity of water as may be considered requisite for the physiological needs of the baby, or for rendering it approximately the same as breast standard. As I have already stated, the majority of these foods should be diluted in the proportion of 1 part of food to 7 or 8 of water, so that, to commence with, each feed might consist of a total of 3 oz. Under special circumstances it may be found desirable to dilute less or more freely, or indeed to give a smaller quantity of the food itself.

Now the chief fault in balance is that the sugar is disproportionately excessive in comparison to the fat and protein content. This defect can be adjusted by the careful and gradual addition of dairy cream. As the first step in advancement towards a milk mixture a small quantity, say 10 or 15 drops, of cream may be added to each feed, and this quantity may be increased as the infant's powers of digestion develop. After a time milk may be added in the same cautious manner, and to the exclusion of a corresponding quantity of the food, and the whole mixture finally modified to breast standard by an adjustment of the cream and milk and by the addition of sugar.

In using proprietary foods, such as Allenbury No. 1, I very strongly advise the addition of vegetable broth, as well as some anti-scorbutic fruit juice, such as that of the orange. The vegetable broth should be given to the extent of some 4 oz. daily, and should be added to the mixture to the exclusion of a corresponding amount of water.

In conclusion, I would once again emphasise the following recommendations in using proprietary infants' foods.

In the first place, give them in quantities that conform to the estimated caloric requirements of the infant. These estimated quantities may have to be altered in conformity with the special reactions of the baby.

In the second place, a note should be made of the " balance " existing in the food as prepared for use. If this departs from the physiologcial standard—*i.e.* that of breast milk—in any serious degree the necessary correction must be made, as soon as circumstances allow, by the addition of supplementary food—cream, for instance.

In the third place, the matter of accessory factors must be taken into consideration and given independently.

In the fourth place, the question of digestibility must not be overlooked. As a rule, proprietary foods owe their popularity to the ease with which they can be digested, and the fact that the digestive functions are consequently ill developed is obscured by the apparently satisfactory progress of the infant and the freedom from dyspeptic symptoms.

Proprietary Foods intended to be used as supplementary to Milk Mixtures.—Such foods as Mellin's, Neave's, Ridge's and Robinson's Prepared Barley, which consist for the most part of cereal flours, malted or unmalted, may be rationally employed as substitutes for sugar in the making of cow's-milk mixtures, but it must be clearly understood that in using them no benefit is likely to accrue to the infant beyond the fact that by their use the starch-digesting functions will thereby be developed.

A baby or a child who can digest starch is clearly in the happy position of being able to " malt " for himself—in other words, he is able to convert starch into maltose. Until he has acquired this accomplishment it is necessary to give him a soluble carbohydrate, such as milk-sugar or sucrose, or to supply in their place some insoluble carbohydrate which has already been malted by the manufacturer. Some of the supplementary foods which are largely used consist entirely of unaltered cereal flours; others are partly or wholly malted. Before making use of them it is as well to make oneself acquainted with their special properties.

Completely malted foods, such as Mellin's, may be used at quite an early age—say, at one month—as a substitute for an equivalent weight of sugar, but not as an addition to it, or otherwise the "balance" of any correctly prepared mixture will be upset.

After a time a partially malted food, as Allenbury No 3, Benger's Food or Chapman's Entire Wheat Food, may be given in place of the more completely malted food, and finally a food which is entirely unmalted, such as Robinson's Prepared Barley or Ridge's Food, may be safely employed in place of the sugar, in part or whole.

I hope in this section I have made sufficiently plain the rational use of proprietary foods. Failures, however, are certain to result when resort is made to one kind after another in the hope that by drawing a bow at a venture the target may be hit.

THE MILK OF GOATS AND OTHER ANIMALS

It is now becoming fashionable to use goat's milk as a substitute for cow's milk, partly because goats are supposed to be more immune to tuberculosis than cows, and partly because it is easy to keep a goat, and thus obtain daily a perfectly fresh supply of milk, in cases in which it would be quite impossible to keep a cow.

There is much truth in the popular belief that goat's milk is safer than cow's milk from the point of view of tuberculosis. On the other hand, in some parts of the world—the Mediterranean littoral, for instance—the goats are subject to a special kind of infection (Mediterranean Fever), which they are liable to convey to those who consume their milk unboiled.

Goat's milk is somewhat variable in composition, but good samples are of the following average make-up:

Total proteins . .	3·5%
Fat	3·7%
Sugar . . .	4·7%

For all practical purposes, therefore, goat's milk should be used in the same way, and with the same degree of modification, as cow's milk. The high casein and total nitrogenous content of this variety of milk demand that it should not be used "whole" for infant feeding; it should be diluted to the extent of 50% and fortified with additional fat and sugar. Since one of the chief advantages of goat's milk would be lost if ordinary dairy cream, with its possible content of tubercle bacilli, were to be the source of this additional fat, it is well to employ other substitutes—as, for instance, cod-liver-oil emulsion or an emulsion made from butter which has been sterilised (p. 480). The following formula may be employed for modifying goat's milk to breast standard :—

Goat's milk . .	10 oz.
Fat emulsion (33%) .	1 oz.
Sugar . . .	1 oz.
Water to make . .	1 pint

A still simpler means of modifying to the required standard is to employ the "top-milk" method (p. 210).

THE USE OF OTHER VARIETIES OF MILK

From an examination of the accompanying table it will be seen that there are great variations in the chemical constitutions of the milks of different mammals. The milks mostly used for infant feeding are ass's milk, buffalo's milk and mare's milk. Each of these requires to be differently modified to make it of breast standard. Sometimes these milks can be used temporarily without modification to suit special purposes—for instance, ass's milk is indicated in cases in which a low protein combined with a low fat percentage is required; mare's milk subserves the same purpose; while buffalo's milk, which like goat's milk is subject to considerable fluctuations in percentage composition, is usually very much richer than cow's milk as regards both fat and protein; the sugar content is low. For ordinary use it should be modified in the following way :—

Buffalo's milk . .	8 oz.
Sugar . . .	$1\frac{1}{4}$ oz.
Water to make . .	1 pint

It is always wise to have an analysis made of the three main constituents of buffalo's milk in order that correct modifications may be carried out. Ass's milk seldom requires modification. Its chief virtue lies in its thinness and poor percentage of solids.

TABLE 59[1]

Comparative Composition of Milks of Different Animals. Taken from Voltz

Milk	Water	Solids	Fat	Casein	Total Proteins	Sugar	Ash	Caloric Value Per Oz.
Ass's milk .	90·12	9·88	1·37	0·79	1·85	6·19	0·47	14
Blue whale's milk .	50·47	39·53	20·00	..	12·42	5·63	1·48	85
Buffalo's milk	82·30	17·70	7·70	..	4·80	4·40	0·8	32
Camel's ,,	87·60	12·40	5·38	2·98	..	3·26	0·7	22
Cow's ,,	87·80	12·20	3·40	2·70	3·40	4·70	0·7	20
Dog's ,,	77·00	23·00	9·26	4·15	9·72	3·11	0·91	39
Goat's ,,	86·30	13·70	4·00	3·60	4·60	4·30	0·8	20
Guinea pig's ,,	41·11	58·89	45·80	..	11·19	1·33	0·57	135
Human ,,	87·58	12·42	3·74	0·80	2·01	6·37	0·3	20
Mare's ,,	90·58	9·42	1·14	..	2·50	5·87	0·36	13
Pig's ,,	82·37	17·63	6·44	..	6·09	4·04	0·59	29
Rabbit's ,,	69·50	30·50	10·45	..	15·54	1·95	2·56	48
Reindeer's ,,	67·70	32·30	17·10	..	10·90	2·80	1·50	61
Sheep's ,,	81·50	18·50	7·00	4·30	5·60	5·00	0·9	31

[1] Oppenheimer's *Handbuch der Biochemie*, vol. iii., p. 403. Jena, 1910.

CHAPTER XIII

THE FEEDING OF CHILDREN FROM THE 9th TO THE 12th MONTH

Dietary for the 9th Month of Life—Dietary for the 10th Month of Life—Dietary for the 11th Month of Life

This period includes the important transitional stage from bottle to mixed feeding. There is, however, no definite line of demarcation between the two, nor between this period and that which is included in the next chapter.

At or about the 9th month the infant usually reaches a stage at which, owing to the eruption of the teeth, a certain amount of solid food is indicated. There are, however, no valid reasons why, on this account, the principles of physiological feeding should be abandoned. At this period quantity, " balance " and all the other essentials for correct feeding are as necessary as during the earlier stages of life, only they are more difficult to control. In the following pages I propose to give a short account of a method of feeding during this transitional period which fulfils the necessary requirements. To take a concrete instance, let me give the case of an infant 9 months old who has already cut six incisor teeth, weighs about 18 lb., and is in other respects normal.

The estimated caloric requirements of such an infant (see p. 8) are about 836 ($18 \times 46{\cdot}5$).

Such an estimate must, in the nature of things, be approximate only, but this figure can be corrected if conditions are known to exist which in any way make the infant's requirements for food deviate from the average (see p. 10).

Assuming that the estimation of 836 calories is correct it is clear that if this infant were fed exclusively on breast milk he would require 41 oz. in the 24 hours, since the caloric value of breast milk is 20 per oz. If such an infant were to be fed on cow's milk modified to breast standard he would, of course, require a similar number of ounces. To make 41 oz. of cow's milk modified to breast standard the following ingredients are required (see p. 202).

Milk	20 oz.
Cream (33% fat) .	2 oz.
Sugar . . .	2 oz.
Water to make . .	41 oz.

If, therefore, in the 24 hours such an infant is supplied with the above quantities of milk, cream and sugar, he will not only obtain the correct number of calories but the food will also be provided in a manner in which the "balance" is correctly adjusted. Now it is quite easy to maintain this correct "balance," and provide also the required number of calories, by substituting new varieties of food in place of a corresponding quantity of any of the above-mentioned ingredients. For instance, instead of giving 2 oz. of cream, a corresponding amount of other fats might be substituted in part or in whole. For instance, a certain amount of butter might be given as an alternative, or an equivalent amount of some other fat, such as dripping, or bacon fat; and the same is true with respect to the sugar: instead of the 2 oz. of sugar which are required, a part or the whole of this might be given in the form of starch. The one essential condition, as far as quantity and balance are concerned, is that in addition to 20 oz. of milk the equivalents of 2 oz. of cream and 2 oz. of sugar should be provided in some form or another. It would be a matter of comparative indifference in what form these foods were given if the question of digestibility had not be to considered. For instance, it would be quite easy to give 2 oz. of starch, in place of the 2 oz. of sugar required by the above formula, were it not for the fact that at 9 months the majority of infants would not be able to digest this amount of an insoluble carbohydrate.

The chief secret in the management of the dietary at this age is to maintain a correct balance and supply the required number of calories and yet at the same time introduce variations into the composition of the food which not only do not disturb the digestive functions, but actually lead to their progressive evolution. At this time it is most important to encourage and develop the function of mastication and the capacity to digest starchy or farinaceous foods. Similarly it is of advantage to habituate the infant to the digestion of other forms of protein than those contained in milk—such, for instance, as the proteins of fish, meat, eggs and cereal foods.

The problem of correct feeding at this period of infancy resolves itself, therefore, into the arrangement of a dietary which avoids the monotonous conditions of exclusive milk feeding without infringing any of the essential laws of physiological feeding.

It is not difficult to fulfil all the required conditions if the formulæ for the total requirements for the 24 hours are kept prominently in view. It is a matter of comparatively little importance in what manner, or in what amounts, the total requirements for the 24 hours are distributed among the different meals so long as the digestive functions are not overtaxed at any one feeding, or the infant allowed to become seriously hungry or uncomfortable owing to too great a spacing-out of the meals. As the infant grows older it is desirable to lengthen out the intervals between meals, and to make the latter gradually approximate in character to the mixed meals of older children. Every change should, however, be introduced carefully and gradually in order that disturbances of digestion may be avoided.

At or about the 9th month the number of feeds should be reduced to 4 or 5, in accordance with the number heretofore provided. Each meal should consist of a certain proportion of the total 20 oz. of milk required in the 24 hours. This milk need not necessarily be given in a bottle, it can with advantage be given in part or in whole by spoon or cup. As far as "balance" is concerned it makes no difference whether it be given in the form of whole milk or whether it be diluted with water or fortified with some portion of the supplementary ration of sugar or cream. The necessary conditions will be fulfilled if at the end of the 24 hours the infant has consumed the statutory allowance of 20 oz. At all or some of these meals a certain proportion of the 2 oz. of carbohydrate food should be given as biscuits, crusts or rusks, in order that the function of mastication may be encouraged; how much or how little of the required total can be given in this way will depend on a variety of circumstances, but speaking quite generally it may be accepted that the more completely starch is substituted for sugar the better will it be for the infant, provided that the functions of digestion are adequately developed. It is of great importance to the infant to learn as early as possible how to masticate solid food. One of the chief reasons why adults and children so often "bolt" their food whole is because the golden opportunity of acquiring the habit of mastication is frequently lost by the giving of gruels, slops, milk puddings, mashed vegetables and minced meats at that particular period of life when habits are most easily established.

When an infant is about 9 months old he should be encouraged to nibble at malted rusks or sweet biscuits, which are pleasant to the taste and which do not impose too serious a task on his still tender gums. There is no advantage in giving at this time tasteless or unnecessarily hard rusks: the object to be aimed at is to encourage habits of mastication.

Between the 9th and 12th months many opportunities arise of introducing the infant to all sorts of new foods which need not disturb the "balance" of the dietary or upset his digestive functions. It is, however, very desirable that at this time the infant should not acquire dislikes or distastes to otherwise desirable forms of food by having them pressed upon him at times or on occasions when he evinces no particular desire to take them. All new foods for this reason should be given with discretion, and too many experiments should not be tried at the same time.

There are many advantages in introducing discreet changes into the hitherto somewhat monotonous milk diet of the child, for no matter how carefully a routine milk diet may be arranged there is always the possibility that some essential element may be absent, or deficient in quality, and if this defect is perpetuated day after day without intermission the cumulative result may ultimately become serious, whereas with a mixed diet omissions on one day may be corrected on the next.

In the following tables I have attempted to draw up dietaries for the 9th, 10th and 11th months respectively, in which all the physiological requirements of quantity, "balance," digestibility etc., are fulfilled. I do not claim that these tables are by any means perfect, or that they cannot be improved upon, but they serve as types on which others, and possibly better ones, can be founded in accordance with existing circumstances.

Dietary for the 9th Month of Life.—By this date, if the number of feeds in the 24 hours has not already been reduced to 4 or 5, it is high time that it should be. The best times for feeding must be determined by circumstances. I shall assume that 5 feeds are to be given. They may be arranged as follows:—6 A.M., 9.30 A.M., 1 P.M., 4.30 P.M. and 9 P.M.

The number of calories required for a normal child of this age is 836.

The correct "balance" can be secured, and the required number of calories approximately afforded, if the diet consists of the following :—

Milk	20 oz. (400 calories)
Cream (33% fat) . .	2 oz. (195 calories)
Carbohydrates . . .	2 oz. (232 calories)

From the point of view of quantity and "balance" it is immaterial in what manner these food elements are distributed amongst the different feeds, or in what particular form the fat and carbohydrates are given. Since, however, it is inadvisable to introduce any drastic alterations in the general arrangements of the meals at this period of life, a certain proportion of the above constituents should be given at each meal in the form of a milk mixture modified more or less accurately to breast standard.

Part of the required carbohydrate total may, however, be given in the form of starch, in substitution for a corresponding amount of sugar, and a small part of it in a dry form, as, for instance, as rusk or crust. As for the fat, the greater proportion of this should still be given as cream, but if thought advisable a small quantity might be given in the form of butter spread on rusk or crust. It must be remembered that in addition to correctness of quantity and "balance" it is still necessary that the diet at this period of life should conform to the physiological requirements as regards accessory factors and digestibility.

To fulfil these it is still necessary to supply daily a small quantity of fruit juice, and in my opinion it is wise to continue also the vegetable broth recommended for the earlier periods of life. As far as concerns the question of digestibility, this hinges chiefly on the amount of starch and solid food which it is safe to give the baby. In the following diet sheet half-an-ounce of prepared barley is substituted for a corresponding weight of sugar, while half-a-drachm of rusk is provided at four of the feeds for the purpose of eliciting the habit of mastication.

The dietary of a 9-months-old infant should therefore include the following ingredients :—

Milk	20 oz.
Cream (33% fat)	2 oz.
(Or pure fat	6 drachms)
Total carbohydrate (in form of sugar or starch)	2 oz.
Vegetable broth	4 oz.
Fruit juice	2 drachms

The exact manner in which these food materials can be best distributed among the 5 feeds will depend on existing circumstances, but the following arrangement is suggested as suitable in the majority of instances. Most of the ingredients should still be combined in the milk mixture, which may be prepared as follows and boiled for fifteen minutes :—

Milk	20 oz.
Cream (33% fat)	2 oz.
Sugar	1¼ oz.
Prepared barley (or other farinaceous flour)	½ oz.
Vegetable broth	4 oz.
Water to make	41 oz.

TABLE 60

Diet Sheet for a Baby 9 Months of Age

6 A.M.	9.30 A.M.	1 P.M.	4.30 P.M.	9 P.M.
Milk mixture 8 oz. Fruit juice 2 drachms at 8.30 A.M.	Milk mixture 8 oz. Rusk ½ drachm	Milk mixture 8 oz. Rusk ½ drachm	Milk mixture 8 oz. Rusk ½ drachm	Milk mixture 7 oz.

Total caloric value, 836

Dietary for the 10th Month of Life.—At this period the feeds may be reduced to 4 in the 24 hours. Since, however, the infant will in all probability still continue to wake up at 6 o'clock in the morning, it is a good plan to give the fruit juice at this time to relieve the restlessness which naturally results from this habit. The other feeds can be arranged at 4-hourly intervals—at 8, 12, 4 and 9, or other convenient hours.

The total amount of food, in conformity with the growth and development of the infant, must now be increased to the value of 873 calories, represented by 43 oz. of breast milk, or its equivalent in other foods. Details as regards "balance," digestibility and accessory factors must be observed as heretofore, but with the expanding of the digestive capacities more solid food, more starch and more variety is indicated in the day's supply.

The total ingredients in the 24 hours will be approximately as follows :—

Milk	22 oz.
Cream (33% fat)	2 oz.
(Or pure fat	6 drachms)
Total carbohydrate (sugar and starch) . .	2 oz.
Vegetable soup	4 oz.
Orange juice	2 drachms
Water to	43 oz.

The ingredients may be distributed among the various meals in different combinations.

The bulk of the ingredients should, however, still be presented in the liquid form, given partly in bottle and partly in cup, but each feed should be made up independently instead of being taken from a stock mixture as heretofore. A small quantity of milk must be reserved for the milk pudding, which will, of course, be eaten out of a spoon, while the meal in the middle of the day may be set aside for little experiments with new foods. In the following diet sheet I have drawn up a typical arrangement which combines all the required conditions. It need not, however, be strictly adhered to, although as regards quantity no serious departures must be permitted.

TABLE 61

Diet Sheet for a Baby 10 Months of Age

6 A.M.	8 A.M.	12 NOON	4 P.M.	9 P.M.
Orange juice, 2 dr. Sugar, 1 dr. Water, 2 dr.	Milk, 5 oz. Cream, 3 dr. Sugar, 2 dr. Water to make 8 oz.	Mashed potato, ½ oz. Gravy or broth, 1 oz. or milk pudding, 2 oz.	Milk, 5 oz. Cream, 3 dr. Sugar, 2 dr. Water to make 8 oz.	Milk, 5 oz. Groats, 2 dr. Sugar, 1 dr. Water to make 8 oz.
	Rusk or bread and butter, 2 dr.	Milk, 5 oz. Cream, 3 dr. Sugar, 1 dr. Water to make 6 oz.	Rusk or bread and butter 2 dr.	

Total caloric value, 873

Dietary for the 11th Month of Life.—At this age the infant should begin to have regular meals, and the use of a bottle should be entirely, or almost entirely, relinquished, except, for obvious reasons, at the 9 o'clock evening meal.

Further experiments may be made with new foods, these experiments being reserved for the most part for the midday meal. At this meal a variety of well-boiled and digestible vegetables, such as cauliflower, brussels sprouts and Jerusalem artichokes, may be given, mashed up with a little potato, while currant or apple jelly may be spread on the bread or butter, or fingers of toast may be dipped in the yolk of egg. The total ingredients for the 24 hours should afford 920 calories, or the equivalent of 46 oz. of breast milk. The following ingredients in combination will fulfil the required conditions of caloric value and "balance":

Milk	23 oz.
Cream (33% fat)	$2\frac{1}{4}$ oz.
(Or pure fat	6 dr.)
Total carbohydrate	$2\frac{1}{4}$ oz.
Vegetable soup (or equivalent in gravy or broth)	4 oz.
Fruit juice	2 dr.

In this instance again distribution of these different food materials among the various meals must be made subject to the prevailing conditions, but the following with slight modifications will probably be found to serve as a useful basis for the arrangements:—

TABLE 62

Diet Sheet for a Baby 11 Months of Age

6 A.M.	8.30	1 P.M.	4.30	9 P.M.
Orange juice, 2 dr. Sugar, 1 dr. Water, 2 oz.	Milk, 7 oz. Sugar, 2 dr. Water to make 8 oz.	Potato, $\frac{1}{2}$ oz. Other vegetables, a trace Gravy, 1 oz. to 2 oz.	Milk, 7 oz. Sugar, 2 dr. Water, 2 oz.	Milk, 7 oz. Groats or prepared barley, 1 dr. Sugar, 2 dr. Water to make 8 oz.
	Bread, toast or rusk, $\frac{1}{2}$ oz. Butter, $\frac{1}{2}$ dr. Currant jelly or yolk of egg, a trace	Milk pudding, 2 oz. Baked apple or stewed prunes, $\frac{1}{2}$ oz. Cream, 2 dr.	Bread or rusk, $\frac{1}{2}$ oz. Butter, $\frac{1}{2}$ dr. Currant jelly, 1 dr.	

Total caloric value, 920

The changes introduced into the infant's dietary during the last three months of the first year of life should lead up by easy stages to the dietaries described in the following chapter as being suitable from one year of age onwards.

CHAPTER XIV

THE PHYSIOLOGICAL FEEDING OF CHILDREN BETWEEN 1 AND 16 YEARS

The Quantity — Balance — Accessory Factors — Digestibility — Psychological Factors—The drawing up of Diet Sheets

The feeding of children immediately becomes more difficult when the bottle stage, with its accurate qualitative and quantitative adjustments, gives place to the pitfalls and complications of a mixed dietary. In the feeding of young children, with the precision and exactitude to which it is entitled by reason of its importance, we must pay attention to the same physiological principles that hold good in the case of infants during the first year of life.

In the first place it is necessary to adjust the quantity of the food to the physiological requirements in accordance with age, weight, rate of growth, energy production, loss of heat and other environmental conditions, and this is best done on a basis of caloric values; in the second place, the ratio or balance between the different constituents of the food—the proteins, the carbohydrates, the fats, the salts, and so on—must also be arranged on a physiological basis; and thirdly, the food itself must be selected with a view to its taste, digestibility, absorbability, physical qualities, variety, etc.

The Quantity.—The quantitative requirements of adult individuals have been fairly accurately gauged by a number of different methods, and we are in a position to say with some degree of precision that an average man, weighing 70 kilogrammes (11 stone, or 154 lb.), when living a sedentary life, needs food of the value of about 2500 calories per day—namely, about 35 calories per kilogramme of weight (16 calories per lb. weight). This estimate is reduced still further if the individual remains at complete rest in bed, while it will be raised to 3000 or more calories if he does hard work, that of a carpenter for instance. The amount of food required by men engaged in laborious occupations varies with the actual amount of work performed. A navvy or a sawyer may be entitled to food of the value of 4000 or even

5000 calories, while women require proportionately less. For instance, the following figures may be accepted as substantially correct for women—see Chapter I., page 8 :—

A needlewoman requires	.	2000	calories *per diem*
A machinist ,,	. .	2100–2300	,, ,, ,,
A domestic servant ,,	. .	2500–3200	,, ,, ,,
A washerwoman ,,	. .	2900–3700	,, ,, ,,

The caloric value of the food required by children is very much less than that required by adult men or women, but not proportionately to their weight, and this for several reasons. Although they are smaller, children have relatively a more active metabolism. They are more energetic physically, and relatively to their weight, they lose more heat by evaporation and radiation. It has been estimated that a child between 1 and 2 years of age requires about 0·3 ($\frac{3}{10}$) of the number of calories allowed for a man doing an average day's work. The following table is from McKillop's *Food Values* :—

TABLE 63

Description of Individual	Atwater and Wood	Mean of Various Authorities	
A woman requires . .	0·8	0·83	Of the 3000 calories required by an average man
A boy over 16 years .	1·0	0·92	
A boy 14–16 years . .	0·8	0·81	
A girl 14–16 years . .	0·7	0·74	
A child 10–13 years . .	0·6	0·64	
A child 6–9 years . .	0·5	0·49	
A child 2–5 years . .	0·4	0·36	
A child under 2 years .	0·3	0·23	

On this basis a child under 2 years of age would require 0·3 or $\frac{3}{10}$ of 3000 calories in the 24 hours—in other words, food of the value of 900 calories. A child between 2 and 5 years would require 0·4 or $\frac{4}{10}$ of 3000, or 1200 calories, and so on. These figures are very useful, but they are not exact enough for the purposes of accurate physiological feeding, for they make no allowance for intermediate requirements as the age advances from 1 to 2 years and from 2 to 5 years, and so on. There is a very considerable increase in the food requirements of a child 2 years old as compared with a child 1 year old, owing not only to the increase in the size of the child but also to the greater physical activity displayed. On the accompanying weight chart

I have plotted out on the right-hand side the food requirements for children of average age and average activities, etc., during the first, second, third, fourth, fifth, etc., year of life.

From 5 years of age until the time of puberty the curve of caloric requirements shows a continuous rise from 1600 to 2400 calories. Up to the age of 10 years there is probably little or no difference in the food requirements of male and female children, since they both play the same games and take, approximately, the same amount of physical exercise. From 10 years of age onwards their habits of exercise diverge, and boys play games which involve greater exertion than those usually indulged in by girls. It is impossible to emphasise too strongly that the one factor which pre-eminently determines the physiological requirement for food is the output of energy, which can indeed be measured in foot-pounds.

One calorie yields up energy to the value of 2975 ft. lb., so that for every foot-pound or kilogramme-metre of work performed so many calories or parts of calories must be expended. Girls after the age of 10 years will, as a rule, require less, by about 10%, than the amount stated in this diagram.

The question of basal metabolism has recently attracted much attention in America and elsewhere, for it is supposed to represent the food requirements of individuals remaining at complete rest in bed. A man, for instance, remaining under such conditions, is calculated to consume 70 calories per hour; if he sits up he consumes per hour 5 calories per cent. more, and so on, in accordance with the following table :—

TABLE 64

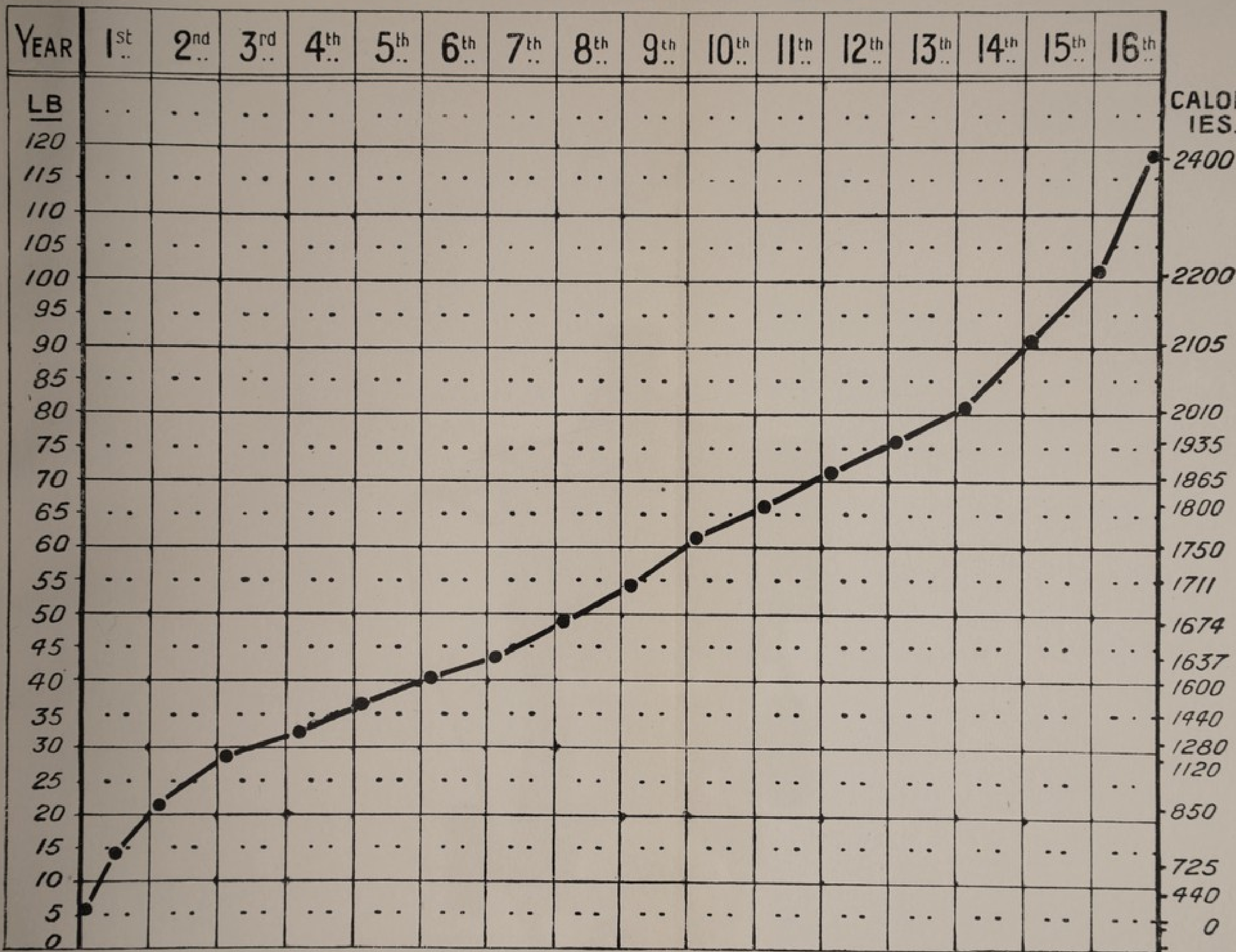
Caloric Expenditure according to Occupation in Case of Average Man weighing 154 lb.

Occupation	Increase in the Basal Metabolism Per Cent.	Total Metabolism Per Hour
Sitting	5	$70+3\frac{1}{2}=73\frac{1}{2}$
Standing relaxed . . .	10	$70+7=77$
Standing hand on staff . .	11	$70+7=77$
Standing leaning on support .	3	$70+2=72$
Standing "at attention" .	14	$70+10=80$
Working as a tailor . .	44	$70+30=100$

TABLE 65

CALORIE CHART

FROM 1st TO 16th YEAR OF LIFE.



The curve mapped out on this chart represents the average weights of children from birth to sixteen years of age.

The number of calories allowed per pound of body-weight ranges from 48 at the sixth month of life to 20 at the sixteenth year of life. At the commencement of the second year it is reckoned at 40 calories; at the eighth year it is 31 calories; at the twelfth, 25, and so on.

NOTE.—After the tenth year of life girls generally require 10% less food than boys of the same age. A corresponding correction should be made in the caloric values.

The left-hand side of the chart gives the average weight in pounds; on the right-hand side the number of calories.

Although these figures will be found of value they must be made the servant and not the master of the practical dietetist, and for one very good reason : these calculations have been made by placing the individual who is the subject of the experiment in the chamber of a calorimeter, where he is entirely cut off from the stimulating influences of a natural environment, such as sunlight, moving air, changes of temperature, surface evaporation and so on. Professor Leonard Hill has shown very conclusively that the metabolism of an individual at rest may be doubled by exposure to the stimulating effect of a cool breeze. No allowance for these considerations has been made in the calorimetric experiments on which these figures are based, neither has the influence of the intake of food, which, under the influence of surface stimulation, appears to cause a definite if temporary rise in the Co_2 output on which the rate of metabolism is based.

It is claimed that the basal metabolism of boys is 25% higher than in men of the same weights and sizes, but in view of the influence of other factors which modify metabolism so greatly—*i.e.* surface stimulation and the amount of work performed—this difference is probably not inherent. As I have already said many times in the course of this book, the one predominating factor which determines the physiological amount of food required is work—not age, sex, appetite or size.

When the dietaries of children are submitted to careful examination it is often found that, as compared to theoretical estimates, they are highly incorrect. Some are far too liberal, while others are quite insufficient. When such discoveries are made it would be extremely bad practice immediately to adjust the quantity of food to the physiological requirement without very careful consideration of the question from all points of view. Children who have been overfed habitually are very wasteful and uneconomical machines. An efficient human engine can utilise about $\frac{1}{6}$ of the potential energy of the food supplied for the purposes of mechanical work. Many an overfed human being does not and cannot utilise $\frac{1}{10}$. Such an extravagance imposes many strains on the system. There is incomplete combustion and a general choking up of the tissues with the semi-oxidised products. The difference in efficiency between an overfed and a physiologically fed child, as far as output of work is concerned, can be compared to the difference that exists between the output of the old-fashioned steam engine and that of a modern internal combustion engine.

If excessive dietaries are reduced at once to normal proportions the child's functions become disorganised, and he cannot do the work required of him; he loses weight, and probably becomes ill. On the other hand, it would be equally bad practice to allow such a child to continue to consume food which is sufficient for an individual doing heavy work, for by so doing a habit of wasteful expenditure may become very inveterate and ingrained, and parts of the machinery of the body may suffer from unnecessary wear and tear.

The digestive and metabolic habits of such a child require *re-education*, but the process must be slow and systematic. It may require weeks or months to effect the necessary change; but however long it may take, and however much trouble it may give, the change must be made if it is desired to do justice to the child's innate capacities. The scientific appeal to the criterion of caloric values and estimated bodily requirements enables the physician to deal authoritatively with such cases.

It is naturally difficult to estimate in calories the value of the food which should be consumed by any particular child. If, however, we know the number of calories required by an average child of the same age and weight we may, by making certain allowances for individual habits of life, arrive at a fairly correct estimate for the child in question.

Food is only required for four purposes—namely, for growth, for the supply of energy, for heat production and for the elaboration of certain bodily secretions; and of these purposes the requirements for energy production transcend all the others combined. If, therefore, we find that the child whose dietary we are arranging is highly active and energetic as compared with the average child, we may say at once that his food requirements are above the average. On the other hand a weak, sickly and listless child will require less, perhaps far less, than the average allowance. Again, the more rapid the rate of growth and the colder the climate or the surroundings, the greater will be the physiological demand for food. At the two extremes in the series we have firstly a very active, energetic child, growing rapidly and exposed to much external cold, requiring food considerably above the average, and secondly a weakly, sickly child, taking very little exercise, growing slowly, living a highly sheltered life and requiring physiologically a greatly reduced ration.

The quantitative requirements of children for food should be estimated on a caloric basis. It has been estimated that the caloric requirements of children under 2 years of age up to the time of puberty range from 900 to 2400 calories in the 24 hours. The most important factor in determining the food requirements is the actual amount of work performed. This one single factor outweighs all the others combined. In correcting or arranging the dietaries of children, previous feeding habits must be taken into consideration. Any change considered necessary must be slowly and deliberately introduced, for wasteful and extravagant habits of digestion and metabolism cannot be suddenly eradicated. The processes of re-education must be slow.

Balance.—One of the most keenly debated points in dietetics arises in connection with the ratio which should be maintained, under various conditions of age, environment and so on, between the amount of protein and of non-protein constituents of the food.

As far as children are concerned there are one or two physiological indications which may be relied upon to guide us in the adjustment of the *balance*. In the first place we know that during the first year of life, when an infant is fed naturally and when it may be assumed that the balance is physiologically correct, the ratio of the protein to the non-protein elements of the food is as 1 to 7. Now, although certain changes take place in the physiological habits of the child at the age of one year, when natural feeding ceases, these changes are not so considerable as to demand any revolutionary modification in the adjustment of the balance. The chief changes that occur at the time of weaning are connected with the evolution of the powers of mastication and with the evolution of habits of independent locomotion rather than with changes connected with rate of growth. The latter is not quite so rapid after weaning as before, and therefore, in accordance with the general principle that protein is specially required for tissue growth, the optimum quantity of protein should be less, not more, than during the earlier period—that is to say, other things being equal, the ratio of the protein to the non-protein elements of the food should be less than 1 to 7 and not greater. Again, with the development of walking powers, which begins at or about the twelfth month, a new demand for energy arises, and for this purpose carbohydrate food is well designed, so that two new factors are clearly introduced which rationally dispose to the reduction rather than to the increase of protein. It is not possible, nor indeed would it be expedient, to attempt to define the "optima ratio" too closely, but it may be assumed to be in the neighbourhood of 1 to 7.

In examining a large number of standard dietaries for children from 2 to 5 years of age, derived from different sources, I find that the protein-to-non-protein ratio does not as a rule fulfil these conditions. More often than not the ratio is as 1 to 3 or as 1 to 3·5. The reason for this failure to fulfil the physiological conditions is apparent. It is as follows. There is great difficulty in drawing up a correct dietary for the child between 2 and 5 if, as is usually the case, the diet consists largely of cow's milk, for in cow's milk the ratio of the protein to the non-protein constituents is as 1 to 2. Now if we accept 1000 calories as the basis of the food requirement of a child during the second year of life, and if we allow, in accordance with our national habits, a ration of something like 1½ pints of cow's milk, which has itself a caloric value of about 600, there only remains over a balance of 400 calories to be supplied by the addition of solid or other food. Now even if the whole of this remainder of 400 calories is supplied in the form of pure sugar it is still impossible to maintain a ratio of less than 1 to 4·5, and if instead of pure sugar a cereal or farinaceous food is substituted the protein excess becomes still greater. If, for instance, the whole of the 400 calories is supplied by bread, the ratio works out as 1 to 3·15. The inference to be drawn from this is that it is impossible to supply a correct dietary for a child during the second year of life if his dietary is allowed to include a larger quantity of milk than 1½ pints. Indeed it is very difficult to maintain a correct balance with more than 18 to 20 oz. On inquiry it will be found that the majority of children between 1 and 2 years of age belonging to the well-to-do classes consume 30 ounces of milk, often much more, and in other forms of food obtain about 600 calories, making a grand total of 1200 calories, representing an excess of at least 200 calories over the normal requirements: a very serious error when the faulty protein ratio is also taken into consideration. Children belonging to the poorer classes as a rule obtain far less milk, and in respect of the protein ratio enjoy a more correct balance, however much the diet may be at fault in other directions.

In the diet sheets which I have drawn up for children of various ages, and which appear at the end of this chapter, I have taken the factor of balance into account, but, inasmuch as the pursuit of the principles already enunciated conflicts very obviously with tradition and practice, I venture to warn those who use these tables that the public, who know nothing about balance or food values, will regard them as highly unsuitable and insufficient for the majority of children. Over and over again children are brought to me for advice in connection with recurrent attacks of migraine or bilious attacks, who obviously owe their troubles to an excessive dietary, and specially to excess of the protein element. These attacks disappear with mathematical certainty with a gradual reduction of the total dietary and a readjustment of the protein ratio, but so great is the faith of the average mother in the "strengthening" properties of "the large quantity," and especially of meat, fish, eggs and other protein foods, that the probability is great that after recovery the child will be brought back again for permission to return to the old "strengthening" dietary which was the original cause of the trouble.

In breast milk the ratio between the protein and non-protein elements of the food is as 1 to 7. For adults the physiological ratio is about 1 to 5·5 or as 1 to 6. There is no reason why, during the second and subsequent years of life, this ratio of 1 to 7 should be widely departed from. An examination of many dietaries for young children shows that in the majority of cases a ratio of something like 1 to 3 or 1 to 3·5 is maintained. This is due to a disproportionate amount of cow's milk in the dietary, and is quite wrong.

The Fat and Carbohydrate Balance.—Let us then fix the ratio between the protein and non-protein elements in the food for young children at about 1 to 7, and let us next consider what should be the ratio between the fatty and carbohydrate elements in the food. Long ago Voit fixed the ratio for the average adult individual at 1 to 10, or, to be precise, 56 to 500, and the actual amount of fat by weight at 2 oz., and the carbohydrate at 18 oz. for the 24 hours. It is doubtful whether this ratio should be maintained during any period of childhood. The fat-to-carbohydrate ratio in human milk is as 1 to 2. What is the reason of so high a proportion of fat? I am not aware that this question has ever been satisfactorily answered, but it is possible that a large proportion of fat is essential for the purposes of growth, or possibly it is required to supply soap necessary to form the basis of a soft stool. The relative digestibility of fat and carbohydrate is clearly a factor which must be concerned in fixing the ratio between these two elements. It is claimed that when a high non-protein food is required, as is the case when hard exercise is taken, if a high proportion of the calories is supplied by carbohydrates to the relative exclusion of fats the digestive resources are too severely taxed. This may be so in the case of adults, but as a matter of clinical experience it will generally be found that young children digest carbohydrates better than they do fats. As long as children can digest fats and carbohydrates equally well I am of the opinion that the fat-to-carbohydrate ratio of infancy—namely, 1 to 2—should gradually give place to the adult ratio, but this change should only take place very slowly. During the second year of life, when milk still forms an important element in the child's dietary, the ratio may be as 1 to 3·3. Later it may be fixed at 1 to 5 or 1 to 6, according to the conditions.

The correct ratio of fat to carbohydrates for breast-fed infants is as 1 to 2. For adults Voit fixed it at 1 to 10. As the child grows older the infantile ratio should only be gradually changed to that fixed for adults. During the second year of life it may be reasonably fixed at 1 to 3·3, and gradually approach a ratio of 1 to 5 or 1 to 6.

Mineral Constituents.—Mineral salts are such important elements in the constitution of the tissues of the body, and play so responsible a rôle in the maintenance of nutrition, that it is impossible to imagine that the supply of these elements in the food can be a matter of indifference. The mineral constituents of the body consist for the most part of potassium, sodium, calcium, iron and magnesium, in the form of phosphates, carbonates, sulphates and chlorides. These salts are very widely represented, though in very different proportions, in the various animal and vegetable substances which serve as food; indeed their distribution varies so much that were we to adhere strictly to certain articles of food we should inevitably overload the system with certain minerals and starve it in others. For instance, potassium salts exist in considerable excess in many vegetable foods, such as the pea, while sodium salts exist in large proportion in spinach. Meat and most of the leguminous vegetables contain only a small proportion of the very important metallic bases, calcium, iron and sodium. Inasmuch as cow's milk contains a considerably higher proportion of ash than human milk—namely, 0·7% as compared with 0·21%—it has readily been assumed that when cow's milk forms the whole or a large proportion of the total diet there can be no mineral starvation. As a matter of fact, the mineral constitutents of cow's milk are not so well absorbed as those of breast milk, a result which may be due to the fact that a larger proportion of the salts in breast milk exist in organic combination. It has been estimated that something like 80% of the ash in breast milk is absorbed, and that about 40% is retained in the system, while the salts of cow's milk are only absorbed to the extent of some 43% to 78%, and retained to the extent of 43% or less. The great defect in cow's milk, from the point of view of ash, consists in a deficiency of iron. There is only half as much iron in cow's milk as there is in human milk, and this deficiency is obviously made greater when cow's milk is diluted with water. This is a matter of considerable importance in the case of children who depend exclusively on cow's milk for their food, but it is probably a matter of little consequence in the case of older children, living on a mixed diet; indeed, most children over two years of age consume too much rather than too little iron in their food. It is quite possible on certain mixed diets to make very considerable mistakes in the mineral balance. For instance, a diet consisting of meat, potatoes and farinaceous foods contains a very low percentage of the three most important of the mineral elements—namely, calcium, sodium and iron. Cow's milk possesses a very high mineral content as compared with many of the foods which bulk largely in the diet of civilised people, so that when a child's diet changes from cow's milk to a mixed one there may be a risk, if only by contrast, of bringing about a relative mineral starvation. It is very difficult to compare the mineral content of a liquid such as milk with that of a solid such as bread or flour. The only satisfactory way of obtaining a common basis of comparison is to reduce all foods which are to be compared to the same solid state by subtracting the water. The total ash of dried milk and other common articles of diet are, after being reduced to the dried state, given in the following tables in a manner in which they can easily be compared.

TABLE 66

Dried cow's milk	contains approximately	6·0 per cent. of ash
Dried human milk	,, ,,	1·5 ,, ,,
Dried meat	,, ,,	4·0 ,, ,,
Dried flour	,, ,,	0·47 ,, ,,
Dried potato	,, ,,	3·7 ,, ,,

A diet which consists chiefly of bread, with the addition of a small quantity of meat and potatoes, contains not only a total deficiency of mineral elements but also a wrong balance of such as may be present. It is indeed of equal importance that the relative proportions of the important mineral elements—namely, calcium, iron, sodium, potassium, phosphorus, and so on—should be in approximately correct balance. It is quite easy to fall into the error of providing a dietary which, if monotonously adhered to, may afford a noticeable deficiency of some particular mineral element which may be highly essential for the purposes of growth or the maintenance of nutrition. It is therefore of some importance to have a knowledge of the particular class of foods in which certain elements predominate or in which others are poorly represented. An idea of the total mineral content of various foods (in the dry state) may be gathered from an examination of the accompanying table, remembering always that these foods contain varying proportions of water, and that in the amounts commonly consumed they will afford very different totals of ash.

TABLE 67

Apples	contain approximately	0·4 per cent. of ash
Beef	,, ,,	0·8 ,, ,,
Carrots	,, ,,	1·0 ,, ,,
Cheese	,, ,,	2·6 ,, ,,
Fish	,, ,,	1·2 ,, ,,
Green peas	,, ,,	0·9 ,, ,,
Jerusalem artichokes	,, ,,	1·1 ,, ,,
Lentils	,, ,,	2·9 ,, ,,
Oats	,, ,,	3·0 ,, ,,
Oatmeal	,, ,,	1·9 ,, ,,
Onion	,, ,,	0·6 ,, ,,
Orange juice	,, ,,	0·4 ,, ,,
Peas, dry	,, ,,	2·6 ,, ,,
Rice	,, ,,	0·2 ,, ,,
Strawberries	,, ,,	0·7 ,, ,,
Tapioca	,, ,,	0·1 ,, ,,
Turnips	,, ,,	1·1 ,, ,,
Vermicelli	,, ,,	0·8 ,, ,,
Wheat meal	,, ,,	1·2 ,, ,,
Wheat flour	,, ,,	0·8 ,, ,,

A good proportion of iron is contained in spinach, yolk of egg, beef, strawberries and potatoes, while there is little or none in butter, cheese and white flour. Calcium is well represented in milk, eggs and cereals, though poorly in meat, fish and potatoes. Sodium is present in abundance in spinach, meat and strawberries, and in poor quantity in flour, peas and potatoes. Potassium is well represented in potatoes, peas and meat, but poorly in white flour. The amount of phosphorus is large in milk, meat, spinach and eggs. In the following table (taken from Lahmann's *Natural Hygiene*) the approximate percentage of the various metallic elements present in a few common varieties of food are given :—

Table 68

Mineral Elements in various Dried Foods

100 Parts of the following Foods reduced to dryness contain	Total Ash	Potash, K_2O	Soda, Na_2O	Lime, CaO	Magnesia, MgO	Oxide of Iron, Fe_2O_3	Phosphoric Acid, P_2O_5	Sulphuric Acid, SO_3	Silicic Acid, SiO_2	Chlorine, Cl
Cow's milk .	4·84	1·204	0·473	1·066	0·149	0·026	1·388	0·015	0·002	0·667
Meat . .	4·06	1·676	0·147	0·115	0·130	0·028	1·727	0·063	0·045	0·156
White flour	0·47	0·169	0·004	0·013	0·039	...	0·245	...	...	...
Rye flour .	1·97	0·757	0·034	0·020	0·157	0·050	0·951	...	...	...
Potato .	3·77	2·276	0·099	0·097	0·177	0·045	0·653	0·245	0·080	0·117
Pea . .	2·73	1·141	0·026	0·136	0·217	0·016	0·995	0·095	0·024	0·042
Spinach .	16·48	2·729	5·816	1·958	1·051	0·552	1·689	1·132	0·745	1·022
Apple . .	1·44	0·514	0·376	0·059	0·126	0·020	0·196	0·088	0·062	...
Strawberry .	3·40	0·716	0·968	0·483	...	0·200	0·470	0·107	0·410	0·048

A consideration of these facts leads to certain conclusions. From the point of view of the total mineral supply it is unsafe to rely on a one-sided diet. With a diet consisting chiefly of bread and meat, even if fat, potatoes and milk be added in fair proportion, the deficit of all or certain salts will not be made good. The combination of an ample supply of fruit and vegetables is highly desirable, and may correct the defect. In order that there may be no preponderance of any one particular mineral element, such as calcium, sodium or potassium, to the exclusion of others, variety in the choice of fruits and vegetables is most desirable.

The chief faults in respect of mineral balance noticeable in the average dietary are a deficient content of sodium and lime, with an excess of potassium, iron and phosphorus in the food consumed, faults which possibly and probably cannot be corrected by the compensatory consumption of sodium and calcium in independent inorganic combination, as, for instance, by adding common table salt for cooking purposes or by drinking large quantities of table waters well mineralised with lime. Although the scientific evidence in this matter is not very conclusive, there appears to be considerable agreement among dietetists as well as among physiologists that mineral elements are better utilised by the tissues when they are in organic combinations than when they are supplied as inorganic salts. It is somewhat difficult to understand why this should be the case, for all such organic combinations must, under normal conditions, be broken up in the stomach by the gastric juices and particularly by the contained hydrochloric acid, and thus reduced to the status of inorganic salts.

Salts are very important elements in the dietaries of children. When the diet changes from a milk to a mixed one there is a risk of a falling off in the mineral supply, especially if the diet is mainly of a farinaceous nature. The balance between sodium, potassium, calcium, iron, magnesium and other salts should be maintained on a physiological basis. This is more likely to be secured by a mixed and varied diet than on a monotonous and non-varied diet. For instance, a diet composed of meat, leguminous vegetables and potatoes is deficient in sodium and calcium. Most dietaries of town children are deficient in the total ash. An ideal dietary should contain a larger proportion of green vegetables and fruit than is usually provided by the ordinary diet of civilisation.

VITAMINES, EXTRACTIVES, LECITHIN BODIES, WATER, ETC.

A certain proportion of all of these foods is essential, or at least beneficial, for nutrition, and no doubt in the near future we shall have a better knowledge of their exact significance than we have at the present time.

Vitamines.—The name vitamine has been applied provisionally to certain indefinite substances which are present in most fresh foods, and which are necessary for the maintenance of nutrition. The exact action of these bodies is not known. They apparently have properties which, while not exactly those of foods, at least produce harmonious interaction between materials in the food and the person who consumes them. These vitalised bodies exist in considerable quantity in rapidly growing vegetables, and to a lesser extent in milk and animal flesh. If the diet is restricted to articles of food which contain little or no fresh fruit or vegetables certain symptoms of malnutrition develop to which the name scurvy has been given. Symptoms of scurvy used to supervene among sailors in the old days of long voyages in sailing vessels, during which they were compelled to subsist on foods which had been preserved in salt or by other means, and which were entirely or partly deprived of their vitamine content. We are familiar with the same result at the present day when infants are exclusively fed on proprietary or patent foods which have been kept or preserved for any length of time. Symptoms will also develop if infants are fed on an exclusive diet of milk which has been too much boiled or preserved too long by artificial means. Symptoms of scurvy are not liable to occur amongst individuals who live on mixed dietaries, for the latter almost invariably contain some element of fresh food with a good anti-scorbutic vitamine content. Symptoms of neuritis sometimes break out in epidemic form amongst coolies or other Asiatics who subsist mainly on a diet of polished rice. This kind of rice contains only a small content of the so-called anti-neuritic vitamine, because this vitamine is contained for the most part in the external parts which are removed in the act of polishing. It is highly probable that many different kinds of vitamines exist in different kinds of food. The disease due to the eating of polished rice, which is known as beri-beri, is due to the want of a vitamine to which the epithet anti-neuritic has been given to distinguish it from the vitamines for want of which scurvy is produced and which are generally known as anti-scorbutic vitamines. Another vitamine, known as the fat-soluble "A" factor, is contained in animal fats (see pp. 161 and 478).

Vitamines, though essential elements in the dietary, are not likely to be absent from a mixed diet which contains any fair proportion of fresh fruit or vegetables. Their exact nature is not at present known. Children subsisting mainly on patent foods and milk artificially preserved are liable to suffer from scurvy or other nutritional diseases due to want of vitamines.

Lecithin Bodies.—These bodies belong to the class of lipoid substances which, with respect to their solubilities, closely resemble fats. Lecithin breaks down, under the influence of disintegrating agencies, digestive or otherwise, into the following bodies:—glycerol, oleic acid, phosphoric acid and cholin. Lecithin bodies appear to play quite important parts in nutrition, especially in connection with the development and maintenance of nerve tissues and red-blood cells. The distribution of lecithin in food is extensive. It exists in milk and is present in abundance in the yolk of egg. Although it is possible, and even probable, that infants subsisting on an exclusive diet of diluted milk may suffer from deprivation of their fair share of lecithin bodies owing to the fact that they are present in cow's milk in smaller proportion than in breast milk, none the less it is improbable that older children, especially those whose diet includes eggs, are likely to suffer from any deficiency.

Lecithin bodies play an important but ill-defined rôle in nutrition, mainly in connection with the development and maintenance of nerve cells and red-blood corpuscles. In a mixed diet it is improbable that they will be deficient in quantity.

Extractives and Purin Bodies.—These substances are found chiefly in soups, gravies, meat extracts, tea, coffee and cocoa. Their main function appears to be of a stimulating character. Of recent years they have come under most undeserved odium for wholly unconvincing reasons. To them have been attributed symptoms of migraine and other manifestations of ill health more probably due to intestinal toxæmias. The class of individuals for whom extractives are unsuitable are those in whom the metabolic processes are defective owing to chronic intestinal inefficiency, and in whom purin bodies are likely to be manufactured in excess whether or not adventitious extractives or purin bodies are supplied in the dietary. There can be little doubt that for ordinary healthy individuals with normal metabolic processes a reasonable quantity of these bodies are not only non-hurtful but even advantageous as stimulants to nutrition. For this reason there is no reason to exclude entirely from the dietary of normal children a moderate supply of soups, broths, gravies and cocoa. It may be questionable from other points of view whether it is desirable or not to allow children under ten years of age to partake regularly of tea or coffee.

Extractives, with the exception of tea and coffee, are, as a rule, found to be useful additions to the dietary of young children; they need not, however, be supplied in large amount.

Water.—It must not be forgotten that water is one of the most important elements, possibly the most important single element, in the dietary. At any rate an individual will die sooner from privation of water than from privation of any other element in his dietary. The amount of water which should be consumed daily by the average child will differ with circumstances. A baby under one year of age and fed under natural conditions consumes from 1 to 2 pints in the 24 hours. An ordinary adult individual usually consumes from 3 to 4 pints. Children require from 2 to 3 pints during the day.

The time at which water should be consumed is a controversial question. It would be unwise to dogmatise in this matter, for habit plays a most important part in determining what is best for the individual. It is difficult to claim that there are any advantages to be expected from greatly diluting the gastric juices by imbibitions of water at meal-times, and there are certainly advantages in washing out the stomach at the end of a period of gastric digestion before the commencement of the next meal. Therefore, unless there are indications to the contrary, I recommend the surplus requirements of water, over and above the amount necessarily taken with the food, to be given about one hour before meal-times. A small quantity of water taken early in the morning, about an hour before breakfast, is as a rule very beneficial to the health of children.

Water is a most essential element. Not less than 2, nor more than 3, pints should be consumed by children in the 24 hours, including that which is necessarily present in the food. Water is preferably drunk by children about one hour before meals.

The Choice of Food from the Point of View of Variety, Taste, Cooking, Digestibility, Absorbability and other Physical Qualities.— In the previous sections the balance or ratio between proteins, carbohydrates, fats and other food elements has been briefly considered. No attention, however, has been paid to the exact form in which the essential elements of a dietary should be supplied. It would be very easy to draw up a dietary of any desired combination or balance if the ordinary table foods were pure proteins, fats, carbohydrates, etc., but unfortunately nearly all the common varieties of food are mixtures. For instance, bread contains 48% of carbohydrate, 7% of protein and 0·2% of fat; again, average beef contains 15% of protein and 15% of fat; while cheese consists of 25% of protein, 33% of fat and 2·4% of carbohydrate; and eggs contain 11% of protein and 9% of fat. On the other hand, some foods in common use may be regarded as almost pure; for instance, sugar is a pure carbohydrate, butter is practically a pure fat, while white of egg is a pure protein, containing about 10% of albumin. Even with this factor of admixture or impurity to complicate the calculation, it would be comparatively easy to draw up a properly balanced dietary from foods in everyday use had we not to take into consideration the further factors of taste, digestibility, absorbability, variety, and so on. These complications make the task of the rational dietetist exceedingly difficult (see Table 89, p. 463).

Choice and Variety.—With a good mixed diet serious mistakes in balance or other respects are less liable to be made than when a strictly uniform diet is adhered to for any prolonged period of time, for in such an event any defect, omission or redundancy with respect to the contained elements is cumulative in its effects. With a reasonably varied diet, if mistakes are made in individual meals or on individual days, they tend to become neutralised or balanced by different mistakes on other days. Further, variety in the diet has the additional advantage of stimulating appetite, promoting digestion and developing the digestive and metabolic resources of the individual. Amongst the chief faults in the food habits of this country are want of resource in the choice of raw foods and want of ingenuity and variety in the methods of cooking. Our conservative habits have led us to stereotype certain dietetic customs for which little justification can be found. In support of this statement I would refer to the dietetic inconsistencies which are to be found from an examination of the average breakfast eaten by the children of the better classes. As a rule such a breakfast consists of milk or milk and cocoa, porridge with milk or cream, egg and bacon or fish. In addition to this, bread and butter is usually consumed, and a certain amount of marmalade or jam. Quite apart from the fact that such a combination will be found on examination to violate the physiological principle of balance to such a degree that compensation is almost impossible at the remaining meals, the quantities usually eaten provide almost a sufficient number of calories for the whole day's needs. The advantages of porridge are very equivocal : it is certainly a cheap food and a favourite one with children ; on the other hand, it is a pappy food which teaches them to swallow insoluble carbohydrates without previous mastication, and it also contains, or at least the coarser varieties do, small husks which are liable to cause irritation of the sensitive mucous membrane of the bowel. If oatmeal is considered a valuable flour for consumption it had far better be supplied in the form of oatcake or oatmeal biscuits, which encourage mastication. Bacon, and especially fried bacon, is a highly indigestible form of meat. It is the stalest variety of animal food that is allowed to appear on the table. The flesh of the pig, owing to the animal's feeding habits, is probably less desirable as a food than that of any other. It is usually converted into bacon by pickling in well-used, if not actually dirty, tubs of brine, and after pickling, the meat is suspended in a chimney or some other place where it is exposed to the fumes of burning wood; it is then allowed to remain exposed to contamination in the grocer's shop, and finally, before consumption, it is burnt to a cinder in a none too clean frying-pan. Further criticism can be applied to the marmalade—one of the most popular preserves in the nursery and schoolroom—for it contains particles of orange peel, which under no other circumstances would be allowed to be consumed for fear of causing intestinal trouble. A breakfast constituted on these lines affords a deficiency of organic salts and generally almost a complete absence of vitamines, and, as has already been mentioned, it lacks variety. The French breakfast, with modifications, is far more rational. A cup of milk flavoured with cocoa or chocolate, with toast or bread and butter and fresh or stewed fruit, is an excellent breakfast, and free from all the objections above referred to. It will not, however, satisfy the average ideas with regard to the constitution of a good breakfast. Not one lay individual in a hundred can believe that a simple breakfast consisting of milk, bread and butter and jam is as "strengthening" as another one consisting of meat, fish, egg, porridge and various other etceteras.

Dinner.—As a rule the dinner or midday meal has a better balance, and is more satisfactorily arranged. It consists for the most part of meat, fish or poultry, with vegetables, stewed fruit and a milk pudding. The chief criticisms that one has to direct against the average British dinner are as follows:—(1) too much meat is given; (2) potatoes are given in excess and there is not a sufficiency of green and leguminous vegetables; (3) the vegetables are as a rule so cooked as to deprive them of most of their organic salts; (4) the second course consists too frequently of pappy or liquid pudding, and not often enough of foods or sweets which require mastication; (5) there is a notable deficiency of fresh or cooked fruits.

In making a selection of the foods to be given at the midday meal it is quite a useful plan to arrange for butcher's meat twice a week, for fish twice a week, for eggs twice a week and for poultry or rabbit once a week. This gives sufficient variety. For a child between one and two years of age quite a small quantity of any one of these protein foods is adequate; it is clearly impossible to define exactly how much should be given. At the commencement of the second year of life, when the child has only just given up a fluid dietary, very small quantities are sufficient. A teaspoonful, or even half-a-teaspoonful, may be as much as it is safe to give in the first instance; there should, however, be a gradual increase in the quantity as the child grows older and becomes accustomed to his new dietary. At or about the 18th month a small egg provides a sufficient quantity of protein—a moderate-sized one weighs from $1\frac{1}{2}$-2 oz. If meat or fish be given the equivalent is about one tablespoonful. Since it is of the greatest importance that children should learn to masticate protein varieties of food it is inadvisable to follow the usual habit of mincing the meat or fish which is given to young children. It would, of course, be dangerous to give large pieces of meat to children if they were swallowed without mastication, but it should be the duty of the nurse or mother to make every effort to induce the child to perform the mincing witd his own teeth.

As regards vegetables, the amount of potato should not be excessive: $\frac{1}{2}$ oz. to 1 oz.—that is to say, about a tablespoonful—is quite sufficient; for preference potatoes should be boiled in their skins so as to avoid loss of organic salts and of that valuable part of the tuber which lies immediately under the skin, which is sometimes wasted. New potatoes should be avoided for young children, unless they are very carefully mashed. The best vegetables for quite young children under two years of age are vegetable marrow, cucumber (boiled), Jerusalem artichokes, brussels sprouts, tender young cabbages (very well boiled), cauliflower, onions and asparagus. Tubers, such as carrots, turnips or parsnips may be given to young children if they are sieved or used as the basis for *purées*. Leguminous vegetables such as peas, beans and lentils are extremely valuable as foods, especially from the point of view of their protein content, but even when well boiled and sieved they are not very easily digested and utilised ; I do not recommend them for frequent use in the case of children under eighteen months or two years of age. Tomatoes, scarlet runners, French beans, celery, sea-kale, spinach and beetroot should be given with very great caution to young children, while mushrooms, capers and truffles should be excluded altogether from their dietary. A special warning should be uttered in the case of spinach, which is such a highly popular vegetable in the nursery, as well as in the parlour ; it is appreciated chiefly on the grounds of its remarkably high mineral content. This very distinct advantage, however, is entirely neutralised by the resistance offered to digestion by the cellulose basis of the leaf. If the stools of children be examined after meals containing spinach, practically the whole of the spinach can be discovered in a completely undigested state. On the other hand, the juice of spinach is valuable as it contains a rich quantity of organic salts ; if this can be expressed from the boiled leaf by squeezing through very fine butter cloth in such a way as to remove all the solid parts it may be safely given with gravy or other vegetables. The amount of these different vegetables which should be given will vary with the kind, with the age of the child and with his digestive capacity. The caloric value of some of the common varieties will be found on referring to Table 89, p. 466. The value of brussels sprouts is about 6 calories per oz., that of cauliflower about 9, of vegetable marrow $2\frac{1}{2}$, of carrots about 13, of parsnips 15, of Jerusalem artichokes 23, of onions 13, and of peas 24. In the diet sheets given at the end of this chapter allowance is made for vegetable food, apart from potato, to the value of 10-13 calories in the 24 hours, this would mean about 1 oz. of carrot, 2 oz. of brussels sprouts, $1\frac{1}{2}$ oz. cauliflower, and so on. A heaped table-spoonful may be reckoned as about equivalent to 1 oz.

As already mentioned, one of the worst faults in our dietetic habits is that of giving carbohydrate food in the form of paps rather than in a solid state on which the child can exercise his masticatory powers. This applies particularly to the custom of giving milk puddings as the second course at dinner. Solid forms of carbohydrate food, such as pastry, biscuits, cakes, shortbread, etc., are usually taboo at dinner in the British nursery, and for no sufficient reason. Pastry is in many ways an excellent form of food ; it has a good carbohydrate-fat ratio, and also a good protein-non-protein ratio. It requires mastication and is much appreciated by children; in fact the only valid objection to its consumption is that children like it too well and eat too much of it. I regard a fruit pie as one of the very best forms of sweet that can be selected for the second course at dinner, especially if care is taken that the pastry does not become so sodden in the cooking as to obviate the necessity of chewing. Fruit puddings are, from the dietetic point of view, equal to fruit pies, but they have the disadvantage that the crust does not require the same amount of mastication and is liable to be swallowed whole. As an alternative to fruit pies and fruit puddings, stewed fruit may be supplied, with biscuits, rusks or cake. Most fruits in pies or puddings are suitable for children over five or six years of age. To younger children those fruits which contain seeds, pips or skins, such as currants, raspberries or plums, should be given with caution, since they are apt to cause irritation and finally chronic catarrhal conditions of the bowel. Stewed fruit such as prunes should be given to the extent of about 1 oz. to 2 oz. for a child about eighteen months of age; such an amount, owing to its large sugar content, affords from 50 to 100 calories. An average plain cake has a caloric value of about 104 calories per oz., and biscuits about 120. The caloric value allowed in my tables for the pudding is about 88-130 calories, so if cake or biscuit is substituted for it about $\frac{3}{4}$ oz. of either should be allowed—that is to say, a 1 lb. cake should be enough for nearly twenty children under two years of age.

Tea.—The tea meal should be arranged on much the same general plan as breakfast for children under six years of age—that is to say, it should consist of 6-8 oz. of milk flavoured with cocoa, chocolate or Ovaltine. At a later age tea may be introduced if thought desirable. Variety in the carbohydrate food may be introduced in the form of combinations of plain cake, scones, tea cake, rusk, biscuit or shortbread. Fat should be confined to butter or margarine, and the stewed fruit or jam should, in the case of children under five years, consist of any of the varieties which do not contain seeds, pips or skins. Honey or treacle may be given occasionally as an alternative, but since they contain about 70% of sugar they should be given in smaller amount than in the case of jam or stewed fruit. The objection to honey or golden syrup is that both tend to give children an undesirable taste for sweets; from the food-value point of view they have nothing to recommend them in preference to such insoluble carbohydrates as bread, except that they are, since they require less digestion, more readily assimilated. As children grow older it may be thought desirable to make the meal somewhat more substantial than that recommended for children under six years of age; the degree of substantiality must be made dependent on the character of the supper or last meal. Quite a light tea will serve if the supper is made a meal of importance; on the other hand, if the supper consists—as in my opinion it should consist—of little more than broth or jelly, or if it is omitted altogether, then the tea must be made a more serious meal.

Supper.—For the majority of children three meals a day are probably the best arrangement, but submission must be made to habit and custom. In most middle-class and lower-class families supper has become such an established institution that it is almost impossible to induce parents to allow their children to go to bed without it. As a compromise I have for a long time past advised that for young children the last meal should consist either of a cup of soup or a small quantity of calves' foot jelly. Both of these have the advantage of giving the stomach little work to do during the sleeping hours and of supplying, in the gelatine they contain, a good fixer of hydrochloric acid, which often, by reason of its presence in excess in the stomach, gives children a feeling of hunger which keeps them awake. The practice of eating biscuits or other carbohydrates immediately before going to bed is undesirable for children under six years of age who have not learned how to clean their teeth properly. Cow's milk also has disadvantages when taken the last thing at night, because it is indigestible, and may cause restlessness, or even night terrors. The food value of clear soups or broths is very small unless some more solid addition in the way of pulses, leguminous vegetables, flour or milk is added. The food value of calves' foot jelly is almost negligible unless sugar is added for sweetening purposes. The caloric value of jellies may be brought up to almost any required degree by this latter means, undue sweetness being corrected by the addition of lemon juice.

Digestibility.—This very elastic and much-abused term requires consideration, but by digestion is properly meant the conversion of solid or other unabsorbable foods to a condition, fluid or otherwise, which is capable of absorption. Thus protein foods in the process of digestion are reduced to the condition of peptones, poly-peptides or peptides; starches are reduced to the condition of monosaccharid sugars; sucroses such as cane-sugar are inverted—that is to say, reduced to the condition of monosaccharid sugars (dextrose, lævulose); fats are split into fatty acids and glycerine. If these changes, which render foods absorbable, are not brought about in the case of any articles of diet by the processes of digestion we are entitled to say that such foods are not digested—or, in other words, that they are indigestible—but this does not necessarily mean that symptoms of indigestion need supervene; far from it. Many foods which we habitually consume are not in this sense digested at all, and yet do not give rise to any symptoms. On the other hand, there are foods which we commonly eat, and many liquids which we are in the habit of drinking, both of which may give rise to symptoms of indigestion even though they normally require no digestion before they can be perfectly well absorbed. For instance, lemon juice, which requires no digestion, may give rise to symptoms of pain and indigestion, and many other fruit juices may bring about the same result. The symptoms we commonly ascribe to indigestion are for the most part those connected with disturbances of the motor functions of the alimentary tract, brought about by over-stimulation or irritation, and not necessarily by foods or other substances which can be correctly described as indigestible. I refer to such symptoms as nausea, vomiting, gastric or intestinal pain (dysperistalsis), wind or colic (generally intestinal spasm), diarrhœa, etc. Such over-stimulation may be dependent on quantitative just as much as on qualitative faults in the food, and thus a food which in itself may be readily digestible may, if given in excess, deserve the epithet indigestible just as much as another food which is truly insoluble in the alimentary tract.

When consumed foods are not converted by the processes of digestion into their normal end-products they are liable to become decomposed by bacterial agencies, with the production of acid or gaseous bodies which cause irritation of the mucous membrane of the intestinal tract, and thus give rise to symptoms of indigestion. When food in excess of the digestive capacity is eaten part of it will be thus wasted, and hence the quantitative factor again comes into play. Foods that are too rich also may give rise to nausea or actual vomiting; the exact significance of the term "richness" is also a matter that is open to different interpretations. Richness may mean that the food is too irritating to the mucous membrane of the stomach and thus brings about the natural reaction of rejection, or it may mean that even after disintegration by mastication and gastric movements the food particles are so coated with fat that the normal digestive ferments cannot get into contact with the protein elements which should be digested, and thus again give rise to the necessity for rejection from the stomach by the act of vomiting. A further possible explanation is that when the food contains too much fat there is a tendency to regurgitation of bile and a fat-splitting ferment lipase from the duodenum into the stomach through the pyloric orifice, and this itself may predispose to vomiting. Two or more foods, each independently quite digestible, may collectively or in combination give rise to symptoms of indigestion owing to chemical reactions which may occur between them. Thus oranges eaten after taking a glass of milk may cause vomiting owing to the sudden precipitation of casein curds in the stomach. The two halves of a seidlitz powder taken independently may, by their interaction in the stomach and consequent liberation of carbonic acid gas, give rise to gastric distension, pain and other symptoms of indigestion. We must therefore be careful to qualify the term "indigestion" when we apply it to the results which follow the intake of certain articles of diet, or otherwise foods which are quite digestible in themselves may undeservedly come under the ban of forbidden articles of diet. From the practical point of view we must be guided by results rather than by theories. If any particular food causes, in any particular child, symptoms of indigestion, this food may have to be eliminated from the dietary, no matter how digestible it may be on theoretical grounds. On the other hand, there are many foods which produce no signs of indigestion but which must necessarily cause injuries for the reason that they are absolutely incapable of being digested, and because they must cause mechanical irritation of the delicate mucous membrane of the intestine; I mean such foods as consist of insoluble and coarse cellulose tissues, such as capers, mushrooms, currants and raisins, and such fruits as strawberries, raspberries, gooseberries and mulberries, which contain hard and resistant seeds, or such fruits as plums or greengages, which possess hard and indigestible skins. Baked potatoes, which possess absolutely indigestible skins, and such foods as coarse porridge, which contains small but particularly irritating husks, should also be given with caution. Certain foods which fall into one or other of the above categories are often given to children suffering from constipation because, owing to the irritative effect of the indigestible part, they give relief to the symptom. I have even known millet or canary seed to be given for the express purpose of relieving the symptoms of constipation. Chronic colitis or enteritis are among the commonest complaints of childhood ; both of these conditions can be caused or kept up by irritation due to indigestible particles such as those above referred to. It would be pedantic in the extreme to proscribe all foods containing indigestible, and presumably irritative, elements such as seeds and skins from the dietaries of adults or adolescents, but until the mucous membrane of the intestinal tract has acquired some degree of tolerance to such irritants they should only be permitted under exceptional circumstances. Children under six years of age are extremely susceptible to intestinal irritation, and it is a safe rule never to allow them to consume any fruits containing seeds, skins or pips, or any vegetables with much tough cellulose fibre, such as celery, cucumber or beetroot. The systematic examination of the stools of children reveals the follies of parents and the limitations in the digestive capacities of children. It is a very common experience to find the cores of apples, the skins of baked potatoes, the stones of plums and grapes, the peel of oranges, as well as large pieces of citron, mushrooms and celery, whole capers and currants, and the residuum of other indigestible vegetables. Material of this kind seldom causes immediate symptoms of indigestion, which is perhaps regrettable, for the reason that did such symptoms supervene at once undesirable articles of food of this kind would soon be eliminated from the list of those which are considered permissible. The results of chronic irritation by indigestible matter of this kind are inevitable, although perhaps long deferred. We may then classify as indigestible all those foods which by reason of their irritative qualities cause immediate symptoms of indigestion, as well as all those other foods which lead to the more chronic and more serious forms of enteritis and colitis, owing to the mechanical and insidious injuries they inflict on the mucous membrane of the alimentary tract.

It must be remembered that the intestinal tract is very susceptible to certain forms of irritation, and is well guarded by the stomach with its mechanisms for rejecting food. This protective mechanism can, however, thus give rise to so-called symptoms of indigestion when it is unduly strained, over-developed or too sensitive. Cardio-spasm (spasm of the cardiac sphincter of the stomach) and pyloric spasm are two instances of over-sensitiveness or over-action of such mechanisms. Children whose digestive functions have been properly educated during infancy and during the early years of life seldom suffer from symptoms of chronic indigestion connected with disturbance of motor function unless the quantity of food supplied is greatly in excess of the physiological limits at any particular moment, and provided also such food is of the simple character adhered to in the diet sheets supplied at the end of this chapter. They may have acute attacks of vomiting or diarrhœa, but these will probably represent the calling into play of protective mechanisms, and deserve to be regarded as expressions of physiological efficiency in the face of threatened danger rather than as pathological manifestations.

All indigestible foods do not cause symptoms of indigestion, neither are all foods which cause such symptoms necessarily indigestible. Most of the recognised symptoms of indigestion are due to perverted motor functions such as cardio-spasm, pyloric spasm, dysperistalsis, entero-spasm, etc., and are caused by the excessive quantities of otherwise digestible varieties of food.

APPETITE, TASTE, IDIOSYNCRASIES, HABITS, ETC.

Appetite.—Appetite is an expression of the needs of the body for food. It is a symptom, however, which can easily be misread. The stomach may require food to silence unsatisfied cravings as in *hyperchlorhydria*, a condition in which there is an excess of hydrochloric acid ; or again, the tissues may require to be replenished with food owing to the fact that they are depleted of existing reserves. There may also be a craving for food because the tissues are themselves unable to use the food material already supplied to them in excess, as in diabetes. There may also be hunger from nervous exhaustion or from liver disturbances, while in the case of infants most feelings of discomfort are interpreted as hunger, to which babies readily give expression by stuffing their fists in their mouths or by other manifestations. Pangs of hunger, unless they really represent requirements on the part of the body for sources of energy needed for the performance of useful work, are blind guides which, if acted upon, are destined to inflict injuries of many kinds, as is well known in cases of hyperchlorhydria and diabetes. The only reliable way to avoid dangers due to misinterpreted sensations of hunger is to study caloric values, bodily requirements and output of work. When we see, for instance, a lanky boy of sixteen sleeping over his lessons and a truant from the playing fields, sallow of face and irrepressible at meals, if we possess a proper understanding of food values and of the law of the conservation of energy, we shall not be misled into believing that this boy's requirements for food are such as to demand extra rations. At the time of puberty special hormones are liberated by the secretory activity of the testes and circulate in the blood of the growing boy. These internal secretions stimulate metabolism and give the boy an extremely keen appetite. It has been estimated by Du Bois that the basal metabolism of boys of 12 years of age is 25% higher than for an adult of the same weight and size. This observation has led to the unfounded belief that growing boys ought to be given more food than grown men. This is a fatal mistake. Basal metabolism is not the same thing as caloric requirements. Caloric requirements depend on basal metabolism, but still more on the output of work. A boy's diet, like everybody else's, should be based on the work he does, and not on appetite or capacity to indulge it, and certainly not on his somewhat increased basal metabolism. It is quite possible that a very large number of children who are taken for medical advice owing to the fact that they have lost appetite are really suffering from an already excessive intake which they cannot put to physiological use. Loss of appetite is a most trustworthy means of defence against the *luxus* consumption of food which is not required. In inquiring into the case of children who have lost appetite the first step to take is to estimate the caloric value of the food which is or has been consumed at legitimate as well as at illicit meals. Then a rough calculation should be made of the physiological requirements by inquiring into the average output of work—making full allowance for age, habit and other factors in the environment. It is often found that children between 5 and 7 years of age, and with an estimated requirement of food of about 1500 to 1700 calories *per diem*, are, in spite of a want of appetite, taking some 2000 to 2500 calories *per diem*, a feat which may very readily be accomplished if a child—as is so often the case—consumes an unconsidered trifle of a pint or two of milk in the 24 hours, which alone may represent some 800 calories. Appetite is a physiological sensation which should be courted and fostered in children; no child can be regarded as reasonably healthy and normal unless he sits down to meals with a good appetite for plain food. A child who has to be coaxed and pampered with delicacies, spices and richly seasoned dishes is not, and cannot be, in a healthy condition. Long intervals between meals, no "snacks," plenty of outdoor exercise and plain food are the secrets of a good appetite and a healthy condition of body, but a careful surveillance must always be observed that the intake as measured in caloric values may correspond approximately with the estimated requirements.

A distinction should be drawn between appetite which represents physiological requirements for food and appetite which expresses the demands of some over-developed digestive organ or the manifestations of exhaustion of some overworked part of the body, such as the brain. Loss of appetite is a physiological means of protecting the body against further abuses.

Taste.—Tastes are peculiar things, and about them it is difficult to argue. "*De gustibus non disputandum*" is an old tag and a true one; however, we know more about the psychology of tastes now than we did when that trite old adage was first uttered. Tastes are acquired and not inherited. They depend almost entirely on nursery or schoolroom management. If a new food is given at a time when a child is not feeling fit and well, especially if it should happen to cause vomiting, he will acquire a distaste for it which may last him throughout life and against which no argument can prevail. Suggestion plays a mighty part in the acquisition of tastes and dislikes for food. If a child is told, for instance, that green vegetables and milk puddings are good for his health he instinctively takes a dislike to them and asks for some substitute which in his judgment is preferable. Full advantage of this psychological, and indeed very obvious, truth should be taken by parents and nurses. It is very easy to create likes and dislikes, but very difficult to eradicate them once they have been formed; consequently there is every advantage in creating at an early date taste for the foods which are desirable and distaste for those which are disadvantageous to health.

Tastes for particular foods are generally matters of habit and due to suggestion. Early recognition of these facts and good nursery training are most important elements in the establishment of good table habits.

Idiosyncrasies.—Certain individuals have peculiar food idiosyncrasies which are not necessarily founded on suggestion or on a psychological basis, but which are dependent on definite chemical and organic reactions. For instance, some individuals cannot eat strawberries, almonds, shellfish or other special articles of food without suffering from certain definite symptoms, such as skin rashes of an urticarial nature or from gastric disturbances. Eggs will make some individuals sick, while others cannot drink milk without violent and unpleasant reactions. This hypersensitiveness to special articles of food is strictly analogous to similar violent reactions which occur after the taking of such drugs as arsenic, or organo-therapeutic preparations such as anti-diphtheritic or anti-streptococcic serums by sensitive people. This phenomenon is known as anaphylaxis. It is well to recognise the genuineness of these anaphylactic manifestations, because they probably have a very important bearing in certain susceptible individuals on the production of symptoms other than of the skin, which may not be so easily recognised as of this character. There is, for instance, reason to believe that certain forms of asthma are of the nature of anaphylactic reactions to foreign proteins contained in food.

Habits.—Food habits are factors which must be taken into account in the ordering of all scientific dietaries. Carnivorous, herbivorous and graminivorous habits of certain animals represent on the grand scale the stereotyping of certain ancestral dietetic habits. We as omnivorous animals are born with great degrees of latitude with respect to diet, but our tastes, as well as our digestive, metabolic and excretory functions, may, by experience and habit, become extensively modified in various directions. We may indeed revert to the habits of our carnivorous, herbivorous or gramnivorous ancestors, not however without suffering some violence to our more recently acquired functions. When our several organic functions have become specially modified in certain directions, and have acquired a certain fixed bias of action in any one direction, it is irrational to attempt to force them into new or unaccustomed channels, even though these new channels are obviously and fundamentally superior to those which they are to replace. Irrational suggestions of this kind are exactly what food faddists are in the habit of trying to enforce on others. They attempt to impose their own dietetic vagaries, acquired by long and persistent service, on normally constituted persons. The ways of the food faddist should be avoided, for unsound habits of diet are difficult to eradicate. No attempt therefore should be made to change them by sudden and revolutionary means; whereas every possible effort should be made to prevent the establishment of habits which may ultimately become dangerous to health. It is in childhood that these habits are chiefly formed, and hence the great importance of sound nursery and schoolroom regimes.

Habits of diet can be acquired. They effect more or less permanent changes in the digestive, metabolic and excretory functions which cannot be quickly changed or easily eradicated. The ways of the food faddist are not to be imitated. Good physiological habits should be instilled in early childhood.

Absorbability.—Food is digested in order that it may be absorbed, and absorbed that it may be utilised for the purposes of energy production, etc. As the chyme passes along the intestinal tract it diminishes in quantity and becomes more and more solid, until finally, on reaching the rectum, there remains only a solid residue. An examination of the fæces gives very important information with respect to the fate of the food consumed. It must not be assumed, however, that all, or anything like all, the food elements found in fæces represent the residuum of unabsorbed food, for the mucous membrane of the alimentary tract is an excretory surface of great activity as well as one that absorbs. It is very difficult at times to say definitely whether certain material in the fæces is the unabsorbed residuum of food which has been recently consumed or whether it is a superfluity of food which has been absorbed and again rejected by the excretory functions as material which is not required. If an empty loop of the intestines of an animal be isolated from the remainder of the intestines, and left in the abdomen with all its blood vessels attached and undamaged, it is found after the lapse of a few days that the contents of this isolated loop are practically of the same nature as the contents of the short-circuited tract, proving that the mucous membrane of the bowel has the power of excreting all those elements which generally go to make up a normal stool. These physiological facts are of special interest in considering whether the fat which constitutes so large a part of the ordinary soap stools of infants owes its origin to unabsorbed fat or to fat which has been thrown off by the mucous membrane in the form of an excretion. Mucus of many kinds and in various degrees of disintegration and degeneration is found normally in the stools of all individuals, children as well as adults, and provides a very large percentage of the nitrogen content of fæces. We should not therefore always be correct in saying that a certain proportion of the fat is unabsorbed after consumption because such-and-such a proportion of fat is found to remain in the stools, nor that so much protein has not been absorbed because so much nitrogen can be detected in the stools. It may rather be the case that the whole of the substances has been absorbed and that what is found in the fæces represents excreted matter. It is generally stated in works of physiology that something between 6% and 10% of all food consumed remains unabsorbed. In the case of adults this calculation may be regarded as substantially correct. Since this is the case, it is clear that in making our estimates of a correct dietary on a caloric basis we must make some allowance for food which will not be absorbed. Some varieties of food are undoubtedly better absorbed than others; for instance, under normal conditions sugar is absorbed entirely; fine varieties of carbohydrate food are well absorbed if not given in excess; coarse varieties containing a large amount of cellulose are not so well absorbed, for the reason that there is no ferment in the intestinal tract which is capable of digesting it, and consequently when coarse food of this kind is consumed such portions of the finer starch granules as may happen to be entangled in the cellulose framework may remain inaccessible to the digestive ferments. Animal proteins such as meat and eggs appear to be better absorbed than vegetable proteins such as are found in the leguminous vegetables, but it is very dangerous to make generalisations in respect to the relative digestibilities and absorbabilities of the different varieties of food, for habit may influence the result. Very little absorption can take place through the mouth, œsophagus or stomach. Nearly all occurs in the intestines, which are especially designed for that purpose with numerous folds and an enormous cell-surface on each villus. By these means a huge absorbing area, estimated at 42 square yards, is provided. It is generally stated that there are two channels by which food is absorbed from the lumen of the alimentary tract —namely, the blood-stream and the lymphatic system. It would probably be more correct to say that all absorbable or diffusible substances enter first into the lymphatic system, and that then such of them as can diffuse into the blood-stream pass into the portal circulation. The residuum, which is incapable of so diffusing, remains in the lacteal system, and consists chiefly of fat, in the form of small globules.

Absorption proper begins in the duodenum, and the products of digestion disappear gradually from the intestinal contents as the chyme finds its way into the large intestine. In the large intestine water is very freely absorbed, so that by the time the intestinal contents have reached the rectum they become practically solid. Too much importance has in the past been attached to the chemical analysis of the stools. It has been believed that, because large amounts of unabsorbed foods have not been discovered in the fæces, the bulk of the available food has been absorbed and assimilated in a form which can be utilised for physiological purposes. This is an unjustifiable assumption, for much decomposition and fermentation of unabsorbed food can take place in the large intestine through the medium of bacterial activities. The products of these activities are or can be absorbed into the blood and fail to appear in the fæces. Since the majority of these bodies are of the nature of poisons it is necessary that they should be destroyed as they pass through the liver, in order that they may not damage the more delicate tissues of the body. There is often clinical evidence to indicate that this kind of damage has occurred, although chemical analysis of the fæces would afford no indications of the event. Offensive breath, sallow complexion, dry skin, high-coloured urine and a host of other symptoms indicate pretty clearly that there has been a large production of toxic material in the bowel, and that this toxic matter has not been rendered completely innocuous in its passage through the liver. Intestinal toxæmias are among the most common pathological disturbances from which children suffer. They nearly always imply an excessive consumption of food—that is to say, excessive in relationship to the amount that can be digested, absorbed or is required for the physiological purposes of the body. Ample provision is made in the large intestine for the disposal of unabsorbed residual material of this kind by the rich bacterial flora which occupies the whole length of the colon and rectum. The rational treatment of intestinal toxæmias consists in (1) carefully regulating the diet so that no unabsorbed residuum remains over; (2) hurrying unabsorbed residual material rapidly through the colon by means of purgatives or aperients, and thus depriving the bacteria of time and opportunity to cause this decomposition; (3) assisting and promoting digestion and absorption by adjuvants such as liquor pancreaticus; (4) the use of intestinal antiseptics, such as sulphur, Dimol or beta-naphthol.

Fæces for the most part consist of excretions from the mucous membrane and not of unabsorbed food. Food which is not properly digested and absorbed is decomposed in the large bowel, with the production of toxic products, many of which are absorbed and cause serious symptoms. It is, therefore, of considerable importance that no great excess of unabsorbed food should be exposed to the action of bacteria in the colon.

THE PHYSICAL CHARACTER OF THE FOOD

Mastication.—It is very essential from the point of view of digestion that solid food should be finely divided in order that the digestive solvents may be able to attack it with success. The human organism is provided with masticatory organs of first-rate quality, which are, if properly employed, well able to reduce the hardest varieties of food to a complete condition of subdivision. It is particularly important that the masticatory organs in childhood should be well exercised in these functions, for otherwise the jaws will not be well developed and consequently will give inadequate space for the teeth. Exercise of the jaws by mastication is the best possible guarantee against overcrowding of the teeth. In older individuals want of use of the jaws simply leads to atrophy, but in young children the results are much more serious, for not only are the jaws and teeth ill developed but other bones of the face also, especially those which form the floor of the nasal cavity. Narrow jaws and want of width of the palate imply narrowness of the floor of the nasal cavity, and this in its turn necessarily predisposes to want of room in the nose, to mouth-breathing and the development of adenoids. From these points of view it is highly regrettable that national customs have led us to feed our children on soft pappy foods which require no mastication, and this is probably one of the explanations of the prevalence of adenoids among our children. We find, as a rule, that rusks are soaked in milk, bread is cut up into small pieces for the making of bread and milk, oats are ground up and eaten as porridge, most of the common carbohydrate foods are eaten in the form of milk puddings, and meat is minced, while nuts, apples, biscuits and pastry, which necessarily require mastication, are excluded from the permissible articles of diet. In fact, every variety of food which can in any way encourage and develop the masticatory habit is banned. Children ought to be taught to use their jaws as soon as, or even before, the eruption of the teeth. They should be encouraged to eat rusks, crusts or toast, and they should be taught to drink their milk separately, and not be allowed to consume pappy foods which are made by compounding the solid with the fluid. Toast is in many ways better than bread, because it is harder, and also because children as a rule like it better. If flour derived from oats is held in high esteem it should be made into oatmeal biscuits or oatcake and not given in the form of porridge. Of recent years nuts and apples have been strongly recommended, not only as valuable substances on which the powers of mastication can be exercised, but also as detergents at the end of a meal to clean and polish the teeth ; if these foods leave any residuum in the mouth it does not exercise the same hurtful influence on the teeth as is exercised by starchy or carbohydrate food such as bread or biscuit. The advantages of nuts and apples from this point of view are incontestable, but to give such articles of diet to children with jaws already deformed, and ill-suited to the purposes of mastication, for the object of promoting development, is to court disaster.

Hard and solid food should be provided for children, in order that they may acquire a habit of mastication at as early a date as possible. By so doing the jaws will be better developed, crowding of the teeth will be prevented and the roof of the mouth properly expanded, and thus a good floor to the nasal cavities provided.

THE DRAWING UP OF DIET SHEETS

In the drawing up of diet sheets information with respect to certain details is necessary. In the first place we must have an approximate idea of the caloric value of the food required for the 24 hours, and for each separate meal. For instance, 1500 calories may be required for the 24 hours, and we may wish to arrange for three meals only, with 500 calories for each meal; on the other hand, we might desire to arrange for four meals, with 400 calories for three meals and 300 for the fourth. In every case the meals must be arranged to provide the correct number of calories. Further, we must know the caloric value of such articles of food as may be available. It is impossible within the scope of this work to give the caloric values of all foods which are likely to be included in all dietaries. A few of the more common ones are given in the table which appears on page 463. One of the chief difficulties in drawing up accurate diet sheets will be found in connection with estimating the caloric value of made-up dishes, owing to complications in the calculations. In making such estimations it is necessary to know the caloric value of all the ingredients, and finally, after adding up the total of such values, to divide this total into as many portions as there are consumers to provide for. To give a simple instance, taken from McKillop's *Food Values*, p. 109 :

TABLE 70

Suet Pudding: Caloric Value

Ingredients and Instructions	Oz. of			Calories
	Protein	Fat	Carbo-hydrates	
Suet, 24 oz.	0·648	19·632	. .	5310
Flour, 32 oz.	3·648	0·32	23·936	3290
Currants, 16 oz.	0·192	0·048	10·240	1335
Eggs (6) 12 oz.	1·428	1·116	. .	460
Milk, 20 oz.	0·660	0·880	1·000	400
	6·576	21·628	35·176	10,795
This pudding weighed 6½ lb. before boiling; so 24 persons can have a 4 oz. helping from it.				
Per portion	0·274	0·901	1·466	449

In this instance it will be noticed that for the making of a suet pudding 24 oz. of suet, 32 oz. of flour, 16 oz. of currants, 6 eggs, weighing 12 oz., and 20 oz. of milk constitute the ingredients.

The total caloric value of these ingredients is 10,795. A pudding of this size is sufficient to provide 4 oz. helpings for 24 persons, each of whom will receive $\frac{1}{24}$ part of 10,795 calories, or a total of 449 calories.

Further details to be observed in the drawing up of diet sheets are connected with the balance between the protein and non-protein elements, as well as that between the carbohydrate and fat constituents. In the diet sheets which I have drawn up for children I have made allowances for difference of age, and although there is no sharp line of demarcation between the dietaries required for each group, I have found it convenient to divide the years of childhood into three different periods: firstly, the period between the end of the first year and the end of the second; that between two and five years of age; and from five up to the time of puberty; from this time onwards it is assumed that the diet is the same as that for adults. The method employed in drawing up the following dietaries involves considerations connected with selection of menu, quantity, balance, digestibility, absorbability and other physical properties of the food elements included. In connection with each of these details a few particulars are appended in the following paragraphs.

The first step is to arrange the "menu" for each meal in accordance with the special requirements, having regard to season and market conditions. The size of the helpings of the chief dishes—the meat, the pudding, and so on—must then be settled, leaving the full complement of calories to be made good by *padding* such as bread, butter, vegetables, sugar, milk, etc. The balance with respect to the protein-to-non-protein ratio, as well as to the fat-to-carbohydrate ratio, and that of one mineral element to another, may be adjusted by the same means.

I append here a sample sheet to show how the caloric values of one meal may be estimated. In working out the estimates for the whole day all the meals must necessarily be dealt with in the same way. In the first column the actual articles of diet, with their quantities, are given. In the table itself it will be noticed that the meal, which is breakfast, consists of 6-9 oz. of milk, to which are added $\frac{1}{4}$ oz. of sugar and $\frac{1}{8}$ oz. of cocoa. The solids consist of $1\frac{1}{2}$-$2\frac{1}{2}$ oz. of bread, toast or oatcake, with $\frac{1}{4}$ oz. of butter, margarine or dripping and $\frac{1}{4}$-$\frac{1}{2}$ oz. of jam, jelly or treacle. In the following vertical columns the protein, carbohydrate and fat content of each of these articles of food is given, together with the caloric value. In the final column the total caloric value of the protein, carbohydrate and fat content of each article of food is supplied. The bottom horizontal line gives the total protein, carbohydrate and fat content of all the combined articles of diet, with their caloric values. In the sheet given it will be noticed that the protein content as measured in ounces is 0·41 to 0·63, while the combined carbohydrate-and-fat content is 1·95, made up of 1·45 carbohydrate and 0·5 fat, giving a protein-to-non-protein ratio of just under 1 to 5—to be exact, 1 to 4·7—which is quite near enough to the required standard.

Table 71

Sheet showing Caloric Value of One Meal (Breakfast)

Breakfast	Protein		Carbohydrate		Fat		Total Calories
	Weight in Ounces	Calories	Weight in Ounces	Calories	Weight in Ounces	Calories	
Milk, 6-9 oz.	0·24–0·36	27–41	0·26 –0·40	30–45	0·21 –0·30	55–82	120–180
Sugar, ¼ oz.	...	...	0·25	29	...	...	29
Cocoa, ⅛ oz.	0·02–0·02	2–2	0·038–0·038	45–45	0·022–0·022	5–5	12–12
Bread, toast, oat-cake, 1½-2½ oz.	0·15–0·25	17–29	0·72 –1·20	83–139	0·018–0·03	5–7	103–176
Butter, margarine or dripping, ¼ oz.	...	...	...	...	0·25 –0·25	55–55	55–55
Jam, jelly or treacle, ¼-½ oz.	...	...	0·19 –0·36	22–44	...	...	22–44
Total	0·41–0·63	46–72	1·458–1·99	209–302	0·5 –0·602	120–149	341–467

In this table the protein-to-non-protein ratio is as 0·41 is to 1·95 (1·45 carbohydrate + 0·5 fat) or as 1 is to 4·7, while the fat-to-carbohydrate ratio is as 0·5 is to 1·458 or as 1 is to 2·9.

The total caloric value for the meal is 341–467 calories.

The fat-carbohydrate ratio is 0·5 to 1·45 or as 1 to 2·92, which is correct for children between 1 and 3 years of age. It will be noticed that the total caloric value for the whole meal ranges from 341 to 467. The working out of such tables is necessarily extremely tedious, but when once it has been done it will serve for all time. For obvious reasons, the figures given cannot be regarded as absolutely exact, but they are quite accurate enough for the ordinary purposes of practical dietetics.

Quantity.—In my tables I have allowed during the second year

TABLE 72

Diet Sheet for Children from 1 to 2 Years

Day	Breakfast	Dinner	Tea	Supper	Total Number of Calories for 24 Hours. Standard 840-1120
First Day.	Milk, 6-8 oz. Sugar, ½ oz. Cocoa, ⅛ oz. Bread Toast Rusk } Singly or combined, 1-1½ oz. Butter Margarine Dripping Bacon fat, etc. } Singly or combined, ¼ oz. Jam (without seeds, pips or skins) Jelly Treacle } ¼-½ oz. 292-351 calories.	Whiting, 1-1½ oz., stewed in milk (2 oz.). Potatoes, 1-2 oz. Carrots, turnips (mashed) *or* boiled onions (Spanish), 1-2 oz. Suet pudding, 1½-2½ oz. Treacle, ¼-½ oz. Bread, 1 oz. 357-527 calories.	Milk, 6-8 oz. Sugar, ½ oz. Cocoa, ⅛ oz. Bread Toast Rusk Plain Madeira cake Oatmeal biscuits } Singly or combined, 1-1½ oz. Butter *or* margarine, ¼ oz. Jelly, treacle, *or* jam without seeds, pips or skins, ¼-½ oz. 292-351 calories.	Broth (potato), 3-4 oz. 40-50 calories.	981-1279
Second Day.	The same. 292-351 calories.	Egg, 1-1½ oz., *or* Stewed mutton (minced), ½-1 oz. Potatoes, 1-2 oz. Green vegetables, carrots, parsnips, turnips (mashed), 1-1½ oz. Milk pudding, 2-3 oz. Stewed prunes, 1-2 oz. Bread, 1 oz. 300-435 calories.	The same. 292-351 calories.	Lentil soup, 3-4 oz. 40-50 calories.	924-1187
Third Day.	The same. 292-351 calories.	Tripe stewed in milk, ¾-1½ oz. (milk, 2 oz.) Potatoes mashed with margarine or other fat, 1-2 oz. (margarine, ⅛ oz.) Vegetables, cauliflower, vegetable marrow *or* Jerusalem artichoke, 1-2 oz. Milk pudding, 2-3 oz. Stewed prunes *or* baked apple, 1-2 oz. Bread, 1 oz. 299-447 calories.	The same. 292-351 calories.	Thin pea soup, 3-4 oz. 40-50 calories.	923-1199
Fourth Day.	The same. 292-351 calories.	Plaice, 1-1½ oz., stewed in milk (2 oz.). Potatoes, 1-2 oz. Green vegetables, carrots, parsnips, turnips (mashed), 1-2 oz. Suet pudding, 1½-2½ oz. Treacle *or* jam, ¼-½ oz. Bread, 1 oz. 371-560 calories.	The same. 292-351 calories.	Lemon *or* orange jelly, 2-3 oz. 10-15 calories.	965-1277
Fifth Day.	The same. 292-351 calories.	Rabbit *or* lean neck of mutton (minced), ¾-1 oz. Potatoes, 1-2 oz. Cauliflower, Jerusalem artichoke, *or* vegetable marrow, 1-2 oz. Milk pudding, 2-3 oz. Stewed fruit *or* baked apple, 1-2 oz. Bread, 1 oz. 273-411 calories.	The same. 292-351 calories.	Artichoke *or* Potato soup, 3-4 oz. 50-65 calories.	907-1178
Sixth Day.	The same. 292-351 calories	Egg, 1-1½ oz., *or* Stewed mutton (minced), ¾-1 oz. Potatoes, 1-2 oz. Green vegetables, carrots, turnips, parsnips (mashed), 1-2 oz. Stewed fruit *or* baked apple, 1-2 oz. Bread, 1 oz. 350-510 calories.	The same. 292-351 calories.	Clear soup, 3-4 oz. 30-40 calories.	964-1252
Seventh Day.	The same. 292-351 calories.	Roast beef *or* mutton (minced), ¾-1 oz. Potatoes, 1-2 oz. Vegetable marrow, Jerusalem artichoke *or* cauliflower, 1-2 oz. Batter pudding, 1½-2½ oz. Treacle *or* jam, ¼-½ oz. Bread, 1 oz. 362-542 calories.	The same. 292-351 calories.	Orange *or* lemon jelly, 2-3 oz. 10-15 calories.	956-1259

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TABLE 73

Diet Sheet for Children from 2 to 5 Years

Day	Breakfast	Dinner	Tea	Supper	Total Calories for 24 Hours. Standard 1120-1600	Notes
First Day.	Milk, 8-12 oz. Sugar, ½ oz. Cocoa, Ovaltine, Chocolate } ⅛ oz. Bread, Toast, Oatcake } Singly or combined, 1½-2½ oz. Butter, Margarine, Dripping, Bacon fat } Singly or combined, ½ oz. Jam, Jelly, Treacle } Singly or combined, ¼-½ oz. *or* Stewed fruit, 1-1½ oz. 373-533 calories.	Steamed whiting, plaice, haddock, halibut, slip, cod, 1-2 oz. Potatoes, mashed (with margarine, ⅛ oz.), 1-2 oz. Cabbage, turnip tops, Brussels sprouts, asparagus *or* other green vegetable, 1½-2 oz. Milk pudding (tapioca, rice, sago, semolina, cornflour, etc.), 2-3 oz. Stewed fruit, *or* baked apple and syrup, 1-2 oz. Bread, 1½ oz. 355-518 calories.	Milk, 8-12 oz. Sugar, ½ oz. Cocoa, Ovaltine, Chocolate } ⅛ oz. Bread, Toast, Biscuit, Plain cake, Shortbread, Oatcake } Singly or combined, 1½-2½ oz. Butter, Margarine, Dripping } ½ oz. Jam, Jelly, Treacle } ¼-½ oz. *or* Stewed fruit, 1-1½ oz. 373-533 calories.	Mutton broth *or* clear soup, 3-4 oz. Bread, 1½-2 oz. Butter, ¼ oz. 175-239 calories.	1276-1823	If possible, bread and butter should be omitted at last meal in all these dietaries for the sake of the teeth, and the required caloric value made good at other meals. Apples or other fresh fruit when in season may be given at breakfast or tea.
Second Day.	The same. 373-533 calories.	Stewed mutton, 2-3 oz. (including gravy); meat, 1-2 oz. Suet dumpling, 1½-2½ oz. Mashed potatoes (⅛ oz. margarine), 1-2 oz. Stewed fruit, 1-2 oz. Rhubarb, baked apple and syrup, *or* prunes, 1-2 oz. Bread, 1½ oz. 459-786 calories.	The same. 373-533 calories.	Jelly, 2-3 oz. Rusk, ½ oz. 70-75 calories.	1275-1927	
Third Day.	The same. 373-533 calories.	Tripe (stewed in milk, 2 oz.), 1-2 oz. Potatoes, mashed, 1-2 oz. (⅛ oz. margarine). Carrots, turnips, parsnips *or* Jerusalem artichokes, 1-2 oz. Suet pudding, 1½-2½ oz. Treacle *or* jam, ½ oz. Bread, 1½ oz. 440-611 calories.	The same. 373-533 calories.	Lentil soup, 3-4 oz. Toast, ½ oz. 80-90 calories.	1266-1767	
Fourth Day.	The same. 373-533 calories.	Steamed whiting, plaice, halibut, slip, haddock, cod, 1-2 oz. Potatoes, 1-2 oz. Cabbage, turnip tops, Brussels sprouts, asparagus *or* other green vegetables, 1½-2 oz. Apple pudding *or* dumpling, 1½-2½ oz. Sugar *or* syrup, ¼-½ oz. Bread, 1½ oz. 331-353 calories.	The same. 373-533 calories.	Broth *or* clear soup, 3-4 oz. Bread, 1½-2 oz. Butter *or* margarine, ¼ oz. 175-239 calories.	1252-1658	On this day a banana might be given, if obtainable (1½ oz., 45 calories), at one of the meals to compensate for low food value.
Fifth Day.	The same. 373-533 calories.	Rabbit *or* stewed oxtail, with onion, carrots and other vegetables, 2-3 oz. (including gravy; meat, 1-2 oz.). Potatoes, 1-2 oz. Pastry, shortbread *or* biscuit, 1-2 oz. Stewed fruit *or* baked apple, 1-2 oz. Bread, 1½ oz. 434-604 calories.	The same. 373-533 calories.	Lentil soup, 3-4 oz. *or* cauliflower *au gratin*, 1½-2 oz. Bread *or* biscuit, 1-1½ oz. Butter, ¼ oz. 175-239 calories.	1355-1909	
Sixth Day.	The same. 373-533 calories.	Boiled *or* poached egg, 1-1½ oz.; *or* Minced beef, 1-1½ oz. Potatoes, 1-2 oz. Brussels sprouts, cabbage, turnip tops *or* Scotch kale, 1-2 oz. Suet pudding, 1½-2½ oz., and treacle, ¼-½ oz. Bread, 1½ oz. 434-611 calories.	The same. 373-533 calories.	Clear soup, 3-4 oz. *or* jelly, 1½-2½ oz. Rusk, ¾-1 oz. 70-85 calories.	1250-1762	
Seventh Day.	The same. 373-533 calories.	Lentil pudding (lentils, vegetables, fat), 1½-2½ oz. Rice, macaroni, vermicelli *or* sago pudding, 2-3 oz. Stewed fruit, 1-2 oz. Bread, 1½ oz. 443-585 calories.	The same. 373-533 calories.	Jelly, 2-3 oz. Bread, 1-1½ oz. Butter, ¼ oz. *or* Rusk, 1 oz. 138-175 calories.	1327-1826	

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TABLE 74

Diet Sheet for Children from 5 to 16 Years

Day	Breakfast	Dinner	Tea	Supper	Total Calories for 24 Hours. Standard 1600-2400.	Notes
First Day.	Weak tea, 9-12 oz. Milk, 1-2 oz. Sugar, ¼-½ Porridge, 2-3 oz. Milk, 4 oz. Sugar, ½ oz. Bread or toast, 2½-3½ oz. Butter or margarine, ½ oz. Stewed fruit or baked apple, 1½-2 oz. Caloric value, 381-502.	Whiting, plaice, halibut, haddock or sole, 2-2½ oz. Steamed or stewed in milk (2 oz.). Potatoes, 1-2 oz. (mashed with butter or margarine, ¼ oz.) Cabbage, turnip tops, cauliflower or vegetable marrow, 1-1½ oz. Suet pudding, 2-3 oz. Treacle or jam, ½-¾ oz. Bread, 1-2 oz. Caloric value, 558-920.	Milk, 9-12 oz. Sugar, ½ oz. Cocoa, chocolate or Ovaltine, ½ oz. Bread, toast, plain cake, scone or biscuit, 2½-3½ oz. Butter or margarine, ½ oz. Jam, jelly, honey or treacle, ½-1 oz. Caloric value, 467-647.	Potato, artichoke or carrot soup, 3-5 oz. Bread, 2-3½ oz. Butter or margarine, ½ oz. Cold rice pudding, 2-3 oz. Caloric value, 367-567.	1773-2636.	Fresh fruit may be substituted for jam, stewed fruit, etc., or salad for green vegetables. Supper may be made a lighter meal, if compensatory increases are made in other meals. Combinations of bread, toast, cake, etc., are recommended for breakfast and tea.
Second Day.	Weak tea, 9-12 oz. Milk 1-2 oz. Sugar, ½-¾ oz. Egg, 1-1½ oz. Bread, toast, oatcake, 2½-3½ oz. (singly or combined). Butter, margarine or dripping, ½ oz. Jam, jelly or marmalade, ½-1 oz. Caloric value, 381-502.	Meat or rabbit pudding, 2-3½ oz. Potatoes, 1-2 oz. Jerusalem artichokes, mashed carrot, parsnips or turnips, 1-1½ oz. Bread, 1-2½ oz. Milk pudding, 2-3 oz. Stewed fruit or baked apple, 1-2 oz. Caloric value, 453-838.	Milk, 9-12 oz. Sugar, ½ oz. Cocoa, chocolate or Ovaltine, ½ oz. Bread, toast, scone, plain cake or biscuit, 2½-3½ oz. Butter or margarine, ½ oz. Treacle or honey, ½ oz. Caloric value, 467-647.	Lentil soup, 3-5 oz. Bread, 2-3½ oz. Butter, margarine or dripping, ½ oz. Milk pudding, 2-3 oz. Stewed fruit or baked apple, 1-2 oz. Caloric value, 410-695.	1711-2592.	See notes first day. In place of milk pudding or stewed fruit, a fruit pie may be substituted either at dinner or supper.
Third Day.	Same as first day. Caloric value, 381-502.	Potato, carrot, artichoke, tomato or pea soup, 3-4 oz. Egg omelette or buttered egg, 1-1½ oz. Bread, 1-2½ oz. Batter or bread pudding, 2-3 oz. Jam, ½ oz. Caloric value, 473-586.	Same as first day. Caloric value, 467-647.	Fish and potato pie, 2-3 oz. Bread, 2-3½ oz. Butter, ½ oz. Milk pudding, 2-3 oz. Stewed fruit, 1-2 oz. Caloric value, 388-672.	1709-2407.	See notes first day. This is a meatless day. If thought desirable, meat, 1-2½ oz., may be substituted for the egg or omelette at dinner.
Fourth Day.	Milk, 9-12 oz. Sugar, ½ oz. Cocoa, ½ oz. Bread / Toast / Oatcake: Singly or combined, 2½-3½ oz. Butter, margarine, dripping or bacon fat, ½ oz. Jam, jelly, treacle or honey, ½ oz. Caloric value, 467-647.	Irish stew, stewed rabbit or other stew, with vegetables, 2-3 oz. Bread, 1-2½ oz. Apple, rhubarb or gooseberry pudding, 2-3 oz. Caloric value, 456-722.	Weak tea, 9-12 oz. Milk, 1-2 oz. Sugar, ½-¾ oz. Bread, toast, plain cake, scone, biscuits, 2½-3½ oz. Butter or margarine, ½ oz. Stewed fruit, prunes, apricots, etc., 1-2 oz. Caloric value, 262-353.	Potato, artichoke, carrot or green pea soup, 3-5 oz. Bread, 2-3½ oz. Butter, ½ oz. Milk pudding, stewed fruit or baked apple, 1-2 oz. Caloric value, 417-697.	1602-2329.	See notes first day. A small helping of white fish, 1 oz. boiled in milk (2 oz.) may be added to the breakfast. This will raise the caloric value of the day's food by about 60 calories, which will be of advantage in the case of children over 12 years of age.
Fifth Day.	Weak tea, 9-12 oz. Milk, 1-2 oz. Sugar, ½-¾ oz. Egg, 1-1½ oz. Bread / Toast / Scone, etc.: Singly or combined, 2½-3½ oz. Butter, margarine or dripping, ½ oz. Jam, jelly, treacle or honey, ½ oz. Caloric value, 381-502.	Fish and potato pie, 2-3 oz. Cabbage, Scotch kale, Brussels sprouts or turnip tops, 1-1½ oz. Bread, 2-3½ oz. Milk pudding, 2-3 oz. Stewed fruit or baked apple, 1-2 oz. Caloric value, 400-705.	Milk, 9-12 oz. Sugar, ½ oz. Cocoa, chocolate or Ovaltine, ½ oz. Bread, toast, plain cake, scone, biscuits, etc., 2½-3½ oz. Butter or margarine, ½ oz. Jam, jelly, treacle or honey, ½ oz. Caloric value, 467-647.	Scotch broth, 3-5 oz. Bread, 2-3½. Butter or margarine, ½ oz. Blancmange, 2-3 oz., and jam, ½ oz. Caloric value, 380-550.	1628-2404.	See notes first day.
Sixth Day.	Milk, 9-12 oz. Sugar, ½ oz. Cocoa, ½ oz. Bread / Toast / Oatcake: Singly or combined, 2½-3½ oz. Butter, margarine or dripping, ½ oz. Jam, jelly, ½ oz. Stewed fruit or baked apple, 1-2 oz. Caloric value, 467-647.	Boiled bacon, ¾-1 oz. Peas pudding, 1½-2½ oz., or beef-steak pudding, 2-3½ oz. Potatoes, 1-2 oz. Bread, 1-2½ oz. Jerusalem artichokes, mashed carrots, turnips or parsnips, 1-1½ oz. Milk pudding, 2-3 oz. Stewed fruit, 1-2 oz. Caloric value, 439-708.	Weak tea, 9-12 oz. Milk, 1-2 oz. Sugar, ½-¾ oz. Bread, toast, plain cake, shortbread, or biscuits, 2½-3½ oz. Butter or margarine, ½ oz. Jam, jelly, stewed fruit, honey or treacle, ½-2 oz. Caloric value, 282-363.	Lentil soup, 3-5 oz. Bread, 2-3½ oz. Butter or margarine, ½ oz. Milk pudding, 2-3 oz. Stewed fruit, 1-2 oz. Caloric value, 410-605.	1598-2323.	See notes first day. The slight deficiency in caloric value may be made good by an additional dish for breakfast, such as 2 sardines, or haddock (2 oz.) stewed in milk (2 oz.) (81 calories).
Seventh Day.	Same as first day. Caloric value, 381-502.	Roast beef, 1-2½ oz. Yorkshire pudding, 1½-2½ oz. Potatoes, 1-2 oz. Cabbage, Brussels sprouts, turnip tops, Scotch kale or cauliflower, 1-1½ oz. Apple, rhubarb gooseberry or other fruit pie, 1-2 oz. Bread, 1-2 oz. Caloric value, 481-995.	Same as fifth day. Caloric value, 467-567.	Same as first day. Caloric value, 367-567.	1696-2631.	See notes first day.

Notes.—The caloric values given above cannot, in the nature of things, be accurate; they vary according to individual methods of cooking. Those who use these Tables are advised to familiarise themselves with the weight values of various helpings. An ordinary tablespoonful helping of milk pudding or minced meat will be found to weigh quite 1 oz. A quarter of an ounce of butter or margarine is about a heaped teaspoonful. The food requirements of children as well as of all individuals depend more on the exercise taken than on all other factors combined. Girls between 10 and 16 years of age will, as a rule, require less food than boys of corresponding age. Sickly and invalid children require a smaller number of calories than healthy children; they should not, therefore, be fed up with cod-liver oil and other foods of high caloric value in addition to the ordinary rations.

Porridge only appears three times in above table, since it encourages the swallowing of carbohydrate food without mastication. Its caloric value (4 oz. oatmeal to 20 oz. of water) is 22 calories per ounce. Oatmeal biscuits or oatcake have all the dietetic advantage of porridge without the above-mentioned objection.

[To face page 274

of life from 840 to 1120 calories as the approximate number required. From the second to the fifth year of life 1120 to 1600 calories, and from the sixth to the sixteenth year 1600 to 2400 calories. The calories required for the intermediate ages are given in Table 65, facing pages 240-241.

Balance.—The protein-to-non-protein ratio has been founded on a basis of 1 to 7, the same as exists in breast milk, with a gradual approximation to 1 to 6 as the child grows older. The 1 to 6 ratio is about the mean of the various estimates which have been suggested by modern physiologists and dietetists. The fat-to-carbohydrate ratio in my tables shows a gradual transition from the 1 to 2 ratio maintained during breast feeding to a 1 to 5 or 1 to 6 ratio, which is the mean suggested by an examination of a considerable number of modern estimates for adults. The old ratio suggested by Voit of 1 to 10 is now considered too low as regards fat. With respect to the mineral ratio, or mineral content of the food, consistent attempts have been made to supply a full allowance of these important constituents by a liberal inclusion of vegetables and fruit in the daily menu. These are chiefly afforded by jam or cooked fruit, although in suitable cases in which sound fresh fruit or salads can be obtained it is permissible for children over two or three years of age to substitute the latter for the cooked articles. The necessity for maintaining a reasonable balance between the various elements of the ash—namely, calcium, iron, sodium, potassium, phosphorus and so on—has not been overlooked.

Physical Properties of the Food.—The necessity for providing hard and solid varieties of food for the purpose of educating the child in the functions of mastication has already been explained, and has not been ignored in the drawing up of these tables. It is impossible in devising diet sheets to indicate the gradual transition from liquid to solid food which takes place at the commencement of the second year of life, or at any rate after the time of weaning. A certain amount of latitude is allowed to those who use these tables to adjust them from this point of view.

Digestibility of the Food.—All the varieties of foods given in the accompanying sheets are of a perfectly simple and easily digested kind. Some of them, however, may prove individually indigestible for children who have peculiar idiosyncrasies or habits of digestion, and allowance must be made for these by those who use these tables.

CHAPTER XV

THE FEEDING OF PREMATURE INFANTS

Introductory Remarks—General Management—The Feeding—Breast Feeding—Artificial Feeding

The general principles which have already been enunciated as applicable for the feeding of full-time infants hold good also in the case of premature infants, but owing to the greater delicacy of the latter it is even more important that they should be rigorously observed.

It would be futile to describe in detail the special precautions which must be taken in feeding premature infants without drawing attention to one or two points in the general management which greatly influence the results.

In the first place it must be remembered that in correspondence with the degree of prematurity of the infant all the organic functions—including those concerned with digestion—are more or less undeveloped, and consequently liable to become disorganised when undue strains are imposed upon them. Apart from such disturbances the chief dangers to be apprehended in the case of premature infants are connected firstly with infection and secondly with low degrees of bodily temperature.

Their prospects of survival are immensely enhanced if premature infants are isolated in separate rooms, from which all visitors are excluded. So great is the danger from infection that it is almost impossible to rear premature infants in the general wards of institutions or hospitals, where they are exposed to air contaminated with a mixed bacterial flora.

In all cases the blood temperature should be carefully watched by means of special low-reading thermometers. Subnormal temperatures often escape detection owing to the employment of ordinary thermometers, the indices of which have not been adequately shaken down before insertion in the rectum. It is by no means uncommon to discover temperatures as low as 90° F. in such infants unless special precautions are taken to maintain the bodily heat. In this connection it should be remembered that the blood temperature is no accurate indication of the amount of bodily heat produced, but only of the efficiency or inefficiency of the heat-regulating mechanisms. An infant may maintain a normal blood temperature in spite of the production of little heat, provided that little heat is lost by conduction, evaporation, radiation and so on—as, for instance, when it is kept in an incubator.

From the point of view of accurate physiological feeding the amount of heat generated by internal combustion processes is of fundamental importance. With an active metabolism, and consequently with the production of much heat, considerable quantities of food are required, whereas with suppression of the metabolic processes not only is little fuel required, but it is positively dangerous to supply much. Before therefore deciding how much food a premature infant requires it is essential to determine what are its metabolic capacities. These can be roughly estimated by observing whether the infant can keep up the bodily warmth without the aid of hot-water bottles or an incubator, or how much artificial heat is required to keep it warm. If a premature infant remains perfectly warm in its cot without special precautions, and if when one places one's hand on the chest or abdomen there is a glow of warmth, one may assume that active combustion is taking place ; but if, on the other hand, in spite of the application of artificial warmth, the child still feels cold to the touch one is entitled to conclude that metabolism is at a low ebb, and the requirements for food extremely small. There can be little doubt that many premature infants are killed by over-feeding.

The main condition for success in the management of these difficult cases is to secure activity of the metabolic processes—in other words, to ensure that the infant provides its own heat and is not dependent for its supply on an incubator or other artificial sources of warmth.

Professor Leonard Hill has conclusively proved that surface stimulation, dry air, changes of temperature and surface evaporation are the chief essentials for stimulating metabolism. If an infant is confined to an incubator, with an automatically regulated temperature and a perfectly still atmosphere, it is deprived of all those sources of surface stimulation on which its health depends. For these and other reasons I never allow a premature infant to be placed in the chamber of an incubator. If necessary I see that it is well provided with electric heaters or hot-water bottles; but I always see that some part of the body, and especially the face, is exposed to the stimulating influences of cool air, and that the air which the child is allowed to breathe is not too warm or too saturated with moisture.

Breast Feeding of Premature Infants.—As far as feeding is concerned, the most important condition necessary to ensure success is that the infant should be fed by its own mother, and chiefly for the reasons that the mother's colostrum contains immunising bodies which protect the nursling from bacterial infections during the period when the dangers are greatest, and also because colostrum serves as the most efficient medium for developing the rudimentary digestive functions. It is well nigh fatal to provide a new-born premature baby with a wet nurse in full lactation, and worse still to give it weak dilutions of cow's milk, since by so doing the stomach and other digestive functions are challenged to perform tasks which they are quite incapable of doing.

The secretory functions of the mammary glands of prematurely confined women are often in a very rudimentary stage of development at the time of labour, and consequently require more than the usual degree of stimulation before lactation is established. Owing to the feebleness of the child, and its ineffectual efforts at sucking, the breast often receives inadequate stimulation. The application of the breast-pump, of massage and of other mechanical means of stimulation are at times useful accessory expedients in establishing lactation. Patience, however, is the one essential for success, for it may require many days, or even weeks, of indefatigable work to induce the recalcitrant glands to secrete normally, but meanwhile a few drops of colostrum are of inestimable value to the child.

All colostrum extracted by the breast-pump should be given to the infant, in spoon, bottle or syringe: it should on no account be wasted. There is no reason to despair of ultimate success so long as a few drachms of colostrum are secured daily by means of such combined efforts.

The amount of food required by the premature infant is at all times small, and sometimes extremely small when the metabolic processes are sluggish, but water and salts are always required in considerable amount. These can easily be supplied independently without danger of upsetting the digestive functions.

There is a very widespread belief that premature infants must be fed frequently owing to the small amount of food capable of being contained by the stomach at any one feeding. Relatively to the exiguous requirements of the premature baby, the stomach of the latter is just as large as that of a full-time baby, and hence there are no grounds for feeding it more often. Moreover, the digestive functions and powers of absorption are often so feeble that more rather than less time is required for the stomach to empty itself. The premature infant, like the full-time infant, should be fed every three hours by day, and not at all at night, in order that regular habits of activity may be established, not only in the digestive functions of the baby but in the secretory functions of the mother's breast also.

If after the first three days of life the amount of the milk or colostrum is seriously short of the standard of requirements mentioned on page 280 the shortage may be made good by supplementary feedings, given very cautiously at first and always in a predigested or highly digestible form. The most suitable varieties of artificial food for these supplementary feedings are:

(1) Cow's milk, modified to breast standard (p. 202) and predigested for three hours (p. 472)

(2) Allenbury Food No. 1, in the proportion of 1 drachm to the ounce of water.

(3) Horlick's Malted Milk, in the same proportions ; or

(4) Whey, prepared freshly from cow's milk, or from dried whey powder (Sec-Wa), in the proportion of 1 drachm to the ounce of water.

Every breast-feed should be measured by the "test-feed" (see p. 127), and a record kept of the amount. If supplementary feeding is required, it should always be given after the regular breast-feed, and not independently, the total quantity being made up to the required amount.

The Artificial Feeding of Premature Infants.—As already stated, premature infants should not be fed more often than full-time babies. This statement is no less true for artificial than for breast feeding. They should be fed 6 times during the day—at 6 A.M., 9 A.M. 12 midday, 3 P.M., 6 P.M. and 9 P.M.—without any night feedings at all.

The receptacle for the food may be a glass syringe provided with an indiarubber tube attached to the nozzle, a pipette or a small glass bottle, such as that supplied by Messrs Bell & Croyden.

As regards quantity the following rules may be adopted. Irrespective of the degree of prematurity, one teaspoonful should be given on the first day of life, making 6 teaspoonfuls for the 24 hours, on the second day 2 teaspoonfuls, on the third, 3 teaspoonfuls, and so on, until the full amount recorded in the accompanying table is reached:

TABLE 75

Quantities of Food required by Infants of Various Degrees of Prematurity

Degree of Prematurity	Average Weight	Amount of Food at each Feed—6 Feeds in 24 Hours	Total Food for 24 Hours	Caloric Value
Infant born at 28th week of gestation—*i.e.* 12 weeks premature	2 lb. 7 oz.	4–5 teaspoonfuls	3–4 oz.	60–80
Infant born at 30th week of gestation—*i.e.* 10 weeks premature	2 lb. 12 oz.	4–6 teaspoonfuls	3–5 oz.	60–100
Infant born at 32nd week of gestation—*i.e.* 8 weeks premature	3 lb. 4 oz.	5–8 teaspoonfuls	4–6 oz.	80–120
Infant born at 34th week of gestation—*i.e.* 6 weeks premature	3 lb. 14 oz.	6–9 teaspoonfuls	5–7 oz.	100–140
Infant born at 36th week of gestation—*i.e.* 4 weeks premature	4 lb.	8–12 teaspoonfuls	6–9 oz.	120–180
Infant born at 38th week of gestation—*i.e.* 2 weeks premature	4 lb. 13 oz.	9–16 teaspoonfuls	8–12 oz.	160–240

In the subsequent feeding of premature infants the quantity of food or its caloric value should be based partly on the weight and partly on the general degree of development of the infant, especially on the degree of its muscular activity. Up to the age of six months the approximate caloric value of the food for the 24 hours should represent the body-weight of the baby in pounds multiplied by 50. For instance, a baby 4 weeks premature weighs 9 lb. when 2 months old. Its caloric requirements can be estimated by multiplying 9 by 50—in other words, they represent 450 calories. If the child is fed with an artificial food made up to breast standard—*i.e.* with a caloric value of 20 per oz.—the total daily requirement will be 24 oz., or 4 oz. at each of the six feeds.

It must be remembered, however, that mere weight in the infant is but a poor guide to the quantity of food required unless the baby is absolutely normal in all other respects. Active, energetic babies require more food per pound of body-weight than inactive, sluggish babies, and those who are freely stimulated with fresh air, sunshine and changes of temperature require more food to support their active metabolic processes than babies who are deprived of these advantages.

The character of the food should be made to conform as closely as possible with the standard of breast milk as regards the balance of the ternary constituents, as well as in other respects, and this standard should be adhered to until the time of weaning. The most convenient food to employ is cow's milk modified to breast standard by the addition of cream and sugar-of-milk (see p. 202), and this combination should at first be predigested for some three hours with Fairchild's Peptonising Powders or with liquor pancreaticus (see p. 472).

As the infant's digestive functions develop the time of predigestion may be reduced day by day until the food can be tolerated without previous digestion—say, by the time the infant is about one month old.

If for any reason a ready prepared food is preferred, Allenbury Food No. 1 may be employed to the strength of 1 drachm to an ounce of water. As will be observed by reference to Table facing page 198 this food, when thus prepared, is deficient in fat. This shortage may be made good by the addition of one teaspoonful of a 33% emulsion of butter fat to each bottle (see page 481), and the addition of vegetable and bone broth (page 476) is advisable.

Accessory factors must be supplied in full amount to premature infants, since their need for them is no less than full-time infants, so that the inclusion of orange juice and animal fats in the dietary must not be neglected.

CHAPTER XVI

SPECIAL METHODS OF FEEDING

Gavage—Rectal Feeding—Subcutaneous Feeding—Inunction, etc.

When, in infants or children, food cannot be supplied *per vias naturales* in quantities sufficient to maintain nutrition, life may be temporarily sustained by one or other of the supplementary methods described in this chapter. It is very doubtful, however, whether any degree of care or skill in the carrying out of these various operations can prolong life indefinitely, or even for any considerable period of time.

It cannot be too strongly emphasised that children, and especially young infants, can maintain life on the most exiguous quantities of food, provided that water and salts are supplied in full amount. This is especially true when the output of energy is reduced to a minimum by keeping the child warm and limiting all forms of exercise. In those cases, in which the intake of food is for any reason seriously restricted, it is far better to keep the patient warm and immobilised in bed than to attempt, by forced methods of feeding, to keep the patient up and about. During periods of enforced starvation no measures must be taken, such as open-air treatment, which cause in any way a quickening of the metabolic processes. The main object of treatment should be to slow down metabolism, and to restrict the output of energy in correspondence with the reduced intake.

In those cases in which there is any impediment to the entry of food into the stomach, as for instance in cases of œsophageal stricture, or paralysis of the muscles of deglutition from diphtheria or any other cause, the introduction of food by means of the œsophageal tube can give most satisfactory results. In extreme cases of vomiting, in which the stomach is intolerant of food, duodenal feeding can be resorted to by the Einhorn[1] method, an apparatus which allows of catheterisation of the pylorus. This method, however, is difficult to carry out in the case of young chlldren.

[1] Max Einhorn. *New York Med. Rec.*, 16th July 1910.

On the other hand rectal feeding can be employed to supplement an otherwise insufficient intake of food, while the subcutaneous introduction of water, salts and food is also a valuable temporary expedient in those cases in which food cannot be administered by other methods.

Gavage.—The introduction of food into the stomach by means of the œsophageal tube is extremely easy in the case of infants, and by no means difficult in that of older children. If a sufficiently small œsophageal tube is not available a No. 12 or 14 " velvet-eyed " flexible catheter can be firmly attached to about three feet of rubber-tubing, which at one end is applied to the stem of a glass funnel. A glass " window " joint may be introduced between the catheter and the rubber-tubing in order that the flow of fluid may be kept under observation, and further a metal clip may be applied to help to control the current.

This apparatus is especially useful in cases in which irrigation of the stomach is indicated in conjunction with forced feeding. The tube should be well moistened with water or oil, and passed boldly through the mouth and pharynx into the œsophagus. There is little danger of passing the tube into the larynx if this precaution is taken, and no danger of the entrance of food into the trachea if only water is allowed to fill the apparatus until it is quite evident by the freedom of flow that the end of the catheter is in the stomach.

The character of the food must be adapted to the requirements. The frequency with which the child should be fed should be reduced to a minimum ; in the case of infants, food should not be administered more than three or four times in the 24 hours, and less frequently in the case of older children. To promote this object the food should be as concentrated as is compatible with the conditions—for instance, whole milk, peptonised or not as may be necessary and fortified with additional sugar and cream, may be used. But it must not be forgotten that a child fed in this unnatural manner has the same need for accessory factors as under normal conditions, and that they should be supplied in adequate amount.

Rectal Feeding.—This method of feeding can be employed as the exclusive means of providing the body with nutriment or as supplementary to other methods of feeding. The chief reason why this method cannot be relied upon to give satisfactory results for more than a few weeks on end is that the rectum usually becomes irritable and intolerant of the presence of such foreign matter as a nutritive enema; and further, the latter tends to become decomposed, through the agency of bacteria, and a source of irritation, through the production of toxins and other products of decomposition. Care and intelligence, however, can minimise these complications and enable the child to tide over temporary crises. The chief points to remember in employing rectal feeding are as follows. In the first place, the rectum and lower bowel must be cleared of all fæcal matter by means of a preliminary soap-and-water enema. The nutritive material can then be introduced into the pelvic colon by means of the employment of adequate pressure—as a rule, to secure this end there must be about three feet of pressure. It has been proved by means of radiography that fluid thus passed under pressure can reach not only the descending, transverse and ascending colon, but also pass through the ileo-cæcal valve and penetrate into the small intestine. To promote this reversed flow of the colonic contents Ewald[1] recommends the addition of 2 or 3 drachms of sodium chloride to each enema, on the ground that this salt promotes anti-peristalsis. My own experience is that, instead of using high pressure, it is equally or more satisfactory to pass a long rectal tube into the pelvic colon by the following means. After the tube has reached well into the rectum, the injected fluid is allowed to flow freely through the nozzle. The stream thus generated opens up a way along which the nozzle can travel without encountering obstruction by folds of mucous membrane or kinks in the bowel. To allay irritation of the bowel, and to restrain bacterial decomposition, Grunbaum[2] recommends the addition of 2 grains of chloretone to each ounce of nutrient fluid.

The quantity of the fluid to be injected will depend on circumstances; in the case of infants it is seldom possible to pass more than 3 or 4 oz., or in the case of older children more than 10 oz. It is, however, advisable to inject the maximum rather than the minimum quantity, especially if the "high pressure" method is employed. I have found that manipulation of the colon by means of massage greatly facilitates the reverse flow of the bowel contents. It is not advisable to repeat the injections too often

[1] Ewald. *Diseases of the Stomach.*

[2] Grunbaum. *B.M.A.*, 1900.

in the 24 hours, since the operation itself tends to promote irritation.

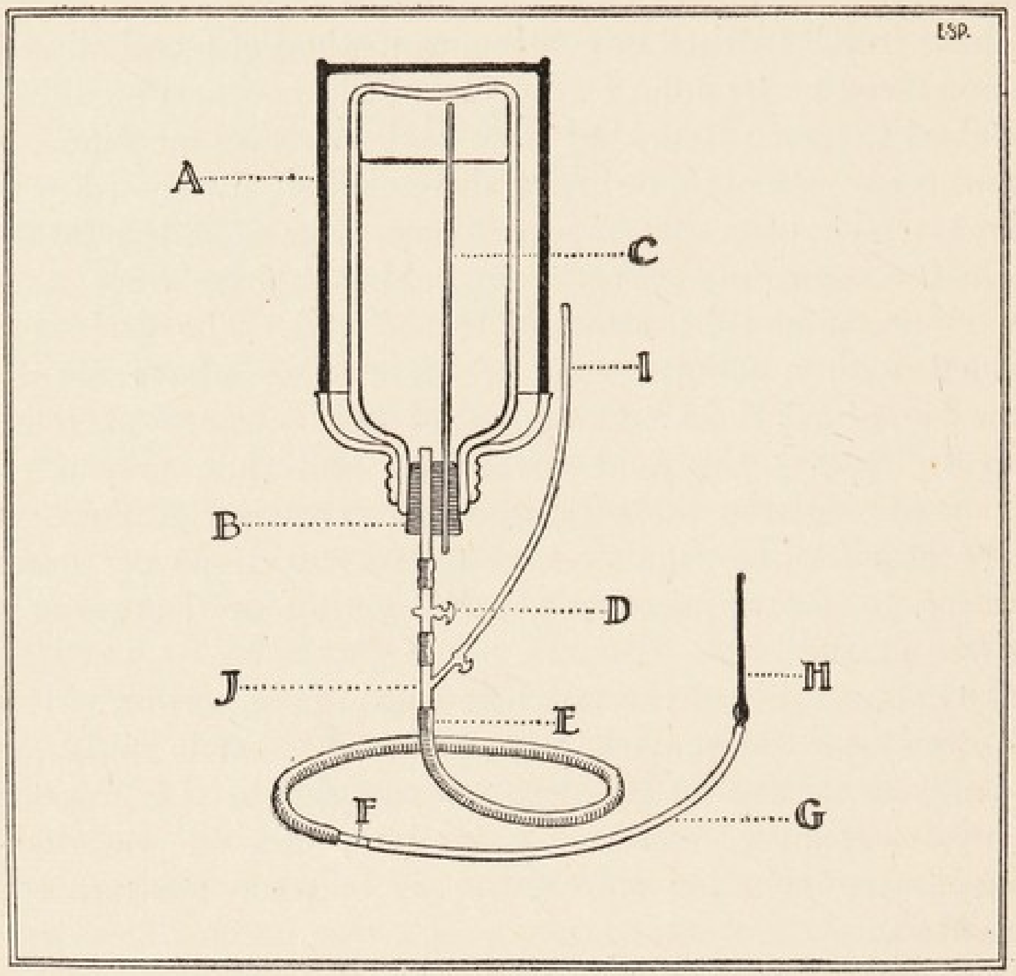
The "drop," "drip," or continuous method of rectal alimentation employed by Dr John D. Murphy of Chicago, and modified by Dr Robert Coleman Kemp[1] of New York, deserves mention. The apparatus consists of an ordinary thermos flask, fitted with a cork through which passes a glass delivery tube. To the latter is attached a four-foot length of rubber-tubing, with a soft catheter or rectal tube attached to the end. The flask is also provided with a filiform tube which reaches above the level of the contained fluid and allows of the entrance of bubbles of air to replace the fluid withdrawn and thus prevents the creation of negative pressure, and the cessation of flow. The rate of flow can be regulated at 60 to 200 drops per minute, according to the requirements, by elevating or depressing the flask (see p. 286).

The composition of the nutrient enema is important. It has been clearly proved that the absorption of sugar is fairly good. No doubt dextrose and lævulose are superior in this respect to maltose, cane-sugar, lactose or dextrine, but all varieties of carbohydrate, including starch, appear in some measure to be assimilated.

Small quantities of fat can also be absorbed, especially when the latter has a low melting-point and is administered in the form of a fine emulsion. Cod-liver oil, well emulsified, is one of the best fats that can be employed for this purpose.

Proteins present the greatest difficulty, since even under the most favourable circumstances they are poorly absorbed from the large bowel and rectum. I cannot help thinking, however, that the majority of experiments which impute a refractory behaviour to protein material have been carried out with foods which have been insufficiently predigested. For the complete peptonisation of milk, egg or meat proteins—that is to say, for their complete resolution into small chains of amino-acids—the artificial digestive process must be continued for many hours: the usual perfunctory method of peptonising nutrient enemas for some 20 minutes is altogether useless for effecting this purpose. It is often forgotten that patients, who are fed by rectal alimentation, require fresh food and accessory factors no less than normal individuals, and

[1] *New York Med. Journal*, 14th August 1916.



(A) INVERTED THERMOS [SECTION] (B) CORK THROUGH WHICH PASSES A GLASS CONDUCTING TUBE. TO THIS IS ATTACHED THE OUTFLOW TUBE (E)

(C) CAPILLARY TUBE PASSES THROUGH SOLUTION TO WITHIN 1/8 IN. FROM THE TOP OF THE THERMOS; ....THIS ALLOWS ENTRANCE OF AIR TO RENDER THE OUTFLOW POSSIBLE. IT IS MADE OF METAL & IT AND THE AIR ENTERING THROUGH IT ARE THUS RAPIDLY HEATED BY THE SURROUNDING SOLUTION. (D) SCREW COMPRESSION VALVE, APPLIED CLOSE TO THERMOS TO AVOID SOLUTION COOLING IN SOFT OUTFLOW TUBE, IS JOINED BY A SHORT PIECE OF GLASS TUBING (F) TO THE CATHETER (G) FOR OBSERVING IF THE FLOW IS CONSTANT.

THE CATHETER FOR RECTAL INJECTIONS PASSES THROUGH A SELF-RETAINING RECTAL TIP (H) & THE FORMER CAN BE INSERTED TO ANY LENGTH DESIRED. A HYPODERMIC NEEDLE CAN BE SUBSTITUTED. (I) A SMALL TUBE CONNECTED WITH OUTFLOW TUBE (E) BY THE T-SHAPED CONNECTION (J) WHICH ALLOWS ESCAPE OF FLATUS.

THE OUTFLOW TUBE (E) IS ESPECIALLY THICK & COVERED BY AN ASBESTOS JACKET TO LESSEN THE DISSIPATION OF HEAT.

FIG. 76.—Improvised Apparatus for Continuous Irrigation, and Rectal Alimentation

for this reason these essentials must not be omitted from the nutrient fluids injected.

I have found the following formula useful for preparing nutrient enemas for children :—

10 oz. of milk (predigested for three hours with 1 drachm of liquor pancreaticus with the addition of 20 grains of sodium citrate) .	200 calories
½ oz. of dextrose	58 calories
1 oz. cod-liver-oil emulsion (33%) . . .	88 calories
¼ oz. of orange juice	..
¼ oz. of sodium chloride	..
20 grains of chloretone	..

In using such an enema the amount will necessarily depend on circumstances, the age of the child, the degree of tolerance, and so on. In the case of babies sometimes not more than 2 oz. can be retained, and in the case of children about five years of age, as a rule as much as 5 oz. is well tolerated, and in certain cases as much as 10 oz. To prevent undue bacterial decompositions it is just as well to boil the peptonised milk before use; the other ingredients of the enema being practically sterile, they can be added to the milk immediately before injection without previous heating. For further particulars the reader is referred to *Dietotherapy* (Fitch), vol. iii., chapter 26.

Subcutaneous Feeding.—As supplementary to rectal or other inadequate methods of feeding, the subcutaneous introduction of food into the system is not without value.

Hypodermoclysis, or the injection of normal saline solution into the subcutaneous tissues, is much the most commonly practised variety of subcutaneous feeding. In serious illness, especially in cases of exhausting diarrhœa, water and salts are often more urgently needed by the tissues than any of the ternary elements of food, and these can be introduced hypodermically to almost any extent. In this connection it must not be forgotten that in conditions of starvation there is almost invariably some degree of acidosis, and under such circumstances a considerable demand for alkaline salts and alkaline bases. If, therefore, the blood is not to be depleted of its alkaline reserves, alkalies should always be added to the saline solution injected. To effect this purpose I recommend the addition of sodium citrate or sodium bicarbonate to the usual constituents of so-called "normal saline." For the preparation of a suitable solution for hypodermoclysis the following formula will be found useful :—

Potassium chloride	gr. xxx
Sodium chloride	gr. xxx
Calcium chloride	gr. x
Sodium phosphate	ʒi
Sodium bicarbonate	ʒii
Distilled or boiled water to make	1 pint

In high degrees of acidosis I have employed much larger proportions of sodium bicarbonate, with much advantage, and with no bad results of any kind.

The best site for injection is in the ileolumbar region, half-way between the crest of the ileum and the last rib, but other favourable situations are in the loose areolar tissue of the axilla, chest, abdomen or thigh.

It is important that all the technique of hypodermoclysis should be carried out with full aseptic precautions, and that too much force should not be employed in injecting the fluid, in order to avoid tearing or other damage to the connective tissue. Serious abscesses have at times resulted for want of these precautions.

The continuous or "drop" method has certain advantages over the ordinary method of injection, and to carry this into effect the same apparatus as that described on page 286 may be employed if a long exploring needle be substituted for the rectal tube. The rate of flow can be adjusted to the absorption capacity by raising or lowering the position of the thermos flask. The total amount of fluid to be injected depends on circumstances, but large quantities (a pint or more) can often be introduced into the system with advantage in the 24 hours.

The temperature of the fluid should be slightly above blood temperature, unless the temperature of the patient is above or below normal. In the former case the injection of comparatively cool fluid, say of 90° F., helps to reduce the pyrexia, while under conditions of subnormal temperature the injection of fluid at 105° F. helps to restore equilibrium.

The Subcutaneous Injection of Food.—This is a much more delicate operation than the subcutaneous injection of saline solutions. In order that such injections may be effective it is necessary that the foods thus introduced into the system should be utilisable, since if they are not they will be expelled, at physiological expense, from the system in the emunctories. We know that monosaccharid sugars, such as dextrose and lævulose, are completely available provided that the tissue fluids are not flooded with excess. We also have reason to believe that fine emulsions of fat are utilisable if introduced in reasonable quantity, but when we come to deal with the proteids we find ourselves on far more debatable ground. Foreign proteins are liable to set up violent anaphylactic reactions, while the products of their digestion—viz. amido-acids—tend to produce toxic results if introduced into the system in any considerable amount. If cautiously administered both ox and horse serum can be supplied in considerable quantities, but to what extent they are physiologically available for the purposes of nutrition is still undetermined; it is, however, quite safe to administer from 25-75 c.c. of horse serum to a child five years of age if the first reaction to a small dose—say of 10 c.c.—is not violent, and if the first injection is followed by a second at an interval of not more than one week, since this method of procedure avoids the risk of anaphylactic accidents. On the other hand, in spite of the fact that the injection of large quantities of amido-acids is liable to produce toxic effects, I can affirm from practical experience that the subcutaneous injection of fully pancreatised milk (5-50 c.c.) or of peptone jelly (1-10 c.c.) can be carried out apart from accident, but I am unable to claim that this method of administering food is followed by any benefit to nutrition. Muggia [1] has recommended the subcutaneous injection of 1 c.c. of raw yolk of egg, followed by gentle massage, as a perfectly safe and useful method of introducing food into the system, and that this initial dose may be gradually increased up to 10 c.c. The advantage in using yolk of egg is that it is a complete food and practically sterile. Taking into account the somewhat problematical value of protein injections, I am of the opinion that the subcutaneous method of feeding should be confined to the hypodermic introduction of water, salts, dextrose and a small quantity of oil emulsion. In desperate cases, if closely consanguineous human blood serum is not available for hypodermic injection, it may be worth while to experiment with increasing doses of horse serum or yolk of egg.

Inunction of Fat.—It appears tolerably certain that small quantities of fat can be absorbed through the skin if the method

[1] *B.M.J.*, 30th September 1899.

of inunction with the hand is vigorously pursued. There is no reason to believe that fat which thus gains entrance to the system by this route is in any degree less available than when it reaches the circulation *per vias naturales*. Cod-liver oil is the fat most usually employed for this purpose, but there are objections to its employment on the ground of its disagreeable odour as soon as it has become rancid or decomposed owing to bacterial activity. A combination of equal parts of cocoa butter, lanoline and butter fat makes a most satisfactory fat for inunction purposes.

PART III

THE FEEDING OF INFANTS AND CHILDREN IN CONDITIONS OF ILLNESS

INTRODUCTION

In the following pages we are faced with problems of very considerable difficulty, and not the least among them is that of arranging and classifying in their appropriate order the various symptoms, or groups of symptoms, which are amenable to dietetic treatment. If these symptoms are classified in accordance with their pathological characteristics one set of difficulties arises, if according to their etiology our task is no lighter, and yet further embarrassments await us if we attempt to classify them in relationship with the various systems to which they most obviously refer. After full consideration I have decided to adopt a middle course, which can only be justified on grounds of convenience, for it is based neither on symptoms, systems nor etiology, but on a combination of all three. The arrangement is as follows. First of all will be described the symptoms which can be directly referred to the digestive system—viz. those of vomiting, diarrhœa, colic, and so on; symptoms which are not necessarily due to primary disturbances of the digestive system, but which may be of reflex origin or due to irritation of the central nervous system. In the next place I shall refer to a group of cases which I have collectively classified under the title of *Disturbances of Metabolism*. This latter group obviously comprises conditions which might equally well be included in a totally different category—as, for instance, marasmus, which might be justifiably classified among the chronic infections, or among diseases of the digestive system.

The next class includes all those chronic and acute infections which are due to the organisms of tuberculosis, syphilis, rheumatism, influenza, pneumonia, or to septic and catarrhal conditions. Since many of the symptoms in infancy and childhood are indirectly due to such infections, though manifested in some particular system, it is difficult to decide under which category they should more properly be described. Other symptoms may conveniently be grouped together as symptoms of special systems, such as the respiratory, nervous, or circulatory systems. In this classification I have deliberately avoided reference to the theories of Czerny and Finkelstein, which find such a prominent place in German literature, and which attribute certain specific results to injuries inflicted on the organism by certain food elements, such as fat, sugar, salts, etc. These theories appear to me to be too fanciful and unsubstantial to justify serious consideration; although there can be little doubt there is some basis of truth in them.

In the whole of Part III. I fear that I shall do scant justice to the claims of children over one year, for most of my efforts will be directed towards the management of the diet of infants under one year of age.

I have found it extremely difficult to confine myself strictly to the dietetic treatment of the various conditions described, and in no few instances I have referred to other therapeutic expedients.

Since it is quite impossible to understand the rationale of the treatment of the pathological conditions described in the following pages without due reference to the physiological activities of the organs concerned, the reader is strongly advised to pay special attention to the references mentioned in the text which refer to this side of the subject.

CHAPTER I

THE DIGESTIVE SYSTEM

Introductory Remarks—Vomiting—Causation—Diagnosis—Treatment

Most of the symptoms referable to the digestive system, such as vomiting, diarrhœa, colic, etc., represent "protective" reactions which are called into play to preserve the life of the individual under conditions which threaten his existence. Vomiting, for instance, disposes of poisons or deleterious substances which gain entrance to the stomach; diarrhœa expels poisons and irritants from the bowel, while colic and abdominal pains warn the consumer against unsuitable varieties of food. It must, however, be clearly realised that symptoms which, in the first instance, possess such prophylactic uses may continue as habits, partly or entirely independent of any further protective significance. Such habits are easily established, but they are difficult to cure, and their significance may be easily misinterpreted. In the following pages I shall deal with the more common symptoms of indigestion from three points of view—viz. from those of causation, diagnosis and treatment. The first symptom to be considered will be that of vomiting.

VOMITING

Causation.—Vomiting may occur as a direct gastric reflex; as an associated reflex connected with other reactions occurring in distal parts of the body; as the result of disturbances of the central nervous system; as the result of psychological processes, or as the result of malformations or organic abnormalities. Taking each of these groups independently they may be further subdivided in the following manner:—

(A) Vomiting as a Gastric Reflex.—The following are the more usual varieties of vomiting included in this group:—

(1) Overfilling of the stomach with otherwise suitable food.

(2) Irritation of the gastric mucous membrane by poisonous or stimulating food or by the presence of foreign bodies (worms, etc.).

(3) Irritable conditions of the gastric mucous membrane due to an existing catarrh, ulcer, etc.

(4) An irritable or overactive condition of the musculature of the stomach.

(5) Delayed or defective emptying of the stomach from (*a*) pyloric spasm; (*b*) pyloric stenosis; or from (*e*) dilatation of the stomach from any cause.

(6) Perverted action of the cardiac sphincter.

(B) **Vomiting as an Associated Reflex.**—Vomiting of this kind may occur when violent reactions are evoked in other parts of the body. Severe pain of any kind may be accompanied by vomiting. In the case of infants abdominal pain, due to colic or other violent spasms of the intestinal musculature, is particularly liable to cause vomiting. The ordinary gastro-enteritis of infancy, which is accompanied by combined vomiting and diarrhœa, is more often than not due to an uncomplicated enteritis, in which the vomiting is a secondary and associated symptom of the enteritis. Some of the more common forms of vomiting due to associated reflexes are:

(1) Violent and painful peristaltic movements of the intestinal tract due to obstruction, appendicitis, colitis or intestinal colic of any kind.

(2) Renal, biliary or other forms of colic.

(3) Violent respiratory reactions, such as coughing, etc.

(4) Irritation of the pharynx.

(C) **Vomiting due to Central Nervous Causes.**—Irritation of any part of the central nervous system from injuries or inflammatory causes may give rise to vomiting. The more common of these are included under the following headings:—

(1) Tumours, injuries and inflammatory conditions giving rise to mechanical irritation of the brain, medulla, spinal cord, or of the meningeal membranes.

(2) Irritation of the central nervous system by blood conditions (infections, toxæmias, uræmia, acidosis, etc.).

(3) Psychological influences (suggestion, habit, emotional states, etc.)

(D) **Vomiting due to Malformations and Organic Causes.**—Malformations and other organic conditions which interfere with the normal carriage of food through the intestinal tract almost invariably lead to vomiting. Among the more common causes of this kind are:

(1) Œsophageal pouches, stenoses, strictures, etc.

(2) Malformations of the stomach and intestines which interfere with the transit of food. Imperforate anus, obliteration of the duodenum, persistence of Mechel's diverticulum, etc.

DIAGNOSIS

Since the rational treatment of vomiting must be based on a correct diagnosis of the cause, it is essential that the latter should be made as accurately as possible by a careful review of all the available evidence. In the first place it is advisable to decide to which of the above-mentioned groups the particular case under consideration belongs—whether, for instance, it should be assigned to the category of central nervous causes, or to some independent pathological conditión of which vomiting is only an associated symptom. The following are some of the sources of information which may help one to arrive at a correct diagnosis.

(1) **The History.**—It is extremely important to learn by inquiry the complete history of the case, its duration, its mode of onset and its association with other symptoms. It is particularly important to know whether the vomiting is directly connected with food causes or whether it is possibly a symptom of an independent constitutional or nervous disturbance. The possibility should never be lost sight of that the vomiting, although originally due to some definite pathological cause, may persist merely as a habit.

(2) **The Character of the Vomiting.**—This may take the form of mere "possetting" or regurgitation of food. When this is the case a small quantity of food is usually returned immediately after a feed, either with or without the expulsion of wind. Vomiting of this kind is usually unaccompanied by other symptoms, and relief generally follows the act. If the vomiting is explosive, projectile, effected without effort, and unconnected with the intake of food, it is probably due to some central nervous cause, especially if it is recurrent and attended with no sense of relief.

If the vomiting is preceded by distress, accompanied by effort and followed by relief it is generally due to some disturbance connected with the intake of food.

If the vomiting affords no relief, and is accompanied by much retching without being actually projectile, the possibility of renal or biliary colic must be taken into consideration.

(3) **The Character of the Vomitus.**

(*a*) The quantity of the vomit affords useful information. As a rule it is large in cases of dilatation of the stomach due to obstruction at the pylorus or elsewhere. A small quantity voided immediately after a feed may be due merely to overfilling, to the expulsion of wind or to habit. If the quantity of the vomit is small, and if it occurs some hours after the intake of food, it is usually due to incomplete emptying, or to some associated intestinal disturbance, set up by the entry of food into the intestinal tract.

(*b*) The appearance of the vomit also affords diagnostic information. It may, for instance, contain undigested food—such as the curd of milk; unmasticated food—such as currants, raisins, fruit skins, orange peel, pieces of meat or cheese.

The length of time which intervenes between the intake of food and the vomiting naturally modifies the condition of the vomited matter. If undigested food is returned after it has remained in the stomach for any considerable period of time it should be regarded as evidence of imperfect digestion. On the other hand, if food is returned immediately after consumption it can hardly be expected to show signs of digestion. If milk is vomited immediately after consumption in a coagulated condition it is justifiable to assume that the stomach contains the remains of a previous feed.

(*c*) The reaction. This may be acid, alkaline or neutral. If acid it must be decided whether the acidity is due to hydrochloric or lactic acid. The degree of acidity may be estimated by titration with decinormal NaHO.

(*d*) The odour. An offensive odour implies regurgitation from the intestines, due to obstruction in the bowel (stercoraceous vomiting), or decomposition in the stomach owing to defective emptying.

(*e*) The presence of mucus, blood or pus. Excess of mucus indicates a catarrhal condition; blood indicates much retching, ulcer or purpura; pus is suggestive of an advanced catarrhal condition or of an ulcer.

(4) **Evidence of the Wash-out.**—Lavage of the stomach gives important information with respect to (1) the capacity of the stomach; (2) the reaction of the contents; (3) the nature of the contents; and (4) the rate of emptying.

For diagnostic purposes the stomach should be washed out shortly before a feed is due by means of a catheter or stomach tube attached to a glass funnel with a convenient length of india-rubber tubing. The total capacity of the stomach can be estimated by the quantity of water capable of admission to the stomach under about twelve inches of pressure.

The reaction of the washings should be tested by litmus paper, and if found to be acid, the degree of acidity should be estimated by titration with decinormal NaHO, allowance being made for the quantity of water admitted to the stomach.

The nature of the contents. The residuum left in the stomach some two or three hours after the last feed affords important evidence as to (1) the digestive efficiency of the stomach; (2) its emptying capacity and (3) the presence or absence of catarrh.

(5) **Evidence of X-Ray Examination.**—Examination by means of a bismuth or barium meal gives most important information with regard to the size, position, movements and emptying capacity of the stomach; it also affords valuable evidence as to the character of the intestinal motor functions and the rate of transit of food through the alimentary tract. This aid to diagnosis should never be omitted in doubtful cases.

(6) **The Character of the Stools.**—An examination of the stools often helps to elucidate the cause of vomiting. In pyloric stenosis or spasm there is usually obstinate constipation, and if the bowels open at all the motions for the most part consist of mucus. If the stools are fairly copious, and of normal consistency, it is quite evident that food passes freely through the pylorus, and consequently a diagnosis of stenosis is excluded. If the motions give evidence of intestinal irritation, by the presence of a green coloration, undigested food, blood or mucus, and especially if the motions are particularly frequent, the possibility must be considered of the vomiting being due to a primary intestinal cause.

(7) **The Character of the Associated Symptoms.**—A careful review of the concomitant symptoms frequently throws considerable light on the cause of the vomiting. If vomiting is only

one of several symptoms occurring concurrently, it is important to decide whether food is a factor in the etiology of the whole complex or whether the latter is quite independent of it, since in the latter case dietetic treatment is not calculated to afford relief.

TREATMENT

(A) Vomiting due to Gastric Causes.

(1) **Overfilling of the Stomach** may give rise to immediate regurgitation, or "possetting," as it is sometimes called. In breast feeding the quantity of milk consumed at a meal should be estimated, and if found excessive should be reduced to normal proportions (see p. 37). Even without overfilling regurgitation may occur, in bottle as well as in breast feeding, if the infant is "joggled" or unduly disturbed immediately after a meal.

If overfilling has led to dilatation or hypertrophy of the stomach the latter may be helped to return to its normal size by a daily washing-out of its cavity, and by the careful regulation of the amount of food supplied. If dilatation has not occurred regulation of the quantity will fulfil all the required conditions without resorting to lavage of the stomach.

(2) **Irritation of the Stomach by Inappropriate or Indigestible Food.**—In infants the food which usually proves most irritating to the stomach is cow's milk, whether whole or diluted, the degree of irritation being more or less directly proportionate to the degree of concentration. The irritation is due to the formation of curds in the stomach, which are not permitted to escape through the pylorus. If heavy curds of casein are noticed in the vomit, especially when the vomiting occurs some hours after a meal, the milk must be given in a form which does not lead to the formation of a bulky coagulum. Various expedients can be employed to secure this result. The caseinogen may be precipitated before it is given to the infant, as in the preparation of "Eiweissmilch" (see p. 211); barley water may be used in the place of plain water in the preparation of the milk mixture, or citrate of sodium may be added to the mixture. The plan of

diluting the milk to the degree of toleration has the disadvantage that the infant may then be starved with respect to the most important of all its food constituents —*i.e.* protein.

Excess of fat is a frequent cause of vomiting, especially in certain cases in which there is fat intolerance. Vomiting due to this cause generally occurs late, usually after an interval of two or three hours. The vomitus is often strongly acid, and is sometimes coloured with bile which has regurgitated from the duodenum into the stomach (see p. 39). In cases of vomiting due to excess of fat the proportion of the latter element must be reduced in the food, and compensated for by giving an equivalent quantity of carbohydrate—that is to say, two parts by weight of carbohydrate for every part of fat omitted. Ordinary condensed milk, which contains a high percentage of sugar and a low one of fat, is often useful as a temporary substitute for other varieties of food which lead to fat vomiting; but its shortcomings as a permanent food must not be lost sight of.

(3) **Irritable Conditions of the Gastric Mucous Membrane.**—Catarrhal conditions of the stomach are comparatively common in infants, and when they exist, either in the acute or chronic form, the vomiting is usually very persistent, even though the food itself is entirely free from irritating qualities. In cases of gastritis of these kinds vomiting is followed by relief, although the child, owing to excessive thirst, appears perfectly ready to take more food. The treatment in cases of acute gastritis is to withhold all food for 12 to 24 hours, during which time thirst may be assuaged by teaspoonfuls of cold sterile water, and by the subcutaneous injection of isotonic saline solution, which may be supplied in quantities corresponding to the rate of absorption. Rectal injections of the same solution serve a similar purpose. After subsidence of the acute symptoms the return to a normal dietary must be cautiously undertaken. The treatment of chronic cases of gastric catarrh cannot, for obvious reasons, be conducted on starvation lines, but every effort must be made to enable the stomach to

retain food, and admit of its passage into the duodenum. In order to effect this object the three following conditions should be fulfilled :—

(*a*) The stomach must be washed out daily and freed of excess of mucus.

(*b*) The food must be as little irritating as possible. There is probably no better food than a well-peptonised cow's-milk mixture of breast standard.

(*c*) The irritability of the stomach must be allayed, as far as possible, by some such mixture as the following :—

℞

Glycerini bismuth. carb. (B. P. Codex) . .	ʒss
Tinct. camph. co.	♏i
Aq. menth. pip.	♏x
Aq. anethi ad	ʒi

Signa.—To be taken a few minutes before each feed.

(4) **Irritability or Overaction of the Musculature of the Stomach.**—In certain conditions of irritability of the neuro-muscular elements of the stomach, vomiting is a troublesome and prominent feature due to perverted or incoordinated action of those muscles, or groups of muscles, which carry out the motor functions. Spasmophilic, rickety and teething infants are liable to give evidence of their nervous irritability in this way if liberties are taken with their feeding. X-ray examination and the opaque meal afford accurate information of the particular abnormality of the motor functions which gives rise to the vomiting. Apart from the careful regulation of the dietary on physiological lines, the treatment consists in the therapeutic management of the underlying condition.

(5) **Delayed or Defective Emptying of the Stomach.**—This condition is easily diagnosed by means of X-ray examination, and by the evidence of the "wash-out."

The simple expedient of placing the infant on its right side sometimes facilitates the emptying of the stomach. In all severe cases of dilatation of the stomach in babies, the daily washing out of the stomach is the best treatment. If the wash-out is found to be unduly acid the viscus may be irrigated with a 5% solution of bicarbonate of soda, while in the rare instances in which the stomach contents are alkaline a solution of common salt of the same strength may be substituted.

Under conditions of incomplete emptying the best food is a well-peptonised milk modification of breast standard which contains a small quantity of veal broth or gelatine solution.

Pyloric spasm is usually well controlled by these simple expedients. Pyloric stenosis, if not severe, yields to similar treatment, although intractable cases may require surgical interference.

(6) **Perverted Action of the Cardiac Sphincter.**—Vomiting may occur from spasm or undue patentcy of this sphincter. When due to the former cause there is difficulty in swallowing more than a very small quantity of food, while vomiting or regurgitation begins to occur almost immediately after a feed. The returned food, which has not reached the stomach, but has been retained in the dilated œsophagus, is usually unaltered in appearance and reaction. This variety of vomiting is often called rumination, from its resemblance in type to the rumination of lower animals. This condition is most successfully treated by the forcible dilatation of the cardiac sphincter by the passage of a bougie, or a special form of pneumatic cardio-dilator.

Aerophagy, or the swallowing of air, with persistent belching of wind or regurgitation of food, is a habit sometimes acquired by quite young infants. As this habit is occasionally acquired owing to ineffectual attempts to extract milk from an empty breast or from a bottle with a faulty nipple, with the consequent swallowing of air, the symptom may be dealt with, and the habit broken, by temporary spoon-feedings.

(B) The Treatment of Vomiting as an Associated Reflex.—The dietetic treatment of cases of vomiting included under this heading does not call for detailed description here, as it will again be referred to in succeeding sections which deal with treatment of the symptom complex, of which vomiting forms a part—for instance, in the sections which deal with whooping cough, gastro-enteritis, intestinal obstruction, etc.

(C) The Treatment of Vomiting due to Central Nervous Causes.—Although vomiting is often the most prominent symptom of central nervous diseases in infants, its diagnosis and treatment will be included in the section which deals with disturbances of the central nervous system (p. 418). In this section also will be included vomiting which is due to irritation of the central nervous system by blood conditions, such as uræmia, acidosis, etc.

(D) Vomiting due to Malformations and Organic Causes.—The treatment of vomiting due to these causes falls more properly to the task of the surgeon. It is mentioned here, however, in order to prepare the reader for meeting with occasional cases of this kind which will not respond to dietetic treatment. Under this head fall cases of vomiting due to obstruction owing to malformations of the alimentary tract, hernias, volvulus, intussusception, duodenal ulcer, imperforate anus, etc.

CHAPTER II

THE DIGESTIVE SYSTEM (*continued*)

DIARRHŒA

Causes—Diagnosis—Treatment

Causation.—As already mentioned, diarrhœa is primarily a protective reflex to rid the intestinal tract of poisonous or irritating material. Unfortunately, however, this symptom is not restricted to this prophylactic object: it may occur as an associated reaction without any specifically protective purpose. It is quite possible that under most conditions of disturbance of health purgation may have an advantageous and teleological significance, but in young infants at least the automatic mechanisms which call this reaction into play are unable to differentiate between those conditions which are benefited by purgation and those which are not, and hence diarrhœa is, in nearly all cases of infantile illness, a frequent though a misleading symptom. We are apt to conclude, for instance, that all infants suffering from D. and V. (diarrhœa and vomiting) are suffering from a specific intestinal infection, although these two striking symptoms may be merely prodromal evidences of some entirely independent condition, such as pneumonia, influenza or septic infection. For this reason it is obviously of importance to be able to differentiate between diarrhœa which is merely an associated symptom of some independent pathological condition and diarrhœa which is due to some primary disturbance of the intestinal tract.

It is not always easy to determine what degree of looseness or frequency of the bowels constitutes diarrhœa. Infants often have somewhat frequent and loose actions of the bowels apart from other symptoms, and without apparent detriment to health. The act of defæcation is an associated reflex which is largely dependent on the entrance of food into the stomach. Infants who are fed too often or on excessive quantities of food may acquire a habit of "rapid transit" with frequent actions of the bowel quite independent of any disturbance of the other functions of the alimentary tract. The neuro-muscular mechanisms which control the functions of defæcation may acquire a high degree of sensitiveness, which leads to an evacuation on very slight provocation. So-called lienteric diarrhœa is often of this character.

When we can exclude all other factors apart from food causes in any particular case of diarrhœa, we are still faced with the difficulty of assigning the condition to the particular element which is responsible for the trouble; the fault may be one of quantity or of quality. The one fault in the food, however, which, as a cause of diarrhœa, surpasses in frequency all others combined is that of excess in total quantity quite irrespective of the qualitative "make-up." On the other hand, special qualitative faults in the food may determine an attack of diarrhœa quite apart from the presence of any actual excess of any one particular element, or of all in combination.

If we are able to single out the particular fault in the dietary which is responsible for the diarrhœa the difficulty still remains of deciding whether the disturbance is due to the irritant character of the food itself or to the irritant influence of its decomposition products. To give an example. The irritant effect of fig seeds may produce a condition of diarrhœa without any change in the seeds themselves, whereas such a comparatively digestible food as sugar may lead to the same condition if the latter undergoes fermentation in the bowel. I am very strongly of the opinion that most food causes of diarrhœa owe their effects to the results of bacterial fermentation or decomposition rather than to the particular irritant properties of the unaltered food. If fermentable or decomposable food material passes through the ileo-cæcal valve into the ascending colon it at once becomes pabulum for bacteria, and the products of their activity may lead to irritation of the mucous membrane and consequent diarrhœa. Diarrhœa may thus be set up by food material which is, in itself, digestible and harmless, if such material is supplied beyond the digestive capacities. All those conditions, therefore, which tend to make an otherwise correct dietary relatively excessive may be predisposing or causative factors in the determination of diarrhœa. Quite apart from the actual irritant qualities or the excessive quantities of the food, diarrhœa may be set up by unfavourable alterations in the bacterial flora of the intestine. The various causes which lead to unfavourable combinations of the bacterial elements in the bowel, or to special degrees of virulence in any one of them, are at present almost unknown; the introduction of new species and special infections are obvious factors in the problem, but, quite apart from this cause, food conditions certainly play an important rôle, since alterations in the media in which bacteria grow materially modify their functional and even their morphological characteristics.

No classification of the different varieties of diarrhœa in infancy and early childhood is wholly satisfactory. The most important distinction is between those which are chronic and those which are acute, the further subdivision into those which are due to food causes and those which are due to infection is helpful in selecting the most rational line of treatment. The following classification is arranged with a view to simplifying the difficulties.

Chronic diarrhœa may be due to:

(1) The defective digestion of food owing to:
 (*a*) Excess as regards quantity.
 (*b*) Irritant properties or other defects in the quality of the food.
 (*c*) Defects in the digestive secretions (acholia, pancreatitis, etc.).

(2) Infective causes:
 (*a*) Definite and specific infections of the bowel, such as those of tuberculosis, syphilis, dysentery, etc.
 (*b*) Indefinite infections leading to chronic catarrhal or membranous inflammations of the small or large intestine.

(3) Constitutional and wasting diseases due to chronic infections and blood conditions.

(4) Nervous causes; psychological conditions and habits.

(5) Endocrine causes: hyperthyroidism, disease of adrenals, etc.

Acute diarrhœa may be due to:

(1) Food causes:
 (*a*) Excess in quantity.
 (*b*) Irritating or poisonous qualities in the food (sour fruits, ptomaine poisoning, etc.).

(2) Purgatives or irritant poisons.

(3) Onset of some general infection, such as pneumonia, influenza, measles, etc.

(4) A definite intestinal infection:

(*a*) Summer diarrhœa, due to, or associated with, various infective organisms, such as the bacillus pyocyaneus, gas bacilli, streptococci, etc.

[i] Mild form.

[ii] Severe epidemic form.

[iii] Cholera infantum.

(*b*) Acute dysenteric ileo-colitis (catarrhal, ulcerative or membranous form), generally associated with the presence of the bacillus dysenteriæ of Shiga.

(*c*) Typhoid and paratyphoid fevers.

(5) Intussusception.

DIAGNOSIS

The distinction between chronic and acute cases of diarrhœa is somewhat arbitrary since there is no definite line of demarcation at which the one passes over into the other. However, from the practical point of view, if an attack of diarrhœa lasts for more than a few weeks it may be regarded as chronic.

The Diagnosis of the Causes of Chronic Diarrhœa.—The history affords valuable evidence, especially that which relates to the character of the onset. Chronic cases of dysentery or ileo-colitis usually have an acute onset; chronic diarrhœa due to tuberculosis and syphilis more often begins insidiously and shows other specific indications, while chronic diarrhœa due to habit, rapid transit or nervous cause is accompanied by comparatively mild constitutional disturbances, and little loss of weight. On the other hand, diarrhœa due to constitutional diseases, blood conditions and endocrine disturbances can usually be recognised by the concomitant symptoms.

The temperature chart should always be carefully studied in cases where the cause is doubtful: it is characteristically irregular in tuberculous cases; there is usually some pyrexia when there is hyperthyroidism; while in syphilis and ileo-colitis from any cause the temperature is usually subnormal.

A tuberculous origin can generally be proved by the characteristic reaction to a diagnostic injection of Koch's old tuberculin. The Wassermann reaction reveals syphilis, and the agglutination test usually comes off after five or six days when the diarrhœa is due to the bacillus of dysentery.

The stools also give invaluable information. In lienteric diarrhœa and cases of rapid transit undigested articles of diet are usually discoverable in the motions. In ileo-colitis pus and mucus in various forms, and occasionally blood, are present in the motions; these should be carefully examined at the time they are passed, and subsequently they should be washed out in a large quantity of water. By these means the site of the inflammatory process and the character and degree of the damage can often be detected. If the mucus is intimately mixed with the motions the situation of the inflammation is probably in the small intestine or proximal portion of the large. If the inflammation is in the lower part of the colon the mucus is not evenly incorporated with the fæces, but it is passed independently, sometimes at the beginning, sometimes at the end of a motion. With inflammation of the pelvic colon or rectum, jelly-like motions are usually passed at short intervals, with straining and tenesmus, occasionally also with blood and pus. In membranous colitis definite pieces of membrane can be detected in the motions on washing out with water. T. B. bacilli can usually be discovered on careful microscopic search in cases of tuberculous ulceration of the bowel. In diarrhœa due to acholia, cœliac disease or pancreatic insufficiency, the stools are usually light coloured, fatty, copious and offensive.

The Diagnosis in Acute Diarrhœa.—In a case of acute diarrhœa the most important points to settle are whether the condition is due to food causes, to definite infections, or whether it is merely a prodromal symptom of some constitutional illness. If due to the first cause the diarrhœa should rapidly subside after the peccant material has been voided and the first results of the irritation set up in the bowel have passed off. If due to the second cause the diarrhœa continues in spite of the complete evacuation of the bowel contents, while constitutional symptoms such as pyrexia and collapse ensue. If due to the third cause neither the diarrhœa nor the constitutional symptoms which accompany it usually subside after the contents of the bowel have been completely evacuated. As a rule, the temperature is disproportionately high and other focalising symptoms may appear.

The facies and general attitude in acute summer diarrhœa are characteristic; the expression is usually mask-like, the eyes are sunken, the complexion is of a lead colour and the child as a rule lies on his back in a collapsed condition with the legs extended and flaccid. The child with summer diarrhœa looks, and in fact is, in a condition of pronounced collapse, whereas the infant suffering from ileo-colitis has, as a rule, less serious constitutional symptoms, while the local conditions dominate the picture.

In ileo-colitis there is usually evidence of severe abdominal pain, the legs are drawn up and there may be considerable tenesmus.

The diarrhœa which accompanies intussusception is seldom misconstrued, but acute diarrhœa with blood in the motions is frequently mistaken for intussusception. The latter usually begins acutely, and is accompanied with pain and shock, while the frequency of motions of blood and mucus without fæcal matter is pathognomonic of the condition. As a rule, an abdominal tumour can be diagnosed by manual examination of the abdomen, but a digital examination "per rectum" should never be omitted. By the latter means I have frequently been able to palpate an abdominal tumour unrecognisable on external examination. In this connection it must be remembered that a pelvic abscess of appendicular origin can also be accompanied by frequent actions of the bowels and tenesmus, but when this is the case bladder symptoms may also occur and help to clinch the diagnosis.

The Bacteriological Evidence.—Considerable attention has recently been paid to this point, but as a rule the findings come too late to be of practical use. The particular form of organism responsible for the trouble is seldom recognisable by macroscopic examination of the stools, except in the rare instance of infection by the bacillus pyocyaneus, which reveals its presence by a characteristically greeny blue coloration which disappears on the addition of nitric acid.

Diarrhœa due to streptococcal infection can usually be diagnosed by immediate microscopical examination, since these organisms, when responsible for the trouble, are generally present almost in pure culture.

The gas bacillus can be recognised in eighteen to twenty-four hours by the following test. A small portion of the stool is added to a test-tube of milk and boiled for three minutes. After incubation for the best part of a day, if the gas bacillus is present, most of the casein is liquefied, and such solid coagulum as remains becomes honeycombed and pinkish in colour, while the odour of the gases generated is that of rancid butter.

From the point of view of treatment it is of extreme importance that the differential diagnosis should be made between diarrhœa due to gas bacilli (and allied organisms) and that due to dysentery bacilli, colon bacilli or streptococci, since the line of treatment which is indicated in the one case is diametrically opposed to that required in the other. Unscientific and unsatisfactory as the method may be, we are, in the majority of cases, driven to base the treatment of cases of diarrhœa of unknown cause on the evidence derived from our experience of other cases of diarrhœa occurring at the same time and in the same place. If in previous cases any one particular line of treatment has proved successful, or unsuccessful, it should serve as a valuable indication in the treatment of subsequent cases, since in the same epidemic most of the cases are of the same type.

An agglutination reaction is usually present by the end of the first week when the bacillus dysenteriæ is the responsible organism.

TREATMENT OF CHRONIC DIARRHŒA

Cases due to constitutional, nervous and endocrine causes will not be dealt with here, since the treatment required goes beyond mere dietetic management. The two important classes are (1) those due to food causes; and (2) those due to infectious causes.

Cases due to Food Causes.—When chronic diarrhœa occurs it is most important that a distinction should be made between cases which are due to faulty digestion and those which are due to constitutional conditions. Nutrition is often allowed to suffer because infants cannot digest ordinary varieties of food which are obviously required to fulfil the physiological needs; under such circumstances nutrition ought not to be allowed to suffer in consequence of failure of digestion, but the required quantity of food should be supplied in a form which is adjusted to the capacities of the digestive functions. Infants are often starved because they cannot digest sufficient food to maintain nutrition; this disaster should be avoided by supplying sufficient food in an adequately predigested condition. In chronic diarrhœa due to food causes the question of quantity must be carefully considered, and so must that of "balance" and the provision of the necessary accessory factors. If the symptom can be referred to faults in any one of these respects the error must be adjusted in the hope that a cure may result. If, on the other hand, no fault can be found with respect to quantity, quality or accessory factors the question of the digestibility of the food must be taken into serious consideration, even though at first it may appear to be beyond reproach.

If some fault of digestion is responsible for the condition the question still to be settled is whether or not the trouble is associated with some defect in absorption.

The treatment will naturally depend on the diagnosis which is made. If there is concomitant frothiness of the stools the diagnosis of carbohydrate excess is justifiable ; fatty or soapy stools suggest excess of fat, while an offensive odour is indicative of protein excess. So-called " curds " in the stools of infants do not as a rule indicate an excess of protein, they imply the presence of soaps and fatty acids, for which a reduction in the total fat ration is indicated.

In children over one year of age various undigested remains may be found in the stools which may suggest by their particular characteristics a restriction of special articles of diet, or call for more complete mastication on the part of the child.

Diarrhœa due to Infective Causes.—Chronic cases of diarrhœa due to such specific infections as tuberculosis, syphilis or amœbic dysentery must be treated in accordance with the particular indications ; as long as the diet fulfils the laws of physiological feeding no special modification is required. In the case of children more than one year old it is always desirable to avoid indigestible and irritating articles of diet which contain seeds, pips or skins of vegetables or fruits, which are liable to irritate the mucous membrane of the bowel.

Diarrhœa due to Miscellaneous Organisms.—In this class are included the majority of cases of ileo-colitis and proctitis. Since time is not an important factor in the treatment, the delay necessary for a complete bacterial examination need not stand in the way of a rational solution of the problem. If any special organism can be ultimately incriminated as the definite cause of the trouble the delay in beginning rational treatment is well justified.

Specific infections require specific treatment, quite apart from ordinary dietetic measures, but all the same there are certain principles of treatment which apply to most cases of chronic ileo-colitis, among the more important of which are the following :—

(1) The damaged mucous membrane must be protected as far as possible, by avoidance of foods which are indigestible or which are apt to cause irritation.

(2) The mucous membrane must be protected as far as possible, by such drugs as bismuth and petroleum (p. 322).
(3) Intestinal decomposition and fermentation must be checked as far as possible, by such drugs as salol, Dimol and other phenol derivatives.
(4) The inflammatory condition of the bowel must be treated by local applications and high irrigation (Plombière method).
(5) Violent or excessive peristaltic movements must be controlled by opium or other sedative medicaments.

The Treatment of Acute Diarrhœa.—In all cases of acute diarrhœa, from whatsoever cause arising, the first essential is to clear the bowel of its irritant contents. A moderate-sized dose of caster oil is the best means of securing this end, but when once the bowel has been emptied rest as complete as possible should be secured by the withholding of all food for some 24 hours or longer, and by the exhibition of opium. In children over one year of age small doses of chlorodyne are most efficacious for this purpose, but in young infants opium and opium preparations must be given with extreme caution, and for this purpose I recommend the giving of very small doses of tincture of opium or Nepenthe, say an eighth of a drop at half-hourly intervals until the desired result has been secured. By this means, in cases of intolerance, the serious results of an overdose of the drug are avoided.

In cases in which there is collapse, with depression of the fontanelle, weak pulse, etc., the hypodermic injection of isotonic saline is often invaluable in maintaining the blood pressure, with or without a supplementary dose of camphor ($\frac{1}{4}$ gr.) dissolved in oil. The amount of saline to be injected should be strictly determined by the rate of absorption, the essential condition is that a small reservoir of the fluid should be kept in existence so that there may always be an adequate reserve. In the first instance from 2-3 oz. of fluid should be injected. If this amount rapidly disappears it should be immediately replaced by a somewhat larger quantity in a new situation. If it is only slowly absorbed the next injection may be on a smaller scale. As far as I am aware, the vaunted advantages of sea-water injections are entirely unjustified, but in those cases in which symptoms of acidosis and rapid breathing complicate the condition there are distinct advantages in adding 5% of sodium bicarbonate to the isotonic solution.

It is often claimed that intestinal antiseptics are worthless for the treatment of acute diarrhœa, and chiefly for the reason that there is nearly always penetration by the infective organisms into the submucous tissues, or even into the lymphatic and blood systems. I cannot say I concur in this policy of inactivity, for something may be done by the use of such antiseptics to limit the multiplication of organisms in the lumen of the bowel, if nothing can be done to destroy them after invasion of the tissues. The antiseptics which I have found most useful are Izal, given in 1-2 minim doses, or Dimol, which is said to be forty times more efficient as a germicide than pure carbolic acid itself, may be tried. This drug may be given in the form of a syrup in drachm doses every two or three hours in cases of acute summer diarrhœa.

Irrigation of the bowel is of decided value, not only in the acute stages of an attack, but also in the more chronic stages at a later date. The great difficulty in employing irrigation of the bowel is to ensure that the fluid reaches sufficiently far into the colon; if the operation is badly performed the fluid merely distends the rectum and does not even reach the pelvic colon. The irrigation should be performed by a properly trained nurse, who should use a small-sized, long rectal tube and an irrigation can large enough to hold two or three pints of water. This can should be held at a level about eighteen inches above that of the buttocks of the child, and the tube should be passed gently into the rectum or beyond while the water is flowing freely from the nozzle; in this manner the bowel is opened up and angles are straightened out, in fact the tube follows the stream without inflicting damage on the mucous membrane by being caught in a kink or cul-de-sac.

As a rule it is not necessary to add anything to the irrigation fluid, but if thought desirable a small quantity of permanganate of potash, boracic acid, iodine or common salt may be dissolved in the lotion. The temperature of the fluid should be in accordance with the condition of the child. If there is much fever, irrigation with a comparatively cool lotion, say at 90° F., will act as a useful antipyretic. On the other hand, if there is collapse and a low temperature, the fluid may be injected at a temperature of 102° F.

During the operation the child should be placed on his back with the hips elevated by means of a pillow so as to allow gravitation to promote the flow of fluid into the colon. The operation should be continued until the outflowing water is practically clear, and may be repeated two or three times a day during the acute stages of the attack.

Diet.—In cases of acute diarrhœa the management of the diet is one of the most important elements in the treatment, since the contents of the bowel materially modify the rate of growth and the degree of virulence of the infective organisms. It must not be assumed that complete and prolonged abstinence from food is indicated in all cases of acute diarrhœa, for the reason that in the absence of food the lumen of the bowel soon becomes charged with inflammatory secretions from the mucous membrane, which are albuminous in character. On such a pabulum organisms of the type of the bacillus dysenteriæ, the colon bacillus and streptococci flourish exceedingly and produce their most deadly toxins. For the same reason the giving of egg water is contraindicated. On the other hand, a good deal can be said for the exhibition of barley water and other cereal decoctions, since carbohydrate foods of this kind have a distinctly inhibitory effect on the growth of bacteria belonging to the above groups, while the fermentative changes set up in this kind of food are not seriously toxic. It is evident, therefore, that when the diarrhœa is due to organisms belonging to any of the above types the food should be of a carbohydrate nature and that nitrogenous foods should not be given until the acute stages of the attack have passed. Peptonised milk is probably the safest food to commence with during convalescence.

If, on the other hand, the cause of the diarrhœa can be traced to the gas-forming type of bacilli the indications are to reduce the carbohydrates in the diet and to introduce acid-producing bacteria of the lactic-acid type. For this purpose there is nothing better than whey prepared from the dried powder (Sec-Wa) and ripened with lactic-acid bacilli of the Bulgarian strain. Buttermilk, if it can be obtained, answers the same purpose. When, as the result of this treatment, the acidity due to lactic acid reaches a certain degree of intensity, the further development of gas bacilli is inhibited.

These facts emphasise the importance of being able to diagnose, or to make a shrewd guess at, the type of organism responsible for an attack of diarrhœa.

CHAPTER III

THE DIGESTIVE SYSTEM (*continued*)

CONSTIPATION

General Remarks—Causation—Treatment of Children under 9 Months of Age—Treatment of Children over 9 Months of Age

General Remarks.—The mere passage of somewhat solid motions does not constitute constipation proper, even in comparatively young babies, it is only when there is no regular movement of the bowels, or when no action has occurred for several days, that the term constipation can be justifiably applied to the condition. In babies a mild degree of constipation is far less serious than a corresponding degree of diarrhœa ; indeed the exercise given to the muscular mechanisms of the bowel in the expulsion of a formed stool is of more value from the educational point of view than the mere gravitation of liquid fæces through the pelvic colon and rectum, but the actions of the bowel should naturally be regular if they are to ensure the establishment of good and permanent habits. From the first month of life onwards a motion of butter-like consistency is the most favourable kind that an infant can pass.

Causation.—The causes of constipation are many and various (see p. 79). The most common one in infants is the abuse of purgative expedients of different kinds—such as the early dose of castor oil given to clear out the meconium, the injection of soap-and-water enemas and the introduction into the rectum of glycerine suppositories. All these methods are usually regarded as harmless and efficacious means of facilitating the act of defæcation in cases of delay in the opening of the bowels ; all of them are, however, in my experience prolific causes of chronic constipation. The employment of cow's-milk mixtures in which the "balance" has not been properly adjusted, especially when the error is connected with excess of protein or fat, is probably the next most common cause of constipated actions. Atony of the bowel wall and dilatation of the colon, and especially of the pelvic portion, in rickety and debilitated conditions are frequently predisposing causes of constipation. Mentally defective infants and children are specially liable to intestinal stasis, so also are those suffering from hypothyroidism. At all ages habit, suggestion and mental concentration play most important rôles in the execution of the important function of defæcation.

Treatment.—It is far easier to prevent constipation than to cure it after it has become habitual. The early training of the infant is the most important essential to ensure this end. All infants should be taught to respond to the application of a soap-dish or chamber to their buttocks or to the influence of being " held out " from the first day of life onwards, methods of suggestion which should always be applied at the same time every day. Purgatives, and especially castor oil, should be avoided at all costs. The most appropriate method of treating an existing case of constipation will depend upon the cause.

In the first place attention should be directed to the consistency of the motions. If they are soft, liquid, or of such a nature as to require no effort to expel them, it is obvious that any attempt to render them more liquid will only defeat its own objects. On the other hand, if they are hard and scybalous, liquid paraffin may be of the greatest use.

The great object in all cases should be to re-establish the bowel function by educational means. To do so it may be necessary to employ for a time drugs which act upon and tone up the neuromuscular mechanisms, such as nux vomica, senna, cascara sagrada or belladonna. Adequate doses of such drugs, either singly or in combination, should be given at such time as to be effective at the hour of election, which is preferably at some time in the morning, say about eight o'clock. When this hour comes round the child should be encouraged in every way to make an independent and co-operative effort by being held out or placed on a chamber. At the same time the abdomen may be massaged along the axis of the pelvic colon, and any other expedient, which suggests itself to promote or initiate an action, may be adopted. The following formula is to be recommended for a convenient and efficient aperient :—

℞

Tincturæ aloes	♏iii
Tincturæ belladonnæ	...
Tincturæ nucis vomicæ āā	♏i
Syrupum ficorum ad	ʒi

If thought desirable, elixir cascaræ sagradæ can be substituted for the tincture of aloes, or given in combination with it.

It is important that the first dose should be adequate, but henceforward it should be decreased daily, until, finally, it can be omitted altogether. If at any time during the course of treatment the motions become hard an independent dose of liquid paraffin should be given.

The dietetic management, both in the prevention and cure of constipation, must be made to conform with the general principles of physiological feeding. In the first place, it must be remembered that excess of fat is, in itself, by no means an uncommon cause of constipation, so that inquiries should be directed to discover the total consumption of fat in the 24 hours. If this is found to exceed the normal physiological limit, and especially if the stools are soapy in character, the rational line of treatment is a temporary suspension of all fat and its gradual reinstatement up to the physiological standard, but not beyond, as the condition improves. Since fat is a cause of constipation the routine treatment of the condition by means of olive oil or cream requires careful consideration before it is adopted. If, on the other hand, there is clearly a deficiency of fat in the food, this error must be corrected by the addition of an appropriate amount to the dietary. In order that the reader may be able to estimate whether or not additional fat is required, he is advised to refer to the accompanying table, which gives the daily requirements of fat at different ages:

Table 77

To show the Average Fat Requirement at Different Ages: Total for 24 Hours

First Month	Third Month	Sixth Month	Ninth Month	First Year	Second Year	Fifth Year	Tenth Year	Twelfth Year
oz. 0·7	oz. 0·8	oz. 1·1	oz. 1·2	oz. 1·4	oz. 1·5	oz. 1·6	oz. 1·7	oz. 1·8

These figures are approximate only, but it will be noticed that, relatively to the total amount of food required by children of different ages, the proportion of fat becomes less as they grow older, although the net amount is greater. Constipation is never rationally treated by increasing the fat supply beyond the physiological limit.

The dietetic treatment of constipation in patients more than 9 or 10 months old is so different from, and so incomparably easier than, that of younger infants subsisting on an exclusive milk diet that the two classes of cases will be described separately.

THE DIETETIC TREATMENT OF CONSTIPATION IN INFANTS UNDER 9 MONTHS OF AGE

Care must be taken to avoid any permanent breach of the basic laws of physiological feeding in order to snatch a temporary advantage. In the first place, a careful review must be made of the details of feeding, and if any serious fault can be found with it—such as excess of fat, deprivation of any of the accessory factors or actual starvation—such errors should be corrected in breast-fed infants as well as in those subsisting on an artificial diet. There is no reason to believe that constipation in the mother can have any direct influence on the state of the bowels in the child, as is so commonly believed, but all the same the mother must not be allowed to suffer from vitamine starvation through the withholding of fruits and green vegetables, since deficiency symptoms in her are liable to be reflected in the child through abnormalities in her milk. I mention this fact because a large number of nursing mothers are unwisely deprived of green vegetables and fruit in the mistaken belief that the consumption of these articles of diet gives rise to green stools in the infant. There is no reason to fear the development of constipation in the breast-fed infant owing to inanition if the precaution is taken of applying the "test-feed." If, however, the milk appears watery, though adequate in amount, it can be submitted to analysis, and if found deficient in fat or other element the fault can be compensated for by supplementary feeding. Care, however, should be taken that the sample sent for analysis consists of representative portions of fore-milk, middle milk and strippings. Constipation existing in breast-fed infants, not obviously referable to dietetic causes, must be treated on the lines referred to on page 317.

In bottle-fed infants constipation is more amenable to dietetic control, since it is comparatively easy to introduce modifications in the food which may have the desired result. Excess of both fat and of casein is a common cause of constipation in infants fed on cow's milk, so that special care must be taken to ensure that the symptom is not due to either of these causes. On the other hand, excess of carbohydrate food is very rarely, in itself, a cause of constipation, unless the stage of rickets has been reached. It is, however, commonly believed that the substitution of starch, or indeed any new carbohydrate, such as maltose, for sugar, is a corrective to constipation. This view must not be acted upon indiscriminately, since new forms of carbohydrate food are not readily digested by young infants, and in the interim symptoms of indigestion are set up, with a temporary correction of the constipated condition. It is obvious that such a line of treatment, though temporarily successful, is not sound.

It is very rare that infants who have been physiologically fed from the first become really constipated, but all the same, constipation from any cause may continue as a habit even though the feeding be conducted on the very best lines. If on examination the food appears to be blameless the condition is most rationally dealt with on the educational lines already explained, and by the temporary use of drugs in accordance with the suggestions made on page 317.

THE TREATMENT OF CONSTIPATION IN CHILDREN OVER 9 MONTHS OF AGE

The treatment of constipation by dietetic means undoubtedly becomes easier as soon as the diet is expanded beyond milk feeding. The introduction of vegetables and fruits, containing as they do a considerable residuum of cellulose material, provides a most efficient means of filling up the bowel and giving it ballast to work upon. It is true that cellulose can be attacked by bacteria, with the evolution of marsh and other gases; but provided that flatulence and wind are not caused to any serious extent there is no danger in pushing this kind of diet to any reasonable extent. There is no reason to anticipate the supervention of diarrhœa in children subsisting largely on sound fruit and vegetables, provided that these foods are substitutes for, and not additions to, the normal carbohydrate requirements. The only reservation that need be made in connection with these suggestions is the avoidance of excess of sour or unripe fruits, or the swallowing of skins, seeds or pips, which are liable to set up irritation of the bowel. No children under 6 or 7 years of age should be allowed to consume fruits such as figs or raspberries, containing irritating seeds, since there is always a danger of colitis resulting.

Although temporary departures from the physiological dietaries set out in Tables 72-74 may be necessary as initial steps in the treatment of constipation, they must not be relied on as permanent measures; the ultimate aim must be regularity of habit under a normal dietetic regime. Apart from the treatment of special conditions, the following expedients will usually effect a cure of any ordinary case of constipation if a little patience is exercised :—

(1) A physiological dietary containing at first a slight preponderance of fruit and vegetables.

(2) Absolute regularity in going to stool supplemented by the exercise of will power reinforced by suggestion.

(3) Abdominal massage with appropriate exercises given with a view to developing the required muscular mechanisms.

(4) Small doses of petroleum emulsion (Semprolin) after each meal if the motions are hard, and diminishing doses of some tonic aperient, such as cascara sagrada or nux vomica, given every night if there is want of expulsive power.

CHAPTER IV

THE DIGESTIVE SYSTEM (*continued*)

Wind and Colic—Intestinal Toxæmia—Abnormal Stools—Large Motions—Scanty Motions—Frequent Motions—Liquid Motions—Dry Motions—Colourless Motions—Green Motions—Pink Motions—Fatty or Soapy Motions—Frothy Motions—"Curds" in the Motions—Membrane and Casts in the Motions—Cœliac or Mucous Disease

WIND AND COLIC

So-called "wind" is a very common symptom in infants. It is, however, not due merely to the presence of gas in the intestine, which is a perfectly normal and physiological condition, but it is due to inco-ordinated and spasmodic contractions of the muscles of the alimentary tract, set up by a variety of different conditions, including excess of gaseous contents. In breast-fed infants it may be due to excess in quantity or to faults of quality in the milk, but in the majority of cases it is caused by the perpetuation of a habit of dysperistalsis, often set up in the early days of life by some trivial event.

In artificially fed infants the fault is generally due to the giving of inappropriate food during the early days of life.

In older children abdominal pain, often described as wind or colic, is a very common symptom, and is usually due to the existence of some form of colitis or enteritis.

The treatment consists in (1) the regulation of the dietary on physiological lines; (2) on the administration of carminatives, lubricants, anti-spasmodics, etc; (3) massage of the abdomen, and (4) by the placing of the infant or child, belly downwards, on a hot-water bottle during the attack.

The following formula is invaluable in the treatment of persistent pain in babies or children due to spasmodic contractions of the bowel wall :—

℞ Glycerini bismuthi carbonatis (B. P. Codex) .	ʒss
Sodii bicarbonatis	gr. v
Aquæ anethi	♏x
Aquæ menth. pip.	♏x
Emulsionem Semprolin ad	ʒii

A dose of this medicine may be given some three or four minutes before feeding. It is not always necessary to adhere strictly to this formula, it may be supplemented or modified in various ways according to the condition of the stools. If the motions are of uneven consistence, or show other evidence of failure of digestion, liquor pancreaticus may be added in 20 m. doses; if the bowels are too loose liquor calcis saccharatus may be added, or the Semprolin emulsion may be reduced in quantity, or if they are too constipated, milk of magnesia may be substituted for the lime water. It must be remembered that so-called wind may not be an intestinal symptom at all, it may be due to pyloric spasm or other perverted muscular contractions of the stomach wall. It must not be too readily assumed that the presence of gas in the stomach or other part of the alimentary tract is the cause of the trouble simply because a certain amount of relief is afforded by expulsion of wind.

INTESTINAL TOXÆMIA

I am inclined to attach quite as much importance to this condition as a cause, in infancy and childhood, of ill health and disease, as has been imputed by certain authorities to intestinal stasis in older individuals. I do not, however, regard either constipation or delayed transit as serious causes of intestinal toxæmia in infancy, although the two may certainly co-exist. Putrefactive changes and the production of toxic substances take place more slowly in solid constipated fæces than they do in liquid stools, and, further, poisons thereby generated are more slowly absorbed. Every physician must be familiar with cases in which patients of all ages may remain in health as long as they are constipated, but immediately manifest serious symptoms of intoxication when the bowels become loose. I do not wish it to be inferred from these remarks that constipation should be encouraged, I only wish to emphasise the point that in my opinion intestinal intoxication is not particularly associated with constipation, and that reliance must not be placed on effecting a cure by ensuring regularity of the bowels.

As I have already frequently had occasion to observe, putrefaction or fermentation occur in the bowel contents when from any reason the food consumed is not digested in the proper place, at the proper time or at the proper rate, by the normal physiological enzymes in the bowel. If food is adequately digested and absorbed in the small intestine the surplus of unassimilated chyme which passes over into the colon through the ileo-cæcal valve affords little opportunity to the bacterial flora of the large intestine to bring about serious putrefactive changes. The causes of intestinal intoxication are therefore to be sought in all those conditions which favour defective digestion, incomplete absorption and the transit of unchanged food material into the ascending colon, and the cure must be founded on an intelligent interpretation of the special etiological factors concerned.

One of the chief predisposing causes of intestinal intoxication is a voluminous or dilated condition of the bowel, which greatly interferes with the transit and assimilation of the intestinal contents. The size of the bowel is more dependent on the character of the early feeding than on any other factor. The overfed or badly fed infant is liable to develop into a child with a dilated bowel, whereas the whole of the alimentary tract of the physiologically fed infant develops along normal lines and shows no evidence of dilatation or impaired motor function. The voluminous bowel, itself the result of over-feeding in infancy, is a continual menace to health, partly because it leads to further overfeeding, and partly because, under conditions of dilatation, all the digestive functions, both motor and catalytic, are carried on at a disadvantage.

Any abnormal condition of the bowel—catarrhal, atrophic, ulcerative or otherwise—necessarily predisposes to intestinal intoxication, and the same is true of any insufficiency of the gastric, pancreatic or hepatic functions concerned in the digestion of food. But look at it how we will, in its direct as well as in its indirect results, over-feeding is the one grand cause of intestinal intoxication, and of all forms of over-feeding protein over-feeding has the most disastrous consequences.

The rate of absorption from the bowel exercises an enormous influence on the chances of decomposition occurring in the bowel. If there is a demand for food set up by the requirements of the tissues, there is a corresponding incentive both for digestion of food and for its absorption. If, on the other hand, there is no physiological demand the stimulus, both for digestion and absorption, is wanting, and, under such circumstances, the food consumed remains at the mercy of the bacterial flora of the bowel. For this reason vigorous exercise is the best preventive of intestinal intoxication, while a sedentary life combined with gross table habits invariably leads in the final result to serious symptoms of poisoning. The effects of the absorption of toxic material from the bowel would be very serious indeed were it not that a most efficient detoxicating organ—viz. the liver—is interposed between the source of origin of the poison and the circulation. As long as the liver is capable of incinerating the poisonous products of decomposition the danger is avoided; but the liver, like all other organs, is liable to break down in function when too much work is imposed upon it, and hence, both in babies and older children, when the degree of intoxication is excessive periodical breakdowns, or so-called liver attacks, occur. When the liver becomes fatigued, and is no longer able to carry on its detoxicating functions, poisonous material is set loose in the circulation which damages the delicate cells of the nervous system, and produces a series of symptoms, such as vomiting, anorexia and lassitude, which are prophylactic in the sense that they lead to the cessation of the fundamental cause of the trouble—viz. the consumption of food.

In older children these periodic liver attacks are very familiar events when over-feeding is indulged in, and they are generally described as cyclic vomiting, migraine or acitonæmia; in young infants, however, their character is not so easily recognisable. As a rule, the attacks are characterised by a high temperature, by vomiting, and sometimes by convulsions.

Quite apart from these acute symptoms of intestinal intoxication there are certain chronic symptoms which are very characteristic, especially in children beyond the age of infancy. They consist for the most part of offensiveness of the breath, foul stools, irritability of temper, disturbed sleep, grinding of the teeth, a muddy complexion, dark lines under the eyes and night terrors; in babies the symptoms are not quite so characteristic, the predominating symptoms are foul-smelling motions, irritability and want of sleep.

Treatment.—Treatment must be mainly based on dietetic expedients, consisting, for the most part, of a strict limitation of quantity and the reduction of protein food to physiological standards. The first step in dealing with a case of suspected intestinal intoxication is to reckon up as carefully as possible the total caloric value of the food consumed at each meal and in the 24 hours; the resulting figures should then be compared with the normal standard of requirements given in the tables on pages 8 and 240. In accordance with the findings the required corrections must then be made, or, if necessary, any errors discovered may be actually over-compensated.

Since, in practically all cases of intestinal intoxication of this kind, a greater or less degree of acidosis co-exists, the daily administration of an alkaline mixture, consisting of sodium bicarbonate, potassium citrate and magnesium carbonate, is rationally indicated.

To prevent or restrict further intestinal putrefaction some form of efficient disinfection of the bowel, by means of salol, Dimol, sulphur, lactic bacilli, petroleum or intestinal irrigation, should be employed.

ABNORMAL STOOLS

Since the character of a motion is dependent on a number of contributory factors, including the nature of the food, the manner of its resolution by gastric, intestinal, pancreatic and biliary digestion, the rate of transit through the alimentary tract, and on the degree of admixture with mucus, it is clear that there are endless opportunities for departures from the normal type. It is, perhaps, hardly necessary to insist that the rational treatment of any existing abnormality must be based on a correct understanding of the underlying cause. For this reason the reader is advised to read conjointly with the following paragraphs the remarks which have already been made on this subject (p. 77).

ABNORMALITIES WITH RESPECT TO THE QUANTITY OF THE STOOLS

Large Motions.—If the total quantity of the fæces is large as compared with the total intake of food it is clear that absorption does not keep pace with the supply or that excretion by the mucous membrane of the bowel is excessive. In either case the implication is that there is some degree of over-feeding. In cases of atrophy of the bowel absorption cannot keep pace with the bodily requirements for food. In such instances there may be relative excess although the actual amount of food consumed may not exceed ordinary physiological standards. Some overfed infants and children habitually pass large motions; others, although continuously overfed, only do so periodically. A sudden increase in the amount of the motions without any corresponding increase in the supply of food is a danger-signal of impending trouble.

Recurrent bilious attacks of the nature of cyclic vomiting are often heralded by the passage of large and light-coloured motions; impending attacks of this character may, if advantage is taken of this premonitory symptom, be warded off by appropriate treatment. The treatment of this condition is to reduce the intake of food to physiological proportions and to increase a demand for it by massage, exercise, fresh air and baths. In order to determine as accurately as possible the exact amount of the physiological requirements, the output of work—*i.e.* the degree of muscular activity—must be carefully estimated. If infants are sluggish and inactive, or if older children are not disposed to take much exercise, their food requirements will be correspondingly small, and the supply must be reduced accordingly.

Scanty Motions.—When the diet is carefully adjusted to the physiological requirements, and when digestion as well as absorption is good, it almost necessarily follows that the motions will be small; they sometimes become hard and scybalous. It is difficult to correct this state of affairs by modifications of the diet without increasing the food beyond physiological limits, especially in the case of infants subsisting on an exclusive milk diet. Under such circumstances it is probably better to supply regular doses of liquid paraffin for the purposes of lubrication and for the softening of the stools. In older children treatment is easier, inasmuch as vegetables and other foods which leave a large undigested residuum of cellulose can be substituted for other varieties of food which leave none. Green vegetables and salads are well designed to meet the required ends, provided that excessive flatulence does not result. The artificial administration of preparations of agar agar, sometimes called Ceylon moss or Japanese isinglass, serves a similar purpose; this can be given in a variety of forms, with or without the addition of liquid paraffin. Regulin, which is a combination of agar agar with cascara sagrada, serves the double purpose of affording ballast for the stools and exercising an aperient action on the bowels.

Abnormalities in the Number of the Stools.—Just as constipation need not necessarily consist in the passage of a smaller number of stools than is normal, so also may stools be passed too frequently without constituting diarrhœa.

Too Frequent Motions.—Unless there is some definite cause, such as indigestion, ileo-colitis, proctitis or constitutional disease, the passing of too frequent motions is quite liable to be due to habit. To break this habit requires the exercise of considerable ingenuity: sometimes a preliminary dose of castor oil, followed by a short period of relative starvation may be all that is necessary to cure the condition. On the other hand, it may be necessary to follow up the initial dose of castor oil by regular doses of some astringent and sedative, such as the following:—

℞

Glycerini bismuthi carb. (B. P. Codex)	ʒss
Tincturæ camphoris co.	♏i
Liquor calcis sacchar.	♏xx
Tincturæ catechu	♏v
Aquam anethi ad	ʒi

If by this means the symptoms are relieved, the next step in the treatment is to establish regularity of habit at some particular time or times in the day. This can sometimes be accomplished by massage of the abdomen, by holding the child out, or by giving an extra large feed just before the time of election.

Abnormalities in the Consistency of the Motions.—Quite apart from the size or the number of the motions passed in the 24 hours the stools may be too liquid or too dry.

Motions which are too liquid.—The consistency of the motions depends very largely on the frequency with which they are passed, so that excessive dryness of the stools can be corrected by securing more frequent openings, and *vice versa*. If, however, the motions are too liquid, in spite of the fact that they are passed at normal intervals, the amount of fluid consumed in the 24 hours should be restricted; if this expedient is not successful a dose of castor oil, if given successively for two or three nights, may, owing to its astringent properties, have the desired effect. In children over one year of age an exclusive milk diet may be temporarily substituted for the mixed diet which at this age is probably provided.

Motions that are too dry.—The chief causes of this condition are:

(1) A too exclusive milk diet.
(2) Too little fluid in the diet.
(3) Want of vegetable and other coarse foods.
(4) The after-effects of an attack of ileo-colitis.

The stools may be softened by the regular administration of a dose of petroleum emulsion after each meal, by an adequate supply of fluid or by an increase in the amount of vegetable matter consumed.

Abnormalities in the Reaction of the Motions.—In the case of infants the motions may be strongly acid and irritating or they may be alkaline. The normal reaction is slightly acid. If the motions are strongly acid, especially if they are also frothy, there is probably excess of carbohydrate in the food; a temporary reduction of this element in the food may be all that is required in the way of treatment. If the stools are alkaline and offensive the condition is more frequently than not due to the action of proteolytic bacteria on an excess of nitrogenous food. A successful line of treatment is to provide a temporary diet of buttermilk or whey to which Bulgarian lactic bacilli have been added.

Abnormalities in the Colour of the Motions.—For particulars as to the sources of colour in fæces see page 81.

Colourless Stools.—When, for any reason, bile is absent from the motions they become pale or clay-coloured; they are rendered additionally pale by excess of fat, which is poorly absorbed in the absence of bile. Under such conditions the fat content of the food should be reduced, while liquor pancreaticus, combined with some preparation of bile, should be given after each meal to facilitate the digestion and emulsification of the fat. Constipated milk stools are often practically colourless although the bile colouring matter may be normal in amount, owing to the fact that the bile pigments may become decolorised if they remain for any prolonged period of time in the bowel.

Green Stools.—A slight degree of greenness is not necessarily of pathological significance; it may be due to hurried transit or to an alkaline reaction of the bowel contents. This condition can usually be cured by an initial dose of castor oil followed by a short course feeding on whey to which lactic bacilli have been added.

Pink Coloration of the Stools.—Comparatively common in young infants when the motions are passed too frequently. It is due to the oxidation of the bile pigment being arrested at this intermediate stage; the exact causes which provoke it are not understood. The treatment is the same as that suggested in the case of too frequent or too liquid stools.

FATTY OR SOAPY STOOLS

This condition should be treated at first by a drastic cutting down of the fat content of the food (see p. 318) and a gradual increase in the supply as the stools improve. The use of buttermilk or separated milk is a practical means of accomplishing this object. It appears that there are individual cases in which there is intolerance of fat, and in hot weather the supply of this element should always be reduced, but in the vast majority of cases when fatty stools are passed the cause is due to its excessive supply.

FROTHY STOOLS

Frothy stools should be treated by a drastic though temporary reduction of the sugar or starch content of the food and by the administration of free doses of saccharated lime water.

"CURDS" IN THE MOTIONS

So-called "curds" very rarely consist of undigested casein; they are, almost invariably, composed of mucus and other intestinal secretions, in which are entangled a considerable amount of fatty acids and soaps. They are the result of irritation of the bowel and hurried transit. Motions of this character should be stirred up in a large quantity of water in order that the mucous basis of these so-called curds may be revealed; they may be microscopically examined also to show to what extent fats or fatty acids make up the total mass of the curds. The condition is not necessarily improved by limitation of the casein in the food—in fact, the curds often remain even though the diet contains no milk at all. The best treatment is the temporary peptonisation of the food, which should contain a rather low fat percentage, but which is otherwise of physiological standard.

MEMBRANE AND CASTS IN THE MOTIONS

These can be readily identified if the stools are washed out in a large amount of water. Since they are liable to be missed in conditions of constipation this means of recognition should not be omitted if there is any reason to suspect membranous colitis. The treatment is tedious and should be conducted on the lines suggested for chronic colitis (see p. 311).

CŒLIAC DISEASE

This condition, sometimes called Mucous Disease, sometimes Intestinal Infantilism, is one of the pathological conundrums of pædiatrics. It is characterised by the symptoms of intestinal toxæmia, but in addition there are :

(1) General want of development or infantilism.

(2) Extreme smallness of the liver.

(3) Large size of the stools, which are light coloured and fatty.

(4) Absence of the usual symptoms of rickets.

The symptoms seem to fit in with a condition in which nutritive material is inadequately absorbed into the system owing to :

(1) Defective pancreatic and intestinal digestion, or

(2) Atrophy of the mucous membrane of the intestinal tract owing to chronic catarrh or other causes.

The treatment is extremely difficult, and requires more patience than is usually possessed by doctors, nurses or parents.

As far as my experience goes, the following details are essential for success :—

(1) Since only a minimum amount of nutritive material can be absorbed from the alimentary tract, the output of energy must be kept within the lowest possible limits, by keeping the child very warm and as completely at rest as is compatible with the circumstances.

(2) Since food material cannot be absorbed in full amount the quantity consumed must be co-ordinated to the amount which can be assimilated.

When conditions begin to improve the real danger arises, for the temptation to increase what appears to be a starvation diet is well-nigh irresistible. Time after time I have yielded to this temptation and have undone the work of many months of patient treatment.

I do not believe that any special articles of diet are indicated or that any need be excluded. It is sufficient if the diet is well balanced, digestible and deficient in none of the ordinary accessory factors. If it fulfils these requirements there is no need to deprive the child of any of the usual articles of diet. In the first place, it is essential to make as careful an estimate of the caloric requirements as is possible under the circumstances. The child with cœliac disease must be supplied with a diet which provides for the requirements of "basal metabolism"—*i.e.* about 50% less than the estimated caloric requirements for health. In making this estimate the weight and size of the child must be regarded as the criteria, and not the actual age. For instance, a child 4 years of age and suffering from cœliac disease may not weigh much more than 25 lb. The treatment in a case like this must be to provide a diet which, as regards quantity, is suitable for an infant 18 months of age and not one for a child of 4 years old. The physician who has the courage thus to drastically reduce the intake of food will assuredly meet with his reward.

In pursuing this line of treatment constipation is almost always a trouble, and to avoid the serious consequences of this condition it is well to fill up the intestinal tract, as far as possible, with somewhat bulky vegetable food of low nutritional value. It is a very good plan to fill up available space with non-assimilable material such as liquid petroleum or with emulsions of petroleum which can be readily taken. I do not hesitate to give 2-3 oz. of petroleum emulsion in the 24 hours if a smaller dosage does not maintain a regular action.

As far as drugs are concerned, I find the regular administration of liquor pancreaticus is a most useful means of maintaining a condition of intestinal efficiency, or if this fails, the regular exhibition of some simple intestinal antiseptic, such as salicylate of bismuth or Dimol, is indicated.

The rational treatment of cœliac disease depends for its success on patience and a correct quantitative supply, and not on drugs or the provision of special dietaries.

CHAPTER V

MALNUTRITION AND DISTURBANCES OF METABOLISM

Introductory Remarks—Rickets—Causation—Treatment

General Remarks.—It is very difficult to classify the conditions which are included under the above heading on any satisfactory or scientific basis. The most important disorders which come under this classification are rickets, marasmus and the so-called deficiency diseases, but there are many other minor disorders, such as glycosuria, lithæmia, oxaluria and phosphaturia, which I am almost tempted to call excess diseases, since they are liable to develop when the limit of tolerance for certain food substances is overstepped, and these also must be included in the list.

Rickets is a term which is allowed to cover a multitude of pathological sins. According to the view which I myself hold, practically all forms of malnutrition in infants, provided they are severe enough and long enough continued, terminate in acidosis and the three pathognomonic symptoms of true rickets—viz. (1) demineralisation of bone ; (2) muscular weakness and (3) increased nerve irritability. In most descriptions of rickets we find all the characteristic symptoms of the various types of malnutrition crowded into its comprehensive and all-embracing syndrome ; the result of this is that there is no symptom to which infancy and childhood is prone which is not by some authority or other regarded as due to rickets.

I almost hesitate to include marasmus or infantile atrophy among the disorders of metabolism, although the outstanding features of the condition are obviously the result of some disturbance of nutrition. The primary causes which lead up to marasmus are often connected with some disturbance of the digestive functions, or of the processes of absorption ; moreover an important factor in the problem is very often some innate constitutional weakness or disability.

There are so many different varieties of malnutrition due, on the one hand, to a deficient supply of certain essential elements, and on the other hand due to excess of others, that it would be impossible for any classification to cover all types. No doubt the time will arrive when it will be possible to disentangle the confused skein of metabolic disorders, whether due to deficiency, excess or other causes, and classify them on a scientific basis.

RICKETS

The successful treatment and, what is far more important, the successful prevention of rickets is so largely dependent on a full appreciation of the underlying causes, that I make no apology for dealing with this complex question in considerable detail. As I have already stated, my view of rickets is that all conditions of malnutrition, from whatsoever cause arising, provided that they are intense enough and of sufficiently long standing, lead, in the final issue, to acidosis and calcium depletion, and that it is to these conditions that the pathognomonic symptoms of rickets are due. One of the arguments raised against the acceptance of this view of rickets is that heretofore it has not been possible to prove that there is any definite calcium deficiency in the blood of rickety infants. The argument is that if there is no deficiency of calcium in the blood there can be no grounds for believing that the bones and other tissues cannot draw upon the blood for such supplies of calcium as they may require. Even this argument is faulty, for the blood may contain excess of calcium which is fully saturated with acid radicles, and not available for the purposes of bone growth. The recent researches of Dr H. A. Stheeman[1] have, however, very definitely shown by an improved method of analysis, which only requires a very small sample of blood, that the calcium content of the blood in cases of rickets is practically always below the normal standard unless a cure has been effected or is in process of accomplishment. Even if calcium depletion were not capable of being proved to be present in the blood of rickety infants, it would be hardly surprising, for there are various automatic mechanisms for preserving the chemical constancy of the blood as regards mineral as well as other elements. The blood is capable of drawing upon any of the less vital tissues by a process of "autophagy" to compensate for losses of any of its essential constituents, including calcium, as long as such

[1] "Adynamie und Blutkalkspiegal" (die Calciprive Konstitution). *Jahr. für Kinderh.*, No. 94, p. 27, 1921.

elements are in any way available. In spite of these automatic resources the calcium content of the blood has been proved by Stheeman to be well below the normal, not only in all cases of active rickets, but also in the many pre-rachitic stages which are liable to result later in the typical symptom complex.

Employing de Waard's micro-chemical method of analysis, Stheeman has been able to prove that under varying conditions the calcium (CaO) content of the serum ranges between 8·2 and 17 mg. per 100 c.c.; that in health it ranges between 12 and 13 mg. and that in those conditions of malnutrition which may be collectively classified as pre-rachitic the figure sinks below 11 mg. per 100 c.c. The interest of these findings lies in the fact that in all conditions of serious calcium deprivation, from whatsoever cause arising, three definite results eventuate in the young and developing child: (1) the bones are soft; (2) the muscles are weak; and (3) the whole of the nervous sphere is in a state of increased excitability. In this "status calciprivus" the softness of bone and muscular weakness are at once demonstrable, while the increased irritability of the nervous system can be shown by Erb's galvanic test, by Chvostek's sign (mechanical percussion of the malar bone, facial irritability) and by Trousseau's phenomenon.

The sequence of events which leads up to the final rickety picture is as follows. All forms of malnutrition conduce to a condition of acidosis—in other words, to the excessive production of acid bodies of large molecular size such as lactic, proprionic, succinic, oxalic, uric, phosphoric, butyric and other fatty acids which must be immediately neutralised by any basic element, such as ammonium, potassium, sodium, magnesium, calcium, etc., available, either in the blood or in the tissues. The first bases to be mobilised will be those which are in a physiological sense the cheapest, while the more expensive minerals, such as calcium and iron, will only be requisitioned in cases of extreme necessity. Hence calcium depletion represents a comparatively late stage of a chronic acidosis, but when it is finally arrived at we meet with the classical symptoms of rickets, softness of bone and all its secondary consequences—muscular weakness and all the phenomena of nervous irritability, such as tetany, laryngo-spasm, eclampsia, and all the other convulsive manifestations which are familiar in a serious rachitic condition.

It is no simple matter to explain shortly why all the ordinary conditions of malnutrition, which are known to have their climax in the rickety condition, lead to this goal through the common channel of acidosis: this question will be dealt with in the next section. Meanwhile, however, I am chiefly concerned to prove that there is not one but many causes of rickets, and that in the usual descriptions of this disease there is a curious confusion between causes and their effects.

I have attempted in the accompanying illustration to draw up a diagrammatic representation of the rachitic picture which is designed to distinguish between conditions which are causative of, and symptoms which are consequential on, the true rickety state. Causative factors are designated by square markings, while effects are shown by circles. The directions of the arrowheads indicate the paths of the effects. In the lower half of the diagram the more common etiological factors are arranged in groups as comprehensive as I have been able to devise. For instance, one group, consisting of chronic infective causes, is shown to include catarrhal, tuberculous, syphilitic, septic, rheumatic and coli infections, while a second group is made to consist of the different varieties of deficiency diseases due to starvation with respect to the three well-known varieties of vitamines. Each of these two groups, as well as each of the others indicated on the chart, has its own little symptom complex, so that in the aggregate the total sum of symptoms which are associated with any particular case may obviously reach an enormous number—a fact which explains the well-known truth that an account of rickets, as usually described, is an account of all the ills to which childhood is heir.

In various ways all these groups of etiological factors lead to the common goal—acidosis—as will be explained in the next chapter. For present purposes it will be sufficient to state that acidosis, which is itself an essential precursor of the true rachitic state, has also its own little group of symptoms, some of which may be described as the acute effects, while others are of a more chronic nature. It is to the chronic effects of a comparatively mild degree of acidosis that the characteristic symptoms of an ordinary case of rickets—viz. (1) soft bones; (2) muscular weakness; (3) nervous irritability—are due.

Personally I would prefer to limit the term " rickets " to the clearly cut syndrome of the three cardinal or pathognomonic

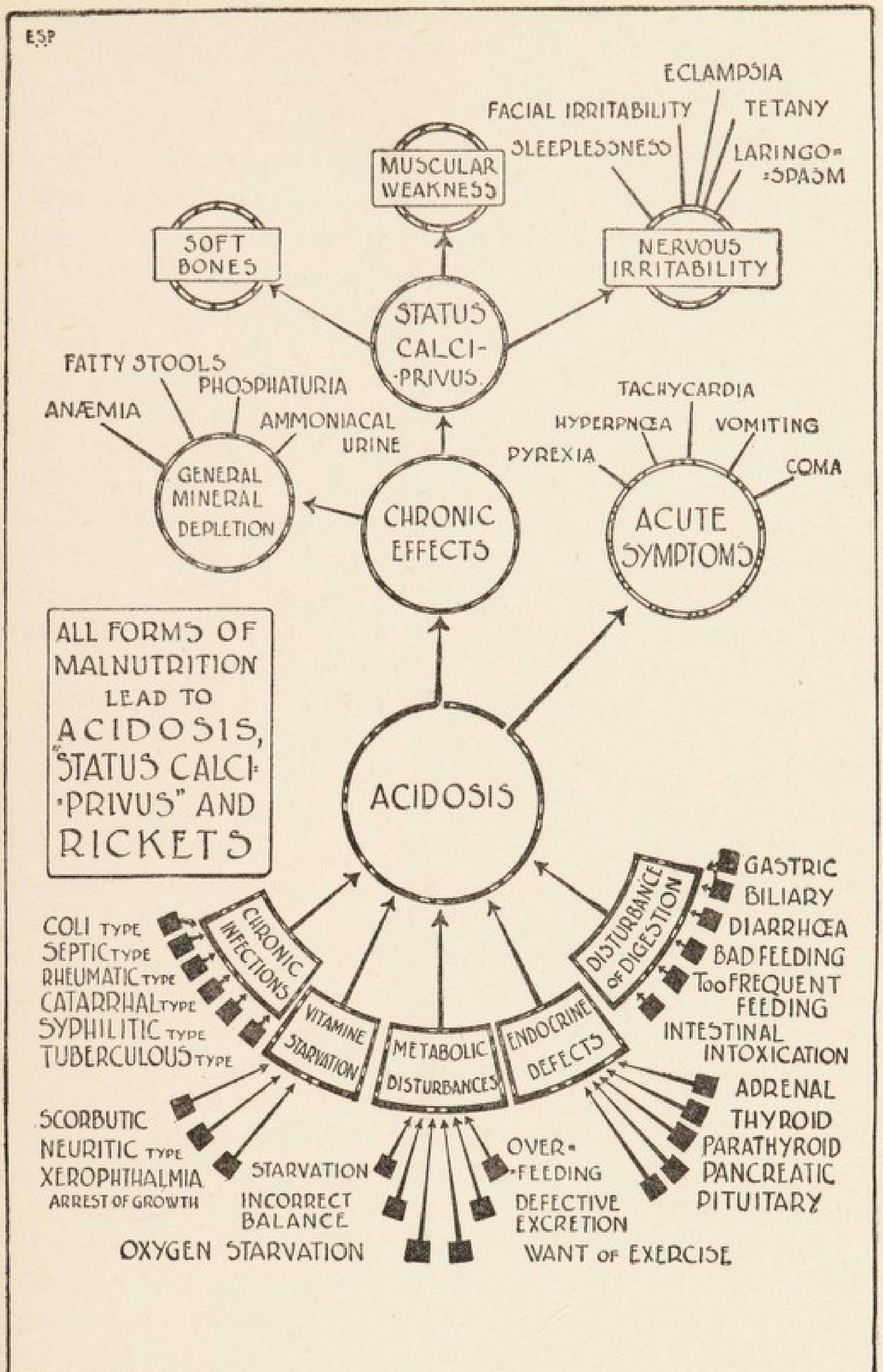


Fig. 78.—Diagrammatic Representation of the Causative Factors and Symptoms of Rickets

symptoms, with a qualifying and distinctive epithet to signify the particular etiological group which is responsible for the causation. For instance, one might speak of an "infective type," a "vitamine type," an "endocrine type" or a "dyspeptic type." This method of nomenclature would avoid the obvious confusion between cause and effect which so detracts from the value of most accounts of the disease. For instance, it is usually stated that sweating and catarrhal inflammations are common manifestations of the rachitic state. As a matter of fact, sweating is a common symptom of two of the etiological conditions which may finally lead to acidosis and rickets; it cannot, however, be regarded as a manifestation of rickets in the narrower sense. The two etiological conditions to which I refer are (1) infective states and (2) overfeeding. With respect to the statement that rickets predisposes to catarrhs, it may be safely said that catarrhal conditions of all kinds are apt to be complications of the various malnutritional states which are included in the etiology of rickets. Catarrhs, therefore, would be more accurately described as causes of rickets than as the manifestations of the rachitic state.

Treatment of Rickets.—It has probably been made sufficiently clear in the preceding paragraphs that a rational treatment for rickets must depend upon a correct diagnosis of the etiological factors concerned. Although the symptomatic treatment of the true rickety syndrome—*i.e.* softness of bones, muscular weakness and nervous irritability—and indeed the symptomatic treatment of the acidosis itself, is practically the same in all cases of rickets, nevertheless it would be obviously absurd to treat a case of rickets which owes its existence to some chronic septic infection on the same lines as a case due to vitamine starvation. The rational treatment of rickets therefore resolves itself into the independent treatment of three definite conditions: (1) the true rickety syndrome; (2) the acidosis, and (3) the underlying malnutritional state. Taking each of these parts of the treatment separately, I will begin with that which is concerned with the true rickety syndrome.

Soft Bones.—The softness of bone is due to the fact that the claims of the growing cartilage for calcium or other salts, important as they may be, are less urgent than those of certain other tissues. In the absence of sufficient calcium to go round, the immediate requirements of growing bone are temporarily sacrificed. The indications, therefore, are (1) to increase the total supply of these necessary mineral elements and (2) to reduce the urgency of the claims for calcium for other purposes. Calcium starvation, as will be shown later, is the result of an existing acidosis: if we treat the acidosis we also treat the calcium starvation. It by no means follows that the administration of calcium salts, such as calcium lactate or calcium phosphate, will be followed by any increase in calcium absorption, or calcium retention; many adverse circumstances may militate against this result. The same end is probably more effectually accomplished by the regular and continuous administration of calcium "sparers," such as citrate of soda, bicarbonate of soda or citrate of potassium. The mistake that is usually made is to give such alkaline salts for a short period only, and then to relinquish the treatment because it is not rewarded with immediate results. A chronic condition such as ordinary rickets cannot possibly be cured in a short time: prophylactic treatment must be continued indefinitely, even though the symptomatic treatment may be relinquished after the urgent manifestations of the condition have improved. The secret of treating the special symptom of softness of bone is to supply continuously an adequate quantum of alkaline bases, if possible, in organic combination, and secondly by ensuring, if possible, the assimilation of fats which, in the form of soaps, carry calcium and other bases into the circulation in a free and available form.

Muscular Weakness.—The marked muscular debility of a typical case of rickets is directly due to the calcium depletion, which affects adversely not only the tonicity and metabolic processes in the muscle tissue, but also the metabolism of the nerve cells, which secondarily controls the nutrition and activity of the muscular tissue. Muscular tone automatically returns as the "status calciprivus" improves under appropriate treatment. Hand in hand with the general treatment of the acidosis, massage of the muscles affords most beneficial results.

Nervous Irritability.—The nervous irritability which is probably the most pronounced feature of a severe case of rickets is quite rationally treated by dealing with the calcium depletion and acidosis on which these nervous manifestations depend. Laryngospasm can be dealt with symptomatically by inhalations of chloroform. Tetany can be most satisfactorily dealt with by washing out the stomach and by the complete suspension of food; eclampsia and all varieties of convulsive seizures are greatly benefited by mustard baths or, when combined with high temperatures, by the wet pack.

The special treatment of acidosis will be reserved for the next section, but the following general indications for treatment apply in all cases of rickets :—

(1) The diet must be made to comply with all the rules of correct physiological feeding—that is to say, paying due regard to the special etiological factors, the food must be correct in quantity, quality, vitamine content, balance and digestibility.

(2) The physiological demand for food must be maintained, as far as possible, by opportunities for exercise and by massage. Metabolism must be stimulated by baths, open-air treatment, currents of cool air, sunlight and surface friction of every kind.

(3) Metabolism must be facilitated by an adequate supply of oxygen, or by the treatment of conditions—such as adenoids, bronchitis and anæmia—which in any way interfere with the delivery of oxygen to the tissues.

(4) Adequate supplies of alkaline salts must be provided, by oral or hypodermic administration, to neutralise acid bodies as they are formed, or to restore the depleted alkaline reserves of the blood.

(5) The nervous irritability is best treated by the continuous administration of small quantities of phosphorated cod-liver oil.

The treatment of the various underlying etiological states must be based on the directions given in the corresponding sections in this book under their appropriate headings.

CHAPTER VI

MALNUTRITION AND DISTURBANCES OF METABOLISM
(*continued*)

ACIDOSIS

Definition—Causes—Treatment—Acidosis in Connection with Surgical Operations—Preventive Treatment

THE subject of acidosis has been repeatedly referred to in the preceding chapter, but the importance of this condition as a factor in disease in children, and as a central feature in the picture of rickets, is so great that it will be dealt with at considerable length in this chapter.

Many differences of opinion still appear to exist as to the precise conditions which the term "acidosis" covers. Some medical men seem to restrict the term to that particular form of acidosis which occurs in diabetes, or to that particular condition which is characterised by the presence of acetone, diacetic acid or oxybutyric acid in the urine.

As a matter of fact these conditions only represent particular varieties of acidosis. The term should, more properly, cover all those conditions in which there is an excessive production of acid bodies in the system and a corresponding reduction of the alkaline reserves of the blood. A condition of acidosis by no means implies or necessitates any alteration to the acid side of the reaction of the blood. The economy of the body does not allow of such a catastrophe ; the acid-alkaline balance of the blood is maintained at a very constant level by several self-regulating mechanisms. The alkaline reserves may be greatly reduced, but the acid-alkaline balance, or hydrogen-ion concentration, remains unaltered except in an extreme crisis. It is in maintaining this constancy of reaction in the blood that so many injuries are inflicted on the body as a whole, and especially on its less important parts, such, for instance, as the bones.

When, for any reason, acid bodies, such as lactic, proprionic, oxalic, uric, phosphoric, sulphuric and various fatty acids, are produced in excessive amount, a general mobilisation of the alkaline reserves or metallic bases in the body is brought about for the purposes of neutralisation. The continued production of such an excess of acids brings about a corresponding demineralisation of the whole body. If the processes of excretion are satisfactory the neutral salts thus formed will be immediately eliminated from the body, in the urine and in the fæces, and thus permanently lost to the organism. It is this impoverishment of the body as a whole, more especially of the blood, that constitutes the basis of acidosis, and gives rise, among other results, to the "status calciprivus" and the classical symptoms of rickets.

A condition of acidosis is, therefore, characterised by the excretion, both in the fæces and in the urine, of an excess of various acid bodies, which have been neutralised at the expense of the metallic bases of the body. A rise in the acidity either of the fæces or of the urine is not a necessary consequence of an excessive acid production. Indeed, if the mechanisms provided for the neutralisation of acid radicles were complete, the reaction of the emunctories would be unaffected, as all such acids would be eliminated as salts, esters or soaps. It often happens, however, that the immediate supplies of alkalies are insufficient for complete neutralisation, under such conditions, and to varying extents the degree of acidity of these excretions may be raised.

Under certain conditions in which, for any reason, the blood may be flooded with acid products, the actual content of the blood with respect to metallic bases, such as potassium, sodium and calcium, may be temporarily raised, owing to the fact that excretion of the neutralised acid bodies cannot keep pace with the production. The occasional paradoxical increase of the calcium of the blood, under conditions of acute acidosis in rickety and other states, has led to many misconceptions of the true significance of mineral depletion as the chief factor in the production of rickets.

The causes of acidosis are numerous, and include all those conditions of malnutrition which in infancy and childhood lead up to the one common goal—viz. rickets. In the skeleton scheme of rickets given on page 337 the main varieties of malnutrition capable of producing this pathological state are given.

Diabetes itself is one of the best known and most typical of the metabolic disorders which is capable of leading to a condition of acidosis. In this vice of metabolism, carbohydrate material cannot be utilised adequately as a source of energy; instead of yielding up the whole of its energy, and in so doing being reduced to the final end products, carbonic acid and water, only a portion of its potential energy is made available with a production of semi-oxidised and middle products of metabolism—viz. butyric acid, acetic acid and acetone, which call for immediate neutralisation and excretion.

Diabetes represents, therefore, the failure of one element of the food to be oxidised to its complete end-products. There are many other vices of metabolism which result in the same fate befalling the protein, fatty, and other elements of a dietary. When for any reason, either from an excessive supply of food or from some vice of metabolism, there is any failure to utilise the food to its full value, the essential elements for the production of an acidosis are present. The prevention of an acidosis can therefore be secured by limiting the intake of food or by creating an increased demand for its physiological utilisation—by work, for instance, or muscular exercise. One of the most successful methods of treating diabetes is now recognised to be starvation and the taking of exercise, the very measures which I have been advocating for years for the treatment of acidosis and rickets in children. The fact that a mild degree of acidosis, accompanied by acetone and oxybutyric acid in the urine, can result from starvation is no argument against the acceptance of the statement that acidosis results from the presence of an unutilisable excess. In starvation the fat reserves are at once mobilised to provide sources of energy, and this fat, being for the moment the sole source of supply, behaves as a one-sided and ill-balanced dietary, one of the results of which is incomplete utilisation and acidosis. Acidosis of this kind can be corrected by an adjustment of balance in the supply, as by the giving of sugar.

The knowledge that the acidosis which is produced by starvation can be corrected by the consumption of sugar, has led to the erroneous belief that all forms of acidosis can be cured by this simple means. The absurdity of this view becomes all the more apparent when we remember that excess of carbohydrate food is probably a far more common cause of acidosis than an excess of fat, than starvation or than all other causes combined. Each variety of acidosis must be treated in accordance with the etiological factors which produce it.

It is impossible here to enumerate all the causative factors which lead to failure of utilisation of food ; apart from actual vices of metabolism such as certainly exist in diabetes—and probably exist in gout—want of muscular exercise, from whatsoever cause arising, is certainly one of the most prolific of all causes. General conditions of debility, by incapacitating the individual from taking exercise, also contribute to the same result.

The chronic symptoms of acidosis are, in infants and young children, in the main those of rickets (see Fig. 78)—that is to say, (1) softness of bone; (2) muscular debility, and (3) nervous irritability. A similar acidosis occurring in older individuals would also probably be called rickets, were it not for the fact that the bones, being already formed, do not give evidence of softness. The acute symptoms of acidosis in infants are for the most part represented by (1) rapidity of breathing without cyanosis (acyanotic hyperpnœa); (2) pyrexia; (3) rapid pulse, and (4) vomiting—a compact syndrome which is often mistaken for pneumonia (see Fig. 78). The chronic results of an acidosis are associated with the elimination from the body of large quantities of acid radicles in combination with alkaline and other metallic bases. The urine is, as a rule, strongly ammoniacal, indicating the voiding of excess of the ammonium base in combination with acid radicles, while the fæces contain a great excess of calcium, and sometimes of iron. The calcium is usually in combination with fatty acids in the form of soaps.

Another result of the acidosis, and one which may possibly be due to the seizure of iron for neutralisation purposes, is the development of hæmolysis and consequent anæmia. I feel fairly well convinced that the beading of the ribs and the enlargement of other bone epiphyses in rickets are due to congestion and over-activity of these blood-forming centres, as compensatory to the hæmolysis.

In older children the more chronic manifestations of an existing acidosis are those symptoms which are due to the raised excitability of the whole nervous sphere—such as sleeplessness, night terrors, cyclic vomiting, sick headaches, migraine, hysteria and loss of weight.

Treatment.—Apart from the treatment of emergencies and acute symptoms resulting from a condition of acidosis, the main therapeutic principles consist in (1) the restriction of food material for which there is no physiological use and (2) the creation of an increased demand for it by exercise. Other factors naturally come into play, including the treatment of the particular underlying conditions which contribute to the acidosis. The degree of acidosis often reaches quite a high level without attracting attention, owing to the extreme efficiency of the automatic mechanisms which are designed to compensate for it and maintain equilibrium. Under such critical conditions small events may upset the balance and lead to serious complications. Infants and children who are thus living on the edge of a volcano often succumb to sudden attacks of diarrhœa, pneumonia or small operations which under ordinary conditions of health, and with an ample alkaline reserve, would cause no disturbance at all. Since extreme degrees of nervous irritability are fairly reliable signs of calcium depletion and acidosis, we clearly have a useful clinical means of providing against accidents due to the superimposition of an acute acidosis on the top of a chronic one which is already in existence. The lessons learnt from the successful treatment of the diabetic condition should be a guide to us in the management of acidosis from other causes. The indications are (1) to raise the depleted alkaline reserve by the administration, hypodermically or otherwise, of alkaline solutions; (2) the strict limitation of food, and (3) the creation of a demand for food material by exercise, massage, exposure to cold and all other forms of stimulation which promote metabolism. The acute symptoms of acidosis in infants, as I have already explained, resemble very closely those of pneumonia. This condition very rapidly yields to treatment if normal saline, fortified with 5% of sodium bicarbonate, is injected hypodermically, if a supply of oxygen be administered by the continuous method and if the intake of all food, except grape juice and Valentine's Meat Juice, is suspended. If there is a high temperature there is no better means of reducing it to normal proportions than by wrapping the infant in a bath-towel which has been wrung out in hot water, and leaving it exposed to the air until the temperature has come down.

The treatment of the more chronic effects of an acidosis in older children is based on the same principles, but it must be persisted in over a considerable period of time before it is safe to relax any of the prophylactic measures. Limitation of diet and the taking of ample exercise are the great standbys. The diet sheets given between pages 274 and 275 should be carefully studied and observed. It is most important that an ample supply of vegetables and fruit should be provided, since there is no better means of restoring a reduced alkaline reserve than by administering a full quantum of the sort of organic salts which are provided in these articles of food. An additional dose of some simple alkaline mixture in the early morning helps to restore the depleted alkaline reserves. A useful gauge of the degree of acidosis is the quantity of alkaline salts which must be administered to bring about an alkaline reaction in the urine.

THE PREVENTION OF ACIDOSIS AFTER SURGICAL OPERATIONS

Many deaths have occurred owing to the development of acute acidosis after surgical operations—a condition to which the terms "late-chloroform poisoning" or "post-operative acidosis" have been given.

So serious is this danger in certain cases that urgent operations are at times postponed or carried out without the use of a general anæsthetic.

The infants and children in whom acute acidosis of this kind is likely to develop are those who before operation have been living in the dangerous condition of a depleted alkaline reserve in the blood—in other words, in a condition of chronic acidosis. Under such circumstances it is the final straw which breaks the camel's back, and it is the small addition of acid bodies contributed to the blood by the starvation necessitated by the operation, by the shock of the operation itself, and by the paralysing influences of the anæsthetic that precipitates the acute crisis.

A great deal can be done to minimise these dangers by the rational preparation of the patient before operation.

In the first place, any depleted condition of the alkaline reserves of the blood must be rectified by the free administration of sodium bicarbonate, potassium citrate, carbonate of magnesia, milk of magnesia, and saccharated lime water, either singly or in various combinations.

The plan I usually adopt myself is to order 1 drachm of mixed salts[1] every morning, in 4 oz. of water flavoured with the juice of an orange and a little sugar, to be taken regularly for fourteen days or so before operation.

Any condition which contributes to the acetonæmia, such as a chronic infection, or want of exercise or fresh air, must be dealt with on approved lines.

[1] See Appendix, p. 486.

The diet is important. It should be constituted on physiological lines, with a very ample inclusion of green vegetables and citrous fruits. Butcher's meat and white bread, which contain little mineral matter, should not be largely indulged in; indeed preference should be given to all articles of food which possess a good complement of salts, but, above all and beyond all, it should not be excessive in amount.

Immediately preceding and immediately after the operation the food must be reduced to a minimum, and this in spite of the fact that starvation itself contributes to the acidosis. This danger is greatest in fat, overfed children and least in the thin and emaciated, but in no case need it be considerable if, during the period before operation, the above precautions are taken.

The night before the operation the child should take a light meal, consisting of a milk pudding and baked apple, and on the morning of the operation itself, if any food at all is permissible, it should be a cup of weak tea with a fair allowance of glucose in it. After the operation there is nothing better appreciated than a few teaspoonfuls of orange ice or iced lemonade; but no solid food should be allowed until all danger of vomiting has passed.

The diet of infants, whether breast fed or bottle fed, cannot of course be seriously modified. It is, however, extremely important to inquire very carefully whether in any respect the method of feeding transgresses the physiological laws enumerated on page 147.

CHAPTER VII

MALNUTRITION AND DISTURBANCES OF METABOLISM
(*continued*)

THE DEFICIENCY DISEASES

Deficiency of Fat-Soluble "A" Factor (Xerophthalmia, etc.)—Deficiency of Water-Soluble "B" Factor (Neuritic or Beri-Beri Type)—Deficiency of Water-Soluble "C" Factor (Scorbutic Type)—Deficiency of Protein (Pellagra Type)—Deficiency of Mineral (Status Calciprivus)—Deficiency of Lecithin Bodies and Extractives

General Statement.—Although at the present time considerable interest is centred on three particular types of malnutrition, due respectively to a defective supply of the three recognised vitamines—the so-called fat-soluble "A," the water-soluble "B" and water-soluble "C" accessory factors—it is highly probable that in the near future other varieties will be added to the list, or they may all be shown to be variants of one type. I have for long drawn attention to the importance of the lecithin bodies as essential factors in nutrition, and in addition we have also to think of the importance of salts in organic combination and various extractives. The rôle which these substances play in nutrition cannot at present be expressed in physiological terms, but that they play some part in the utilisation of proteins and other food elements cannot be doubted.

Deprivation of any accessory food factor leads to one of the many disturbances of nutrition, most of which have no distinctive label, but there are three types which at the present time are recognised as clinical entities. First of all we have a series of symptoms which are described as due to deprivation of the fat-soluble "A" factor, consisting in arrest of growth and an inflammatory condition of the eye, including conjunctivitis and keratitis, and ultimately leading to acidosis and a condition of rickets. Owing to the latter complication this particular vitamine has, in my opinion, been wrongly described as the anti-rachitic vitamine. I say wrongly, because I believe that all forms of malnutrition, and not exclusively that due to starvation in this particular accessory factor, must lead to rickets, since they ultimately induce a condition of acidosis. Secondly, we have the so-called neuritic type, due to deprivation of the water-soluble "B" factor. Beri-beri is the best-known example of this disease in adults; it is due to the too exclusive consumption of polished rice, which in process of preparation has been deprived of its natural vitamine; the polyneuritis of pigeons and fowls, which can be experimentally produced by a diet consisting for the most part of autoclaved rice, is probably of the same nature. In infants we very rarely meet with anything like a typical case of this kind of malnutrition, for the reason that, in this country at least, they are not fed on an exclusively farinaceous diet; on the other hand, we often meet with cases of proprietary-food-fed infants who show mild degrees of the disease if the food is composed of an unduly large amount of malted or unmalted farinaceous food. Thirdly, we have the well-known hæmorrhagic condition of infantile scurvy, due to deprivation of the water-soluble "C" factor.

Whether or no we are entitled to regard these three types of malnutrition as definite disease entities due to deprivation of one or other of the three vitamines described above, such a conception may help us to crystallise our views with regard to the classification of different types of malnutrition due to different causes, or developing under different intrinsic and extrinsic conditions.

The diagram on page 350 represents an attempt to indicate the specific characteristics of the three somewhat hypothetical types of malnutrition due to deprivation of the above-mentioned vitamines. Great confusion is likely to arise in connection with the often complicated combinations of these three forms of malnutrition unless we can keep in our mind's eye some such schematic picture as I have attempted to outline. In this diagram I indicate certain of the special symptoms regarded as characteristic of these three primary types; I also show how each of them may lead to the final goal, rickets, through the common channel, acidosis. Since both rickets and acidosis each possess a special group of symptoms, it is easy to understand how it has come about that in drawing the clinical picture of any one of these deprivational symptom-complexes, secondary results have become confused with primary symptoms. For further particulars with respect to the special symptoms of acidosis or rickets see page 337.

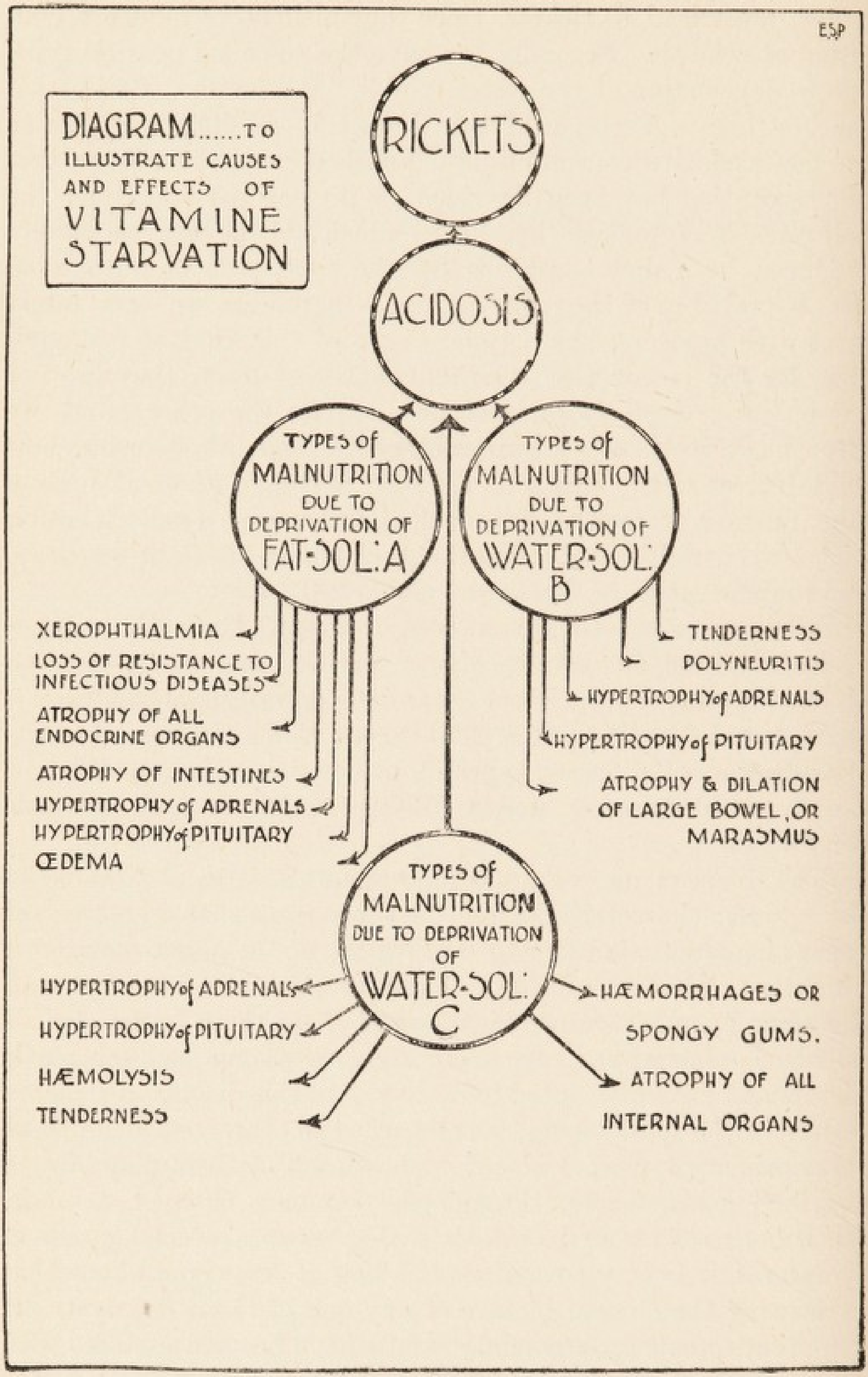


Fig. 79.—Diagrammatic Representation of Diseases due to Vitamine Starvation

In the following pages the above conditions will be described in greater detail.

MALNUTRITION DUE TO DEPRIVATION OF THE FAT SOLUBLE "A" FACTOR

Thanks to some very careful observations made on animals, there appears to be little doubt that deprivation of this particular vitamine leads to arrested growth, xerophthalmia and finally rickets. In infants I have had opportunities for observing an unsatisfactory condition of nutrition arising from lack of animal fat, which alone of edible fats contains this vitamine in adequate amount. Some years ago I attempted to feed infants on separated dried milk fortified with sugar and an emulsion of linseed oil. After a time the infants ceased to put on weight, and showed other signs of malnutrition. At first I attributed this result to the fact that linseed oil was, in its chemical composition, entirely unlike butter fat, and in this belief I substituted an alternative emulsion, the chemical composition of which very closely resembled that of the fat in breast milk. As a result of this change the infants immediately improved. In the light of more recent experiments I now recognise that my improved results were due to the presence in the new emulsion of a certain amount of animal fat—viz. suet —which contains a good proportion of fat-soluble "A." In view of its deficiency in this essential vitamine the original Marylebone Cream, which was merely an emulsion of linseed oil, has been repeatedly criticised as a dangerous substitute for cream. While fully agreeing that nutrition would seriously suffer if this Marylebone Cream were used as the exclusive source of fat in the dietary of infants, I utterly fail to see the impropriety of using it as a supplementary oil to the fat which already exists in cow's-milk or dried-milk dilutions. So far I have not been able to satisfy myself with regard to the exact amount of this vitamine which is necessary for adequate nutrition, but I am very much inclined to believe that no great quantity is required under ordinary circumstances.

During the last fourteen years I have been using very large quantities of Marylebone Cream to supplement the deficiency of fat in ordinary milk dilutions and I can safely say that I have never seen any definitely rickety symptoms result from this method of feeding and in later childhood the teeth are peculiarly good.

Attempts have been made to classify oils in accordance with their estimated content of fat-soluble "A." On page 478 I give a table which is taken from the *Medical Research Committee's Report*,[1] and which represents our present state of knowledge with respect to the value of various oils from this point of view.

From this table it appears that the substances which contain the largest proportion of the fat-soluble "A" factor are butter fat, cod-liver oil, yolk of egg, cabbage, lettuce and other green vegetables. Adult animals can obtain this essential vitamine from green foods, but young animals have to depend on more easily digested foods. As a rule, the butter fat contained in milk supplies an adequate quantum so long as the animal which supplies the milk consumes a reasonable supply of green food from which this vitamine originates. It is obvious for this reason that stall-fed cows in winter are liable to afford a milk which is deficient in this accessory factor, and the same is true of the human mother if green food is excluded from her diet.

The final conclusion to which I would point is that all artificially fed infants require for their normal nutrition a certain amount of animal fat, but not necessarily to the exclusion of vegetable and other varieties of oil which have good nutritional value.

According to Zilva, Giessen and Muira,[2] crude cod-liver oil is 250 times more potent than butter fat as a specific in the treatment of that particular form of malnutrition which develops in consequence of deprivation of the fat-soluble "A" factor. If this is so, a very small quantity of such crude oil added to the food of artificially fed infants would effectually prevent the development of symptoms due to this cause. It cannot be supposed, however, that such a precaution can prevent the development of rickets due to different causes. Further, it is my experience that infants do not tolerate cod-liver oil very well if given in large quantity; they vomit and become dyspeptic.

MALNUTRITION DUE TO DEPRIVATION OF THE WATER-SOLUBLE "B" FACTOR

Deprivation of the so-called water-soluble "B" factor leads, in the case of adults, to a comparatively definite group of symptoms which are most typically represented in the disease called beri-beri. It takes the form of a severe peripheral neuritis, with paralytic symptoms and frequently general œdema. As already stated, this disease develops in consequence of the withholding of the water-

[1] Special Report Series, No. 38. Published by H.M. Stationery Office.

[2] *Lancet*, 1921, vol. i., p. 823.

soluble "B" vitamine. The importance of this accessory factor does not appear to be great unless a considerable amount of starchy or farinaceous food is consumed. It would almost seem as though farinaceous food cannot be utilised by the animal organism unless a corresponding amount of this supplementary element is provided at the same time. Ordinary crude forms of farinaceous food appear to contain the necessary quantum of this ancillary factor, but when the same foods are submitted to a very thorough refining process they may lack the required complement. There is no real danger of the ordinary diets, such as we adopt in this country, being seriously deficient in this factor, although the highly refined white bread usually consumed may itself be seriously wanting in it. The foods which contain the largest proportion of it are eggs, wholemeal bread, haricot beans, germinated pulses or cereals and yeast preparations. "Marmite," which is prepared from a yeast refuse, and is sometimes used as a culinary flavouring material, contains this vitamine in rich amount. Infants very rarely suffer from the typical symptoms of this form of malnutrition, but it is quite possible that older children and adults, who live largely on meat, white bread, margarine and jam, may manifest mild symptoms of the disease. As a precaution, in the case of infants, it is wise to supply regularly a small quantity of the yolk of egg or Marmite. Older children would no doubt benefit by the occasional consumption of soups or purées made from peas or lentils previously soaked for a day or two in water and which have begun to germinate. "Marmite," which is also rich in the water-soluble "B," makes a nice flavouring for soups or gravies, or it may be used for making sandwiches. The addition of this vitamine to the dietary is said to promote lymphocytosis, appetite, fat assimilation and resistance to infective disease. Once again I would insist that although a certain quantity of this vitamine is necessary for good nutrition, you do not get better nutrition by supplying it in excessive amount. Half-a-teaspoonful of Marmite is an adequate allowance for the 24 hours.

MALNUTRITION DUE TO DEPRIVATION OF THE WATER-SOLUBLE "C" ACCESSORY FACTOR: SCORBUTUS, INFANTILE SCURVY OR BARLOW'S DISEASE

This type of malnutrition was the first of all the deprivational diseases of infants to be discovered. My revered teacher, the late

Dr W. B. Cheadle, pointed out as early as 1878 that the development of scorbutic symptoms was a late manifestation of rickets and due to feeding with "dead" food, while Sir Thomas Barlow in 1883 drew attention to the characteristic symptoms, apart from true rickets, which were apt to supervene on a diet deficient in meat and fresh vegetables. The disease is the same as that which used to develop among sailors who subsisted for long periods of time on pickled and preserved foods. At the present day infantile scurvy in its florid form is comparatively rare, but typical cases are still met with among infants who are exclusively fed on patent foods, dried milks or dairy milk which has been too thoroughly sterilised.

The symptoms of the disease in infants are for the most part hæmorrhagic in character, with spongy gums, extravasations of blood under the periosteum of bones and general tenderness of the whole body. These symptoms are so easily prevented and so easily cured by the addition to the food of small quantities of the raw juice of fruits or vegetables, without any other alteration in the diet, that it can scarcely be doubted that this symptom-complex is a true instance of a deprivational disease. The fact that the disease sometimes develops in infants who have been breast fed does not militate against this view, for a nursing mother may soon exhaust her reserves of this essential factor if she does not consume green foods or animal fats, which are practically the exclusive sources of supply. The same is also true of dairy milk produced by stall-fed cows in the winter. The animal body seems quite unable to synthetise this vitamine out of its constituent elements; plants and vegetables alone seem to possess this power.

This disease has frequently been described as an acid intoxication, such as develops in animals when they are fed on a diet containing an excess of acid and a deficiency of salts and alkaline bases. This view seems to me to put the cart before the horse. The ultimate result of the long-continued presence of this form of malnutrition will be, as in the case of other forms of malnutrition, the development of a definite acidosis, with all its characteristic symptoms, as described on page 344, while the ultimate result of the acidosis in infants and young children will be the evolution of the true rickety syndrome. The persistence of the term "scurvy rickets" shows that confusion still exists in the minds of some with respect to the relationship of these two distinct clinical entities.

The treatment of infantile scurvy is so simple and satisfactory that it is unnecessary to give details, further than to insist that grape juice, orange juice and turnip scrapings, given in small quantities every day, will rapidly effect a cure. On page 479 is given a list of foods which contain a good supply of this vitamine.

PROTEIN DEFICIENCY

Much attention has recently been directed to the nutritional disturbances which result from protein deficiency—deficiency which depends not so much on the absolute quantity of protein consumed as on its defective biological value.

The biological value of proteins, originating from different sources, has been found by K. Thomas [1] to differ essentially in accordance with their specific "make-up." The nearer a protein corresponds with the specific "make-up" of the tissues of the animal which consumes it the greater is the biological value, and the further it departs from it the lower is the biological value. This fact explains the great nutritional value of animal as compared with vegetable proteins as foods for the human individual. In the case of certain vegetable proteins their low value is explained on the grounds of their defective "make-up." For instance, zein, the protein of maize (see p. 105), lacks two essential amido-acids—*i.e.* tryptophane and lysin—while two other important amido-acids—*i.e.* argenin and histidin—are present in unduly small proportion. It is thus quite in accordance with theoretical expectations that the exclusive consumption of proteins of low biological value or defective amido-acid "make-up," such as zein for instance, should lead to nutritional disturbance, and especially in the case of growing animals, in which the various tissue proteins cannot be built up out of food proteins which do not contain the required amido-acid elements, since the latter cannot be synthetised in the animal body. It appears from the observations of Professor W. H. Wilson [2] that the disease pellagra is a typical instance of a nutritional disturbance due to the consumption of protein of inadequate biological value, and frequently ascribable to the too exclusive consumption of maize flour, the specific protein of which is zein, which, as already explained, has a defective biological value.

[1] K. Thomas, *Arch. f. Physiol.* (Du Bois Raymond), pp. 228, 229 and 266. 1909.
[2] "The Diet Factor in Pellagra," *Journal of Hygiene*, vol. xx., 15th July 1921.

It is highly probable that less typical symptoms of protein deficiency may result in growing animals from the consumption of varieties of protein which, though not deficient in actual quantity, may fall short of the required biological value. Throughout the pages of this book the pathological results of protein excess is frequently mentioned, but in this connection it must be remembered that proteins may supply the full allowance of calories and yet, if they are not of the required amido-acid "make-up," their biological value may be insufficient.

If the biological value of milk proteins be accepted as of the standard of 100, that of other proteins may be estimated in comparable terms; for instance, beef proteins have a somewhat higher value—viz. 104; the proteins of rice a lower value—viz. 88; the proteins of potato, 79; of pulses, 55; of wheat, 39, and of maize, 29. In other words, if the proteins of beef, rice, potato, etc., be substituted for the proteins of milk they must not be provided weight for weight but in accordance with their estimated biological value —*i.e.* in smaller or larger amount.

There can be little doubt that a judicious combination of different proteins is, in a physiological sense, more economical than an exclusive adherence to any one single variety, no matter how well adapted this particular variety may, on theoretical grounds, appear to be; the deficits of one variety of protein may be compensated for by the chemical "make-up" of another. Highly suitable as are the milk proteins for the building up of the tissues of all young mammals, it is quite conceivable that the occasional admixture of proteins derived from other sources may be of physiological benefit.

Pellagra, the best-known instance of a disease due to protein deficiency, is no doubt in the full efflorescence of its symptoms a composite disease, dependent on intestinal injuries as well as on a toxæmia of infective origin. The more common symptoms of the disease are debility, pain in the spine, insomnia, digestive disturbance and an exfoliative dermatitis; later the symptoms are those of a nerve-cell degeneration, with paralysis, spasms and mental disturbances.

It is very difficult in the case of infants or children to draw a clinical picture of the results of protein deficiency, for the reason that the degree of deficiency is seldom extreme or uncomplicated by other errors of diet. Defective growth and feeble resistance to infective disease appear to be two of the more characteristic manifestations. The suspicion of protein deficiency should always be entertained when the ratio of protein to non-nitrogenous elements falls below 1 to 7 in any diet in which the total energy-value is reasonably adjusted to the physiological requirements.

In order to determine whether, in the case of any particular child or infant, the diet contains an adequate allowance of protein, the theoretical caloric requirements should be estimated accurately and this figure divided by 5; the resulting number will give the required calories which must be supplied from protein sources. Since the caloric value of protein is 116 per oz., if the total number of calories which must be supplied by protein be divided by 116, the resultant will represent in ounces the daily requirement of protein. To take a concrete instance. If a child is estimated to require food of the value of 1500 calories in the 24 hours, the number of calories which must be provided by proteins is $1500 \div 5 = 300$. To supply 300 calories very nearly 3 oz. of protein of full biological value are required.

This calculation can only be regarded as correct for milk proteins or proteins of the same biological value. If other proteins are provided they must be substituted in larger or smaller quantities in accordance with their biological value (see p. 356).

MALNUTRITION DUE TO DEPRIVATION OF MINERAL SALTS

A very brief consideration of the many functions performed by mineral salts in the animal economy is sufficient to impress us with the importance of an adequate supply of these essential elements. The following are among the more important of these functions:—

(1) To regulate the specific gravity of the blood and other fluids of the body.

(2) To control the rate of absorption by osmosis.

(3) To preserve the tissues from disorganisation and putrefaction.

(4) To enter into the permanent composition of tissue structure, especially the bones and teeth.

(5) To serve special purposes in the elaboration of secretions—such as hydrochloric acid in gastric juice, and alkaline bodies in saliva and in the intestinal secretions.

(6) To act as carriers of CO_2, O, etc.

(7) To neutralise acid bodies of large molecular size and maintain the normal acid-alkaline balance of the blood.

Life cannot be maintained on a diet deficient in inorganic salts. Animals die more quickly on a demineralised diet than under conditions of absolute starvation, since in a very short time acidosis or acid intoxication results.

An examination of the above functions will suggest that while a more or less fixed quantity of mineral matter is required for the various purposes numbered 1–6, the quantity that is required for No. 7 will vary greatly under different circumstances. If many acid bodies, other than CO_2, are formed in the body a large supply of alkaline salts or available mineral bases will be required for the purposes of neutralisation, and these bodies will be lost to the body permanently and excreted in the emunctories. It is quite clear that all mineral elements consumed in the food are not available for this purpose, since many of them are already completely saturated, but citrates, carbonates, oxides and metallic bases in organic combination are essentially available, because they can liberate their own acid radicles—*i.e.* CO_2—and combine with other acid radicles of greater molecular size, while the CO_2 can be disposed of in the free state at the lungs' surface.

Vegetables and fruits, especially the citrous fruits, supply these organised mineral elements in liberal amount, while in meat and farinaceous foods they are present in small quantities. For this reason fruits and vegetables should constitute a considerable proportion of the diet of all children, in spite of the popular belief that fruits and vegetables, owing to their acid tastes, produce acidity of the blood. The exact contrary is the truth. The majority of town dwellers suffer from an inadequate supply of carbonates and citrates owing to the faulty character of their food, while on the other hand, owing to the conditions of their life, they create an excess of acid bodies which require neutralisation. I have already had occasion to point out that a diet of meat, fish, white bread, jam and margarine is not only defective in its vitamine content, but also in its content of sodium and calcium salts. According to Dr H. Lahmann such a diet is from 6 to 11 times poorer than cow's milk in mineral elements. More important still is the fact that the mineral content of such a diet is essentially unavailable—that is to say, the proportion of carbonates, citrates and oxides is particularly low. When we come to consider the character of the diet of many of our young children and adolescent girls it is hardly surprising that so many of them are found to be suffering from acidosis, anæmia and other effects of mineral depletion.

There is little danger that nurslings or infants fed on properly modified cow's milk will suffer from mineral inanition provided that no excessive demand is created for alkalies by over-feeding, under-exercising or any other condition which leads to sub-oxidation processes, but there is every danger when any of these etiological causes exist. There can be very little doubt that relative mineral deficiency is one of the causes of acidosis, and hence of rickets.

Salads, or fruits and green vegetables cooked in a minimum of water are the safest prophylactics against mineral starvation; but most of these foods are not available for infants; for them I would suggest vegetable soups and orange juice in liberal amounts.

MALNUTRITION DUE TO DEPRIVATION OF LECITHIN BODIES, EXTRACTIVES, ETC.

Mild degrees of malnutrition, with slow or arrested growth, appear to result from complete deprivation of lecithin bodies and meat and vegetable extractives. At present we have little definite knowledge on this subject, but I would repeat here what I have already had occasion to refer to frequently—viz. that it is a wise precaution to provide all artificially fed infants with a small quantum of vegetable and bone broth, since this contains not only meat and vegetable extractives, but certain other indeterminate substances present in red marrow, and of value from the nutritional point of view (see p. 476).

CHAPTER VIII

MALNUTRITION AND DISTURBANCES OF METABOLISM
(*continued*)

EXCESS DISEASES

Gout (Uricacidæmia, Lithæmia, etc.)—Glycosuria and Diabetes—Phosphaturia—Oxaluria

Gout.—It must be clearly understood that uncomplicated forms of malnutrition due to nitrogenous excess are extremely rare : the purity of the condition is liable to be marred by symptoms due to over-feeding with other varieties of food.

It is very difficult to define the exact limits of a physiologically constituted diet ; habit certainly plays a part with respect to the amount of protein which can be normally disposed of. Indeed, the human organism can, at certain cost, tolerate comparatively large amounts of protein if the total caloric value of the food is kept within physiological limits by a corresponding restriction in fats and carbohydrates. The view was originally held that if protein food was given in excess there was a danger that only part of it would be oxidised to urea and ammonia and that the remainder would undergo suboxidation processes, with a production of uric acid and the amino-purins—guanin, adenin, zanthin and hypozanthin. We now know that this is not strictly true, and that uric acid and its congeners can only be derived from such purin bodies as are contained in the food or are contributed to the general stock by the metabolism or breakdown of cell nuclei. There can be little doubt that the dissolution of the nuclei of white-blood corpuscles, which is constantly occurring as the result of alimentary leucocytosis, must contribute very largely to the total amount of uric-acid output. Since leucocytes themselves can apparently be built up from a purin-free protein material, it is clear that to some extent at least a purin-free dietary can contribute indirectly to the total output of uric acid and similar bodies. I mention this because it is at first somewhat difficult to understand how it is that on an exclusive milk diet, which is practically purin-free, the output of uric acid, in children as well as in adult individuals, can be indefinitely maintained. The endogenous fraction of uric-acid output seems to be fixed for each individual at a fairly constant figure, so that we have an important means of controlling the output of uric acid in the control of the quantity of purin bodies supplied in the dietary.

There does not appear to be any real danger attaching to any ordinary, or even to any moderately excessive, intake of purin bodies, so long as the means for their elimination remains normal. The danger arises when, through renal insufficiency, these bodies tend to accumulate in the system, or when, through any reduction in the alkaline reserves of the blood (acidosis), there are not an adequate number of basic carriers to neutralise them and effect their removal from the body. The normal liver can transform, and the normal kidneys can excrete, a normal quantity of purin bodies, but when either of these organs break down in function, owing to inherent weakness or prolonged strain, an accumulation in the blood and tissues of urates and other purin bodies inevitably follows.

It will thus be observed that one of the possible results of an excess of nitrogenous elements in the food is a defective elimination of purin bodies. Quite apart, however, from this consequence other troubles are liable to result owing to the strain which is thrown upon the liver in the de-amination of amido-acids. As long as an excess of amido-acids can be satisfactorily dealt with by the liver, and transformed into urea, comparatively little strain is imposed on the organism in the elimination of this physiological end-product. The trouble arises when the liver breaks down in function under prolonged strain, and especially when this event is precipitated by concomitant strains imposed on it in connection with the detoxication of the products of an intestinal intoxication. When this stage is reached the acute symptoms of a uric-acid crisis supervene—symptoms which are combined with those of the acidosis which invariably co-exists.

The signs of the defective metabolism of excess of protein, apart from those due to intestinal toxæmia and liver-failure, are therefore as follows :—

(1) Excess of uric acid and its congeners in the urine.

(2) Excess of ammonia, and urea-nitrogen in the urine and blood.

(3) Excessive acidity of the urine and high coloration.

(4) The accumulation of urates in the system and their deposition in the tissues.

(5) A state of acidosis, high blood pressure, mineral depletion and nervous irritability.

Protein excess is extremely common in the case of infants, as well as in the case of older children, when the dietary is largely composed of cow's milk, with its high protein content (see p. 244).

The treatment is the reduction of protein foods to physiological proportions, the stimulation of the liver by colchicum and mercury, and the free exhibition of alkaline salts.

GLYCOSURIA AND DIABETES

It is impossible in this book to explain in detail the causes and treatment of glycosuria or diabetes in infants and children; these matters, and other considerations connected with the defective metabolism of carbohydrates, can only be outlined in the briefest manner.

Sugar is eliminated in the urine or disposed of in some other way when its presence in the blood exceeds 0·15%. The body is provided with a number of very efficient mechanisms for maintaining the degree of saturation at the physiological level of about 0·1%. They are as follows:—

(1) When the sugar content exceeds the physiological level the superfluity is converted into glycogen and stored up in this form in the liver and other tissues; under certain conditions it may possibly be stored up in the form of fat.

(2) When the percentage of the sugar in the blood falls below the physiological level it is supplemented at the expense of stored glycogen, which is converted into sugar.

(3) When the maximum rate of storage and the physiological demand for sugar are exceeded by the rate of contribution from alimentary sources, the superfluity is excreted by the kidneys, and also most probably by the mucous membrane of the bowel.

As the result of the operation of these mechanisms it is clear that glycosuria will develop when the incoming supplies of sugar exceed the limits of storage and the physiological demands for this element. The amount of sugar that any individual can consume without the supervention of glycosuria is termed "the degree of sugar tolerance" or "the index of sugar utilisation." This index will vary in different individuals, and in the same individual at different times, but there are certain standards or limits within which the utilisation of sugar may be regarded as physiological and certain limits outside which the degree of tolerance becomes pathological. These indices have been better worked out in the case of adults than in that of infants or children, but the following figures derived from various sources may be regarded as fairly reliable:—

TABLE 80

SUGAR TOLERANCE

Grape-Sugar (dextrose or glucose)			
	Gm.		
In babies	5	per kilo. of body-weight	(Langstein & Meyer)
,, ,,	12	,, ,,	(W. Kahn)
In 1-mth.-old baby	8·6	,, ,,	(Greenfield)
In adults	3	,, ,,	
Lævulose			
In babies	1	,, ,,	(Keller)
In adults	3	,, ,,	
Maltose			
In babies	7·7	,, ,,	(Reuss)
Lactose			
In babies	3·1 to 3·6	,,	(Grosz)
In adults	3	,,	
Cane-Sugar			
In babies	3·5	,,	(Reuss)
In adults	2·5 to 3	,,	
Galactose.—No accurate data			

NOTE.—
1 kilogramme = 2 lb. 3 oz.
1 gramme = 15 grains
1 oz. = 28 grammes

To test the sugar tolerance for any particular sugar in the case of a child or baby a feed of the experimental sugar consisting of 50% more than the average amount tolerated should be given at one feed. If sugar appears in the urine it is proof that the degree of tolerance has been exceeded, and smaller and smaller quantities of the same sugar may be given on succeeding days until sugar ceases to be eliminated by the kidneys. The largest amount of sugar tolerated without the production of glycosuria represents the "index of utilisation" or "degree of tolerance." For instance, to test the tolerance for milk-sugar of a baby 8 months old and weighing 8 kilogrammes ($17\frac{1}{2}$ lb.), 42 grammes ($1\frac{1}{2}$ oz.) of milk-sugar should be given in about 5 oz. of water. If sugar does not appear in the urine 56 grammes may be given in a similar manner on the following day, or if sugar should appear 28 grammes (1 oz.) should be given on the next day, and so on until the exact degree of tolerance has been estimated.

In making these experiments it must be remembered that there are many circumstances that temporarily or permanently interfere with sugar tolerance: starvation temporarily increases it, over-feeding of any kind temporarily decreases it; exercise increases it, rest decreases it; cold increases it, heat decreases it; pancreatic disease or insufficiency decreases it, while thyroid or pituitary insufficiency decreases it. These factors must be taken into consideration in estimating in any individual child the index of sugar utilisation.

Speaking quite generally, strong, vigorous, active and physiologically fed infants have a high sugar tolerance, while debilitatated, inactive and badly fed infants have a low one. Children with a tendency to diabetes invariably show low tolerance long before sugar habitually appears in the urine. The line of demarcation between simple alimentary glycosuria and true diabetes is somewhat arbitrary, since the one condition may pass almost insensibly into the other. In all those cases in which a low degree of sugar tolerance is recognised in babies or children the carbohydrate consumption should be carefully watched and kept within physiological limits in case the comparatively harmless condition of glycosuria should pass over into the grave stage of true diabetes, while the various factors, such as the taking of exercise and the provision of internal secretions, as well as the factors which influence the rate of absorption from the bowel, should be kept under constant observation and control.

Provision should be made to prevent any sudden flooding of the blood with contributions of sugar; the maintenance of a regular and equable supply is better from this point of view than larger and more spasmodic increments.

Insoluble carbohydrates, such as starches, which are only slowly converted into soluble sugars, and hence can be only slowly absorbed, are in this regard preferable to sugar solutions which can be immediately absorbed from the alimentary tract. Since tolerance for different varieties of sugars varies with the individual, it is well to discover in any case of sugar intolerance that particular variety of carbohydrate which can be best utilised by the patient. It will be noticed in this connection, from reference to the table on page 363, that maltose is usually better tolerated by babies than either lactose or dextrose. Advantage may be taken of this property of maltose, by developing as rapidly as possible the starch-digesting functions of infants with low degrees of sugar tolerance, since the slow conversion of starch into maltose by the action of diastase promotes the object in view most satisfactorily.

Infants and children with a low degree of sugar tolerance should be encouraged, as far as possible, to create a demand for sugar by the taking of as much muscular exercise as is compatible with their condition. Massage and resistance exercises are both beneficial in this respect. The giving of thyroid extract also helps to promote the metabolism of carbohydrates.

The results of disturbed or strained carbohydrate metabolism, due to relative excess of this element in the diet, or to some inherent intolerance of sugar, depend on the degree of the defect; in extreme degrees diabetes, with all its characteristic symptoms, —acitonæmia, acidosis and coma—must be reckoned with, but short of this final stage every degree of glycosuria and chronic acidosis is at times met with.

Children with sugar tolerance of high degree have a marked capacity for storing glycogen and becoming obese, particularly when their tolerance is due to hypopituitarism, and conversely, children with low degrees of sugar tolerance are often thin, emaciated and incapable of being fattened up. In all cases in which abnormal sugar tolerance is suspected its degree should be carefully estimated by the method described on page 363, and if found defective, the carbohydrate ration should be reduced in amount to physiological limits. If, after estimation of the total caloric requirements, the physiological balance in the dietary cannot be maintained without exceeding the limits of sugar tolerance, the necessary calories must be afforded at the expense of a disturbance of the normal balance by increasing the ratio of the proteins, as is usually necessary in cases of diabetes. In all cases of sugar intolerance, not only should the total ration of carbohydrates be adjusted to the capacity for utilisation, but the amount of exercise taken should also be most carefully regulated, and increased to the limits of fatigue.

Genuine diabetes is a serious condition in children—in fact it is almost universally fatal. The management of the condition is the same in principle as in the case of adults, but for obvious reasons it is more difficult to carry out. To pursue successful treatment a careful estimate should be made of the approximate caloric requirements of the child or infant in accordance with the directions given on pages 10 to 14. What is commonly called a "starvation diet" is now the fashion in treating diabetes, but in my opinion a diet which is correct as regards caloric value without being physiologically deficient is more in accordance with the principles of rational treatment. In making an estimate of the caloric requirements of a diabetic patient the question of exercise must be taken into careful consideration. Children who are too weak to take exercise and are confined to bed can subsist on very exiguous diets, whereas ambulatory cases, taking plenty of exercise, require on physiological grounds a much larger ration.

The exact relative proportions in which proteins, carbohydrates and fats should supply the required quantum of calories is the crucial question in the rational treatment of diabetes. In the case of healthy babies and young children the physiological balance is approximately as follows:—protein, 2; fats, 3·5 and carbohydrates, 7—in other words, the standard of breast milk.

In diabetes, as a rule, this ratio cannot be maintained, and the protein ratio has to be increased at the expense of the carbohydrates and sometimes of the fats. The details to be observed in the attainment of the required balance are quite easy in the case of bottle-fed infants subsisting on a purely milk diet, but more difficult in the case of older children partaking of a mixed diet. In drawing up satisfactory diet sheets for children over one year of age pages 10, 152 and 238 should be carefully studied, and the necessary corrections made for increasing the protein elements and decreasing the carbohydrates, but it must be remembered that the goal to aim at is not to eliminate all carbohydrate food, but to find the correct caloric value of the total diet, and the highest carbohydrate ration that is compatible with the degree of sugar tolerance. In all cases of diabetes in children, fruits and vegetables should afford as large a proportion of the total carbohydrate allowance as is possible under the conditions, rather than cereals, since the latter are peculiarly deficient in those mineral elements which are so requisite in conditions of acidosis.

PHOSPHATURIA

Phosphaturia is the term usually applied to that condition of urine which is associated with the precipitation of earthy phosphates owing to excess of fixed alkali. Cloudiness of the urine often gives rise to unnecessary anxiety in those who do not understand its true significance. It by no means implies an excessive excretion of phosphoric acid, but rather the reverse ; indeed, it clearly shows that the urine is alkaline, which could hardly be the case with an excess of phosphoric acid. As a rule the condition is not, strictly speaking, a pathological one, although, if the condition is complicated by any considerable quantity of earthy phosphates, there may be some danger of the formation of phosphatic concretions in the urinary passages. As a rule, however, this does not occur unless the urine becomes extremely alkaline by reason of ammoniacal decompositions.

The term phosphaturia would be more rationally confined to conditions in which the total amount of phosphates in the urine is excessive—a condition which does not as a rule attract attention unless a quantitative analysis of the urine is made. The normal quantity of phosphorus excreted in the urine by infants is, according to Keller's [1] results, 0·0618 gm. in the 24 hours in breast-fed infants, and 0·4106 gm. in infants fed on cow's milk. The figures give some idea of what may be considered normal excretions in infants, but they must not be relied on too implicitly. An excessive output of phosphorus usually takes place owing to an excessive consumption of cow's milk, but it also occurs when there is a large breakdown of cell nuclei, as for instance, in leukæmia, and in other conditions of active leucocytosis.

So-called phosphaturia—viz. cloudiness of the urine—should not be regarded as a pathological condition requiring special treatment, for the alkalinity of the urine which gives rise to the precipitation of the phosphates represents the calling into play of one of the special mechanisms which control the acid-alkaline balance of the blood. When this balance turns on the alkaline side there is a compensatory excretion by the kidneys of alkaline bases, often

[1] Pfaundler and Schlossmann, *Diseases of Children*, p. 19. American translation. 2nd edition.

accompanied by phosphaturia. At present we do not know enough about this condition to entitle us to interfere with it by artificial means. Paradoxical as it may seem, the free administration of acid phosphate of sodium is the most practical means we possess for raising the degree of acidity of the urine and curing so-called phosphaturia.

It is interesting to note that Soetbeer has demonstrated that when the calcium-excreting functions of the intestines are interfered with by any morbid process, the kidneys vicariously take on the function, and cause an excessive excretion of calcium, in combination with phosphorus, in the urine; according to this view the basis of a phosphaturia is a calcarinuria.

Phosphorus enters so largely into the composition of the bodily tissues, and is required in such large amount to form the nuclein basis of the cell, that no restriction in the supply should be attempted without the fullest consideration, certainly not for mere cloudiness of the urine, but in those cases in which there is a genuine excess of phosphates in the urine the foods which contribute large quantities of phosphorus—such as milk, cheese and other milk products, yolk of egg and leguminous vegetables—should be avoided or reduced in quantity.

OXALURIA

Oxaluria—*i.e.* the presence of calcium oxalate in the urine and its tendency to fall out of solution either in the urinary passages or in the chamber—does not necessarily imply any absolute excess of oxalic acid in the urine; it rather implies a condition of the urine unfavourable for keeping it in solution—*i.e.* either excess of calcium or a diminished acidity. It is probable that in most cases such a deposition of oxalates is due to alimentary causes rather than to any inherent abnormality of metabolism. Although theoretically it is conceivable that a certain proportion of the oxalates present in the urine in oxaluric patients may be contributed by defective oxidation processes of normal food products—such as occurs in gouty and rheumatic subjects—nevertheless from the practical point of view the condition, which may be dangerous and lead to calculus formation, is best treated by avoiding those articles of diet which contain a high percentage of oxalates, such as rhubarb, spinach, tea, cocoa and pepper. Large contributions from these sources are avoidable and may raise the proportion of unavoidable contributions from other sources to the point of saturation. Children who have this oxaluric tendency often show marked intolerance of rhubarb, and in such cases, not only should all those articles of diet referred to above be excluded, but as far as possible, and within reason, the diet should consist of foods which contain a large proportion of magnesium salts and a small proportion of calcium. From this point of view eggs and milk are not so good as meat, while cereals, peas, beans, potatoes and apples are specially indicated.

CHAPTER IX

MALNUTRITION AND DISTURBANCES OF METABOLISM
(continued)

DISEASES OF THE ENDOCRINE GLANDS

Introductory Remarks—The Thyroid—The Adrenals—The Pituitary—The Pancreas

Introductory Remarks.—Although the part which the endocrine glands play in the control of nutrition is undoubtedly great, we are only just beginning to recognise clinically the results of over-action and under-action of individual glands or of combinations of them.

Organo-therapy is concerned with the artificial supply of the secretions of such glands as the thyroid, adrenals, pituitary, testes and pancreas in those cases in which there is believed to be a deficiency in the natural supply. We cannot claim that at present very satisfactory results have been achieved except in the case of thyroid-therapy, but then it must be remembered that in "team work" such as that performed by the many glands of the group it is very difficult to say whether any particular pathological result is due to failure on the part of one of the team, to over-action on the part of another, or to combined defects.

The part that food plays in the final result is probably considerable. M'Carrison [1] believes that vitamine starvation has a profound influence on all the internal secretions, leading to atrophy of all the endocrine glands, with the exception of the adrenals and pituitary, which, under certain circumstances, may actually hypertrophy. Whether in time we shall be able to distinguish the different influences of the various vitamines on the several endocrine secretions remains to be seen. In the following sections I shall confine myself to an account of the few facts that are known about the influence of food on the more important of the endocrine glands.

The Thyroid.—Over-activity of this gland results in a general

[1] "Dietetic Deficiency and Endocrine Activity." Robert M'Carrison. *B.M.J.*, 14th August 1921, p. 236.

quickening up of the metabolic processes, with increase of appetite, acceleration of the pulse rate, increase of glandular secretions, and later by exophthalmos, tremors of the hand and many other symptoms. It is by no means clear whether dietetic factors are directly concerned with the causation of Graves' disease or with lesser degrees of hyperthyroidism, but indirectly they may be associated with the pathology of these conditions by predisposing to bacterial infections which clearly lead to increase of activity of this gland.

According to H. R. Harrower [1] in hyperthyroidism the more important dietetic indications are:

(1) To increase the total caloric value of the food from 10% to 50% above the estimated normal allowance.

(2) To give concentrated and digestible rather than bulky and watery foods.

(3) Meat should only be allowed in small quantity, while purin bodies should be reduced to the lowest possible quantity, owing to their stimulating qualities.

It has been suggested that since the pancreatic hormone is antagonistic to the adrenal secretion, and possibly to that of the thyroid also, it may be rational to attempt to stimulate pancreatic activity by all available means (see p. 374) in order that indirectly the activity of the thyroid may be restricted.

Apart from its connection with nervous causes and with the activity of the sexual functions in females, little is known of the pathology of hyperthyroidism. It is probable, however, that when the system is seriously threatened with the dangers associated with bacterial infections, the thyroid comes to the aid of the defensive mechanisms by increased activity and the pouring out of internal secretions which stimulate metabolism. In adults alveolar pyorrhœa appears to be commonly associated with goitrous conditions, but in children this is naturally a rare combination. On the other hand, coli infections are common in both infants and children and may predispose to hyperthyroidism, and since coli infections are clearly connected with food causes and unhealthy conditions of the bowel, an indirect connection between over-activity of the thyroid and diet may be surmised.

Hypothyroidism.—Thyroid insufficiency must be much more common in infancy and childhood than over-activity of the

[1] *Dietotherapy*, vol. iii., p. 477.

gland if one can judge by the frequency with which the artificial administration of thyroid extract gives good results. In infants subnormal temperatures and sluggish metabolism are extremely common; symptoms which are strong indications for a restriction of the food intake. There is nothing more fatal than to attempt to fan sluggish metabolism into life by an increase of food. Under such conditions excess of food cumbers the body and becomes pabulum for bacteria. There can be no doubt that thyroid-therapy is invaluable as a means of stimulating the metabolic processes. Whatever measures are contra-indicated in hyperthyroidism are of service in hypothyroidism. Stimulating foods, such as meat and purin-containing articles of diet, certainly promote thyroid activity, and it has been suggested that, since iodine is one of the essential elements in thyroidin—the specific therapeutic constituent of thyroid secretion—foods with a good iodine content are indicated. In this connection it is interesting to note that Benedict has made the suggestion that the prevalence of goitre and hypothyroidism in mountainous districts and in regions far removed from the sea may possibly be due to want of iodine, which is confined chiefly to marine foods, animal as well as vegetable.

It has been my personal experience that Irish moss, which contains a rich percentage of iodine, is a most useful addition to the food of infants. In the form of a decoction it can be added to milk modifications, or it can be employed as the emulsifying agent in the preparation of cod-liver oil and other fat emulsions. Shrimps, oysters, lobsters and other shellfish have a high iodine content, but they must be given to children with caution. Peas, beans and other leguminous vegetables also contain a good percentage of iodine, but these vegetables are also somewhat dangerous foods to give young children unless they are very well cooked.

The chief precaution to take in cases of hypothyroidism is to reduce the food to the level of the restricted requirements.

THE ADRENAL GLANDS

The internal secretions of these glands subserve two distinct functions. The hormone manufactured by the medullary or cromaffin portion is connected with the maintenance of blood pressure and tonus of unstriped muscle, while that elaborated by the cortical portion appears to be associated with the development of certain of the sexual characteristics.

Over-action of the adrenals in children leads to precocious sexual development, hirsutism, somnolence, high blood pressure, spasm and over-action of sphincters (pyloric spasm, etc.). Whereas adrenal insufficiency, from destructive lesions of these endocrine glands, leads to asthenia, fall in blood pressure, pigmentation of the skin and looseness of sphincters. According to M'Carrison [1] the suprarenals enlarge either in regard to cortex or medulla in consequence of deficiency diseases. In disturbances of the adrenal secretions care must be taken to supply all the necessary accessory food factors, and in over-action of the gland, pancreatic secretion should be encouraged, since it has antagonistic properties, and in this connection it is important to safeguard the alkaline reserves of the blood as far as possible, since any depletion of alkaline bases must prejudice unfavourably the amount of the alkaline secretions poured into the duodenum by the liver, pancreas and intestinal glands.

Pancreatic secretion is not only dependent on adequate supplies of alkalies, but it is also dependent on the formation of acid in the stomach, and for this purpose an adequate supply of sodium chloride must be present in the food.

The two indications in the food, therefore, are a full provision of vegetables and fruits for the supply of alkaline bases, and the provision of sufficient table salt in the food.

On the other hand, all those conditions which predispose to acidosis (see p. 341) tend also to lead to hyperchlorhydria and pyloric spasm, results which in themselves tend to restrict pancreatic secretion.

THE PITUITARY GLAND

As in the case of the adrenals this gland appears to possess a dual function: the anterior part elaborates a secretion which has relationship with growth, and a posterior part is connected with metabolism of sugar and fat deposition.

With hypopituitarism is associated reduced rate of growth, defective development of the genital organs, obesity and increased sugar tolerance.

The significance of diet in connection with abnormality of the pituitary secretions is still undetermined, but if M'Carrison [2] is

[1] *B.M.J.*, 9th June 1920, p. 1237.
[2] *Ibid.*, 19th June 1920, p. 237.

right, vitamine starvation may bring about a simultaneous hypertrophy of this gland along with that of the adrenals.

In hyperpituitarism there is excessive metabolism, as there is in hyperthyroidism, and consequently the diet should be above the normal in quantity. Apart from this indication, and the adequate supply of vitamines, the condition does not call for special treatment.

In hypopituitarism there is often an excessive appetite (bulimia) and rapid deposition of fat. The craving for sugar and carbohydrate food should not be humoured, indeed the total intake of food should be limited in accordance with the general lowering of the metabolic processes.

THE PANCREAS

The influence of the " external " secretions of the pancreas have already been considered in connection with digestion (see p. 41). As a rule the formation of the pancreatic hormone is influenced by the same factors that influence the external secretions, so that the same causes which lead to atrophy or hypertrophy of the gland as a whole may be assumed to influence the special functions of internal secretion. M'Carrison claims that vitamine starvation leads in the case of growing animals to atrophy of the pancreas, along with corresponding want of development of the whole series of endocrine glands as well as of the entire digestive system. Owing to the antagonistic action of the pancreatic secretions, whether internal or external, on the adrenal secretion, it would appear to be a rational proceeding in adrenal or pituitary excess to adopt any dietetic measures which are calculated to promote pancreatic secretion. As already mentioned, the pancreas is stimulated indirectly by the admission of acid chyme into the duodenum, since thereby the secretion of " secretin " is promoted. All dietetic means which promote gastric secretion and the passage of acid chyme into the duodenum, as the giving of protein food, for instance, should be adopted in cases of pancreatic insufficiency. Sugar tolerance should always be estimated in cases of suspected pancreatic insufficiency, and, if found to be low, the supply of carbohydrates should be adjusted accordingly.

CHAPTER X

MALNUTRITION AND DISTURBANCES OF METABOLISM
(continued)

MARASMUS

Marasmus (Infantile Atrophy—Athrepsia, etc.)

This condition, which is sometimes called infantile atrophy or wasting, is, like rickets, a late or terminal phase of various constitutional diseases, such as tuberculosis and syphilis; it also results from various disturbances of the gastro-intestinal tract. It appears, however, to occur independently of any obvious or detectable organic lesions, and has been regarded by Holt as a "vice of nutrition." The number of apparently idiopathic cases is, however, becoming progressively smaller as our methods of diagnosis improve and our knowledge of the pathology of the endocrine glands and of the influence of accessory food factors develops. The fact that improvement or ultimate cure can be effected by dietetic measures alone in quite a considerable number of instances is very suggestive that in many cases the ultimate cause of the condition is not an inherent vice of nutrition but some fault in feeding. Another argument in support of this is that a certain number of infants who eventually become marasmic often enjoy a short period of perfectly good health after birth.

While fully realising that the majority of cases of atrophy can be traced to some fault of digestion or absorption, there can be no doubt that the condition itself represents a genuine atrophy of the tissues.

It must be admitted that the fact that the majority of marasmic infants do not become typically rickety requires a good deal of explanation. My own view is that the majority of marasmic infants would become definitely rachitic were it not for the fact that absorption from the alimentary tract is in the majority of cases so defective that growth is extremely slow. There is undoubtedly a connection between the rapidity of growth and the extent of the characteristic bony deformities. If bones grow quickly without being adequately reinforced with calcium and other mineral elements they soon become large, soft and distorted; in conditions of starvation they grow slowly, and even in the absence of adequate mineralisation they do not show typical evidences of rickets. Although the evidence is not completely convincing, I cannot help thinking that in a very large number of cases infantile atrophy is due to genuine atrophy of the absorbing surface of the alimentary tract, the latter itself being due to damage inflicted by a condition of severe ileo-colitis.

Treatment.—Successful treatment depends very largely on an accurate diagnosis of the underlying cause. The possibility of an hereditary or congenital vice of metabolism must be recognised, and inquiries should be instituted with a view of discovering etiological factors existing before birth; if, however, the infant appears to be healthy at birth, and to remain so even for a few days, all such prenatal causes may be disregarded and the diagnosis narrowed down to some environmental influence such as bad feeding or infection of a septic, catarrhal, tuberculous or syphilitic character.

Tuberculosis can, as a rule, be recognised by the characteristic temperature chart; syphilis can be diagnosed by the Wassermann reaction; catarrhal and septic infections can be recognised by the general course of the symptoms; failure of the digestive processes can often be inferred by the appearance of the stools, while failure of absorption is suggested by a disproportionately large size of the motions in relationship to the amount of food consumed.

The temperature must be very carefully considered in relationship to the treatment; in progressive wasting from tuberculous, septic and other infections the atrophy is accompanied by pyrexia, and requires a totally different kind of treatment from that which is characterised by a subnormal temperature, and in this connection I would once again emphasise the importance of taking the temperature with a thermometer with a well shaken down index. In the one case the metabolic processes are active and in the second case they are depressed.

Irrespective of the nature of the underlying cause the following general principles must be observed in the treatment of all cases of marasmus:—

(1) First of all the very greatest patience is required in the treatment, since, under the most favourable conditions, improvement must be slow.

(2) A definite line of policy must be pursued, in spite of the importunity of anxious relatives, who invariably press for new and experimental measures.

(3) The diet must fulfil the following physiological requirements:

(*a*) The quantity must be co-ordinated to the actual requirements of the child; it must not be based either on age or on weight, but on the output of energy. As a rule, especially in apyrexial cases, the requirements are extremely small.

(*b*) The balance of the individual food elements must be arranged on the basis of breast milk. There is a great danger of departing widely from this standard owing to digestive difficulties.

(*c*) Particular attention must be paid to the adequate supply of all the accessory factors. Since fat is often badly tolerated in these cases there is a grave danger in humouring this idiosyncrasy by depriving the child of his due allowance of the fat-soluble "A" factor. In such cases quite a small quantity of crude cod-liver oil, which contains a great deal of this essential vitamine, may be substituted for other fats with a poorer content. In all cases of marasmus I find some 3 or 4 oz. of vegetable broth (p. 476) a most valuable addition to the diet. I find also that a small dose of lecithin, say from 1 to 2 grains in the 24 hours, a useful adjunct.

(*d*) The food must be adapted to the existing powers of digestion; it is often necessary to predigest the food very thoroughly (see p. 472).

(*e*) The intervals of feeding should not be less than 3 hours. As a rule marasmic infants digest slowly and absorb slowly.

(4) If the marasmic infant has a low temperature, and gives other evidence of sluggish metabolism, the latter must be stimulated by all available means—as, for instance, by massage, open-air treatment, baths, sunshine and stimulating foods, such as extractives and meat juices. The most reliable stimulus of metabolism is, however, extract of thyroid gland; this may be given in

comparatively large doses if the temperature and pulse rate are carefully watched.

(5) The energies of the marasmic infant must be carefully conserved, and all unnecessary loss of body heat prevented by suitable coverings; this does not, however, mean that the infant should be deprived of the invigorating influence of breezes playing upon his face and other exposed parts of his integument. Professor Leonard Hill has shown most conclusively that surface stimulation by moving air is one of the most potent factors for insuring active tissue metabolism.

(6) Drug-therapy is not, as a rule, an important element in the treatment, but complications must be dealt with as they arise. Intestinal intoxications often play a most important part in the etiology of marasmus. There is no completely satisfactory intestinal disinfectant: Izal, Dimol and sulphur are among the more efficient. Low blood pressure is a common symptom, and must be treated by cardiac tonics, such as digitalis and citrate of caffein. Defective excretion must be met by the administration of diuretics, laxatives and diaphoretics. Nerve exhaustion and muscular adynamy is rationally treated by calcium glycerophosphate and phosphorated cod-liver oil. Should there be evidence of endocrine insufficiency of any kind it must be treated by appropriate organotherapy.

CHAPTER XI

INFECTIVE DISEASES

The Chronic Infective Diseases.—Tuberculosis—Syphilis—Rheumatism
The Acute Infections.—Acute Rheumatism—Acute Coli Infections
The Acute Exanthematous Infections, etc.
General Remarks.—Measles—Scarlet Fever—Chickenpox—Influenza—Diphtheria—Whooping Cough—Typhoid Fever—Paratyphoid Fever

TUBERCULOSIS

General Considerations.—On the subject of diet in the treatment of tuberculosis controversy has long raged furiously—some authorities advocating forced feeding and excess dietaries, while others have insisted on dietaries unbalanced in various directions; some in the direction of protein excess, others in the direction of carbohydrate excess, while yet again others insist on excess of fat. The ultimate aim, however, of all methods has been to improve nutrition although by various means. Tuberculous disease, or consumption, has at all times been correctly regarded as a wasting disease, and it is only commonsense, on this supposition, to aim at an improvement of general nutrition and to repair the ravages of the underlying wasting processes. Irving Fisher, who has made a more careful inquiry into the methods and results of different authorities than most other writers, points out the very wide variations in caloric value recommended by different schools of thought. While some recommend a caloric value of 5500, others place the requirement as low as 2100 for the adult individual. He urges that both extremes cannot be right and that probably physiological economy is better subserved by the lower than by the higher standard. At the same time he draws attention to the importance of studying the particular metabolic individualities of the patient. It seems difficult to believe that good nutrition can be compatible with over-feeding—that is to say, with relative over-feeding; the one obvious essential of good nutrition is that the supply of energy should be exactly adjusted to the output. If the amount of food supplied exceeds the latter in the least degree, strains are immediately thrown on the mechanisms which are concerned with the maintenance of metabolic equilibrium, and such strains must prejudice nutrition unfavourably. Similarly good nutrition is incompatible with under-feeding, for under such conditions the fixed tissues and food reserves must be drawn upon to supply the deficit.

Tuberculous disease takes a hold on the individual and flourishes when metabolism falls to a low level, and especially in tissues which from any cause are undergoing degenerative or involutionary changes—in other words, in tissues in which the rate of catabolism exceeds the rate of anabolism. Hence the aims of dietetic treatment should be to speed up the general metabolic processes, with the preponderance on the anabolic as opposed to the catabolic side. This explains why we usually regard favourably the effects of treatment when there is a gain of weight in the tuberculous subject. It should be clearly understood that although a gain of weight is of good augury as a general rule, certain kinds of gain are very superior to others. The mere fattening of the patient with storage of glycogen and deposition of fat does not necessarily imply any quickening-up of the metabolic processes. It may, indeed, represent want of oxidation and a slowing-down of the vital processes, whereas a gain in weight in muscle and other physiologically active tissues clearly implies increased possibilities for chemical change. The real advantages of the open-air treatment lies in the full exposure of the patient to the stimulating influences of cold air and heliotherapy, both of which are capable of producing increased metabolic activity in the muscles and other physiologically active tissues without necessitating the actual taking of muscular exercise which may cause concomitant fatigue. Muscular tonus, no less than muscular contraction and physical exercise itself, implies activities in the muscle cell. The goal to aim at in the treatment of tuberculosis is to create increased physiological demands for food by stimulating metabolism rather than to increase the supply, which may defeat its own ends if at the same time the demand is not provided.

The Caloric Requirements of the Tuberculous Child.—If I were to venture to express in terms the caloric requirements of the tuberculous child, I should define them as equivalent to the maximum demand which can be created by physiological stimulation —that is to say, by reasonable exposure to cold air, by the taking of reasonable amounts of exercise, and by reasonable exposure to sunlight. Relative over-feeding, with all its attendant evils, must be avoided, but reasonable demands should be created for food by reasonable stimulation. To what extent the diet should be increased above normal standards will consequently depend on the extent to which the metabolic processes can be stimulated beyond the average limits by the various expedients which are available in the treatment of the particular case. An adult individual of average weight remaining at complete rest in bed creates a demand for not much more than 2000 calories in the 24 hours, as compared to about 3000 calories when he takes ordinary exercise. If the supply of such an individual at rest is more than 2000 calories he will be relatively overfed, and his nutrition will suffer in consequence. If, however, the individual is a consumptive patient undergoing open-air cure his metabolic processes may be stimulated into increased activity by exposure to sunshine, cold air and invigorating breezes, and under such conditions his caloric requirements may be increased from 50% to 100%.

It is somewhat difficult to make any definite statement with regard to the extent to which the diet of any tuberculous patient may be advantageously increased, but, making allowance for individual variations in the functions of digestion and assimilation, it may be stated in general terms that the metabolic processes may be increased by some 25% to 35%. On this basis the caloric requirements of any tuberculous child may be calculated by referring to the table given on page 240. These figures represent the caloric requirements for normal children taking an average amount of exercise: they must be reduced by about 30% if the child remains at rest in bed, so that the diet of a tuberculous child at rest in bed is practically the same as a non-tuberculous child of the same age and weight taking normal exercise. If, on the other hand, the tuberculous child is sufficiently well to take exercise, the caloric value of the diet should be increased about 30% above the normal standard.

The caloric requirements of the tuberculous child are about 30% higher than that of the normal healthy child of the same age and weight and taking the same amount of exercise. This increment is not justified unless it is accompanied by open-air treatment.

The Character of the Dietary.—In my opinion one of the main principles that should be observed in arranging the "balance" of the above high caloric diet is that the ratio of the proteins to the other constituents of the food should be higher than normal. Bardswell and Chapman think that the protein allowance should be increased from 25% to 30%. I concur in this view, and suggest that if these additional calories be provided exclusively by such protein-rich foods as meat, fish, eggs and milk, the necessary addition will be fairly correctly provided. There is, on theoretical grounds, good reason why, in tuberculosis, a high protein diet should be afforded. In the first place, the elaboration of those anti-bodies which are essential for active resistance to the tuberculous process must be a function of nitrogenous metabolism, and in support of this theoretical argument we have the practical experience that carnivorous animals are, as a rule, highly resistant to tuberculosis, and, further, that gouty individuals who consume large quantities of meat have an enhanced degree of immunity, while sugar-fed individuals are highly susceptible to all infectious diseases, including tuberculosis, and show little resistance.

Apart from the preponderance of protein foods in the diet of tuberculous children, it may be stated that the diet should fulfil to the utmost all the essential laws of physiological feeding—that is to say, it must be otherwise correctly "balanced": it must be digestible and assimilable; it must contain representatives of all the essential vitamines, salts, extractives and other accessory factors and, further, it must be varied and appetising. In my experience the usual diets of tuberculous children are too dull and monotonous. Personally I am a strong believer in the advantages of a fresh-food diet for tuberculous as well as other children, and I think it should contain a rich proportion of vegetables, fruits and milk to provide an adequacy of salts in organic combination. On the other hand, I do not advocate large quantities of cod-liver oil, except in those cases in which cream, butter and animal fats cannot be supplied in sufficient amount.

The "balance" or composition of the diet of the tuberculous child should be so arranged that the proteins are about 30% higher than in a normal dietary; in other respects it should comply with the general physiological principles applicable in the case of normal children—that is to say, it should be digestible, assimilable, fresh, varied and appetising; it should also contain representatives of all the accessory factors.

The Feeding of the Tuberculous Baby.—Both the tuberculous and pre-tuberculous baby stand pre-eminently in need of breast feeding. No food is better than breast milk : for this reason the tuberculous baby should not be deprived of the advantage of it without good reason. If the mother herself is tuberculous, breast feeding is not necessarily contra-indicated ; the danger to the child of direct infection is very little, if at all, enhanced by this proceeding. I believe it to be a rule almost without exception that all infants living in the same house, or in direct contact with tuberculous mothers, invariably become inoculated within a very short time of birth. Such inoculation, unless it is massive, may actually lead to immunity, but the chances of acquiring immunity are enormously increased if the infant's powers of resistance are reinforced by the protective bodies which exist in considerable amount in colostrum and to a small extent in the milk of a mother who is herself tuberculous. Whether active tuberculous lesions result from such inevitable infections depends very largely on the general health of the infant : the better this is, and the better the method of feeding, the more likely is it that the infant will escape serious damage. If, under such circumstances of exposure to infection, the infant's powers of resistance are reduced by local damage or intercurrent infections of a catarrhal, influenzal, colonic or septic character, the more probable is it that the tubercle bacillus will gain a firm footing. Infants who have once suffered from bronchitis, enteritis, adenitis, or such-like inflammations, readily develop tuberculous lesions at the site of the damage. For these reasons infants liable to exposure to tuberculous infection should be specially carefully fed and safeguarded against vicarious infections of all kinds. Therefore, there are very distinct advantages that the infant who is a candidate for tuberculosis should be breast-fed by the mother, even though she is herself a source of infection.

If the mother's health is definitely impaired by the strain of breast feeding she must clearly give up all attempts to nurse her child, but in my experience the majority of tuberculous mothers benefit rather than the reverse from the effects of lactation, just as they do from the physiological stimulus of pregnancy itself. Nevertheless, if a tuberculous mother attempts to feed her own child she must be kept under very careful supervision and her weight regularly recorded.

The tuberculous infant should, if possible, be breast-fed, since breast milk is not only the best food but it also may convey a certain *amount of passive protection. What is true of the tuberculous infant is still more true of the infant who is a candidate for tuberculosis.*

The Feeding of Tuberculous Children over 1 year of Age.—In my experience the majority of tuberculous children, especially those immobilised by reason of their physical infirmities, are not only overfed, but they are also irrationally fed as regards balance and other details. In accordance with the principles enunciated in the foregoing pages the chief desiderata in arranging appropriate dietaries for tuberculous children are as follows :—

(1) To create a good physiological demand for food and thus secure a raised standard of metabolism.

(2) To adjust the intake of food to the requirements of these raised metabolic processes and thus avoid the disadvantages of over- or under-feeding.

(3) To so arrange the " balance " of the food with respect to the three main elements that the total quantity of the proteins given in the 24 hours should be about 30% greater than is correct under normal conditions.

(4) To comply with all the other requirements of physiological feeding as regards digestibility, absorbability, variety and taste.

In order to provide a diet of correct caloric value the table on page 240 should be studied, remembering that for ambulatory cases an extra allowance of 30% should be made in the caloric value, and that the requirements of bedridden cases are about 30% less than those of children who can take active exercise.

In order to correct the " balance " in favour of a 30% protein increase, the tables between pages 274-275 may be employed as a basis for general use, but the protein foods should be increased in amount by rather over 30%, while the carbohydrate and fat elements should be decreased by a corresponding amount. To take a concrete example, let us imagine that the tuberculous patient is a child of 6 years of age, with a weight of 40 lb., and capable of taking ordinary exercise. On referring to the chart on page 240 it will be seen at a glance that the daily caloric requirements of such a child in normal health are 1600 ; according to the above computation the requirements of a tuberculous child of similar age and weight would be about 30% greater—in other words, about 2100 calories. On referring to the diet sheets for children between 5 and 16 years of age, between pages 274-275, the full details for feeding will be found for providing an allowance of 1600-2400 calories. In using these tables the range of quantities will be considerably more than the minimum amount, and slightly short of the maximum. If it is thought necessary to make a very exact estimation of the quantities of the different foods which are required to afford the exact number of calories, independent calculations must be made, but otherwise some 14% or 15% may be omitted from the maximum amount.

As regards "balance," the different food elements are so combined in these tables that the resulting ratio of the proteins, carbohydrates and fats is correct for normal conditions. For tuberculous cases the protein ration should be raised by some 30% and the carbohydrate decreased by corresponding amount. Taking the meals as they are given for the first day on this chart, the following changes may be made to secure the necessary adjustment in balance.

For breakfast, the total amount of milk given may be increased by $\frac{1}{3}$—that is to say, $2\frac{1}{2}$ oz. may be provided for the tea and about $3\frac{1}{2}$ oz. for the porridge; while the amount of bread may be decreased from 3 oz. to $2\frac{1}{2}$ oz.

For dinner, the amount of fish may be increased from $2\frac{3}{4}$ oz. to about 3 oz., while the amount of potatoes and bread may be decreased from 2 oz. to 1 oz. For tea the milk may be increased to about 12 oz. and the bread reduced to about 2 oz.

For supper, either the milk in the milk pudding may be increased by 30%, or if milk is used for making the soup there may be a similar increment, while the amount of bread may be reduced in similar proportion.

These details are given not so much for the reason of preventing slight errors as for obviating the enormous mistakes which are commonly made with respect to the caloric value of the supply. Tuberculous children are often filled to repletion with cream, butter and cod-liver oil, until the caloric value of the food supply exceeds the physiological limits by a very large amount, and a dangerous condition of acidosis and liver exhaustion is calculated to supervene. Tuberculous children are often given sufficient milk in the 24 hours to provide the total number of calories required for this period, without taking into account any of the other articles of diet with which they are amply provided. Under such conditions it is scarcely surprising that they lose appetite and become bilious. For obvious reasons tuberculous children should be kept sufficiently hungry to ensure appetite and enjoyment of meals. These ends cannot be obtained if they are given glasses of milk between meals and before going to bed. Open-air treatment and exposure to cold and sunshine, which so effectively stimulates the metabolic processes, combined with physical exercise, when this can be taken with safety, are the most reliable expedients for ensuring the continuance of appetite, and the physiological demand for food. Psychological expedients, such as suggestion and variety, appearance and flavouring of the food, are important adjuvants for maintaining appetite. Large helpings of overcooked meat and potatoes, or large slices of suet pudding and treacle, are not reliable means of tempting the appetite or provoking the secretion of digestive ferments. There can be little doubt that fresh foods, and especially those rich in vitamines, are as essential for maintaining nutrition in tuberculous subjects as in the case of young infants. Fresh food, such as salads, raw fruits and cooked vegetables, should be provided in ample amount as long as they are fully digested and assimilated, while cream, butter and leguminous vegetables, rather than cod-liver oil, should be largely relied on to provide the required number of calories.

It often happens that infirmities of one sort and another prevent tuberculous children from digesting or assimilating the excessive dietaries that are indicated for maintaining a high level of metabolism. Under such conditions there is ample scope for resourcefulness and ingenuity in arranging the daily menu. The patient's digestive functions must not be overtaxed in order that metabolism may be maintained at a high level, neither must absorption of large quantities of fat be expected to take place by way of the lacteal system when the circulation through mesenteric glands and lymphatics is obstructed by tuberculous granulomata. These obvious facts should be remembered when a tuberculous child is unable to digest and assimilate the required quantities of food which are essential for maintaining metabolism at the desired level. For further particulars with respect to the dietaries of children suffering from general tuberculosis or involvement of special organs the reader is advised to consult Dr W. E. Fitch's[1] admirable text-book on diet.

[1] *Dietotheraphy*, vol. iii., pp. 198-246 and 687 (Appleton).

SYPHILIS

General Remarks.—There are few special indications in the dieting of syphilitic children beyond remembering that dietetic liberties cannot be taken with them in the same way that they can be taken with healthy children. It is sometimes urged that during mercurial treatment the diet should be "very generous." If this means over-feeding I cannot agree. The diet in syphilis should be adjusted to the output of energy even more accurately than in the case of a healthy child, since any error, whether of excess, deficiency "balance," digestibility or other quality, will necessarily produce more serious results owing to the abnormal condition of the child.

The Feeding of the Syphilitic Baby.—The greatest dietetic misfortune that can happen to the syphilitic baby is to be deprived of his rights to breast feeding, and to be relegated to the bottle. Syphilitic infants are very vulnerable, their tissues are easily damaged, they easily become infected, while functional disturbances of the digestive system are readily provoked by comparatively small mistakes. On the whole, syphilitic babies require food of a smaller caloric value than healthy babies, for the reason that they are physically feebler and because metabolism is carried on at a lower level.

Syphilitic babies not infrequently die suddenly for no very obvious reason. I cannot help thinking that in some cases this may be due to the supervention of some extraneous infection, to which, owing to their enfeebled condition, they show little resistance. Since breast feeding confers some additional resistance to infective disease this is a further argument against bottle feeding. The "fœtus in utero" appears to be protected in some degree against infection by the "filter" action of the placenta, and to some extent this maternal protection is carried on after birth by the colostrum and milk of the mother, both of which contain certain quantities of protective bodies. Since wet nursing must be obviously denied to the syphilitic baby it is of importance that bottle feeding should be conducted on the very best lines in those cases in which the mother is unable to nurse.

The general feebleness of the syphilitic baby and its debased metabolic functions preclude either the digestion or the utilisation of large quantities of food, hence such food as is provided should be of the most digestible character, and somewhat restricted in quantity. If peptonised milk is employed, the artificial pre-digestion should be carried to a further stage than would be considered necessary for a healthy infant of the same age and size, and the change to unpeptonised milk should be more gradual and more carefully carried out. Somewhat stimulating varieties of food are sometimes indicated. I can recommend the addition of raw-meat juice as a substitute for part of the milk, and the addition of red marrow and other extractives is well worth trying from this point of view. Owing to their feeble metabolism, syphilitic babies often fail to generate sufficient heat to maintain the body temperature. For this reason their temperatures should be carefully watched, and a subnormal thermometer employed if necessary. If the temperature is found to remain permanently subnormal, the administration of a small quantity of thyroid extract will be found useful.

CHRONIC RHEUMATISM

Rheumatic manifestations, or the "status rheumaticus," are somewhat intangible entities in childhood. Growing pains, enlarged tonsils, chorea, nervousness, erythema nodosum, fibrous nodules, in addition to endocarditis, myocarditis, pericarditis and arthritis, make up in various combinations the rheumatic picture at this period of life.

I am very strongly of the opinion that the rheumatic diatheses is not an imaginary condition. I believe that there is a habit of body or metabolism which favours the development of various pathological organisms to which the so-called rheumatic symptoms are due. It will be often noticed that the children who eventually become rheumatic have certain clinical features in common, among which the following may be included :—a dirty complexion, tainted breath, nervousness, night terrors, abdominal pains, foul motions, in addition to all the usual symptoms of a mild chronic acidosis. The dietetic treatment of the pre-rheumatic condition or rheumatic diathesis should be directed to prevent both intestinal toxæmia and acidosis.

Various extremes of diet, and all sorts of restrictions, are advocated by one authority or another : meats of all kinds are forbidden by some, by others sweets, and yet again, by others, all varieties of fruits. For my part I cannot understand why any of these articles of diet should be entirely vetoed in rheumatism. On the other hand, it is quite certain that if any of these foods are given in excess they may lead to intestinal toxæmia or to some metabolic disturbance which will ultimately result in an acidosis. In my opinion the diet in rheumatism should be arranged on the same physiological basis as in health, with a full appreciation of possible idiosyncrasies or anaphylactic reactions. The caloric requirements should be most carefully estimated and observed. The balance should be normal, since both protein or carbohydrate excess are equally injurious. It is of advantage that the protein allowance should be made up of such proteins—as those of milk and meat—as possess high biological values (see p. 356). In view of the tendency to acidosis and the "status calciprivus" (see p. 341) I consider that fruits and vegetables, so far from being contra-indicated, are of the greatest value, for the reason that they supply rich quantities of salts in organic combination, and that these classes of foods should contribute a considerable proportion of the required caloric allowance. The following are suggestions which I offer for the feeding of children suffering from chronic forms of rheumatism :—

Table 81

DIETARY FOR A RHEUMATIC CHILD

On rising.—Give about 40 gr. of mixed alkaline salts (see p. 486) in 6 oz. of water and the juice of an orange.

Breakfast.—Milk, about 8 oz., with cocoa, chocolate or Ovaltine; toast and butter; jam or stewed fruit.

Dinner.—Meat, fish, egg or poultry on alternate days. Vegetables of all kinds, with reasonable amount of lettuce, or other green salads. Stewed or fresh fruit, milk puddings or plain cakes and biscuits.

Tea.—Milk, about 8 oz., with cocoa, chocolate or Ovaltine, bread and butter and jam, plain cakes, rusks and biscuits.

Supper.—Vegetable soup, Scotch broth or calves' foot jelly.

It will be observed that in this diet all meat, eggs, fish, bacon, porridge and prepared cereal foods are excluded from the breakfast programme. Apart from these restrictions no variety of food is absolutely forbidden. The two really essential conditions are that the "balance" shall be correct, and that the quantity shall be accurately adjusted to the physiological requirements. In reference to quantity the diet sheets for normal children (pp. 274-275) should be carefully studied in order that the caloric value of the food for the 24 hours may fulfil the requirements.

ACUTE RHEUMATISM

If acute rheumatism develops in infants it is practically never diagnosed; in older children it is of more frequent occurrence, though seldom in the articular form. The more common manifestations are tonsillitis, growing pains, erythema nodosum and myo-, endo- and peri-carditis. The dietetic treatment is the same in all these cases, and should consist of a well-balanced dietary, in which milk, cereals, vegetables and fruit afford the required number of calories, in the correct relative proportions. In acute cases practical experience proves that butcher's meat is contra-indicated. The chief concern should be the management of quantity. This must be strictly adjusted to the physiological requirements. A rheumatic child immobilised in bed creates small demand for food, certainly not more than 70% of the estimated requirements of a healthy child of the same age and weight taking active exercise. I cannot repeat too often that the ill child requires less food than one who is in good health, because the belief that sick children require a generous diet seems to be so generally held. When a child is ill or suffering from some wasting disease, such as rheumatism, the anabolic processes are, relatively speaking, in abeyance, the cell-machinery runs down rapidly, with a preponderance on the catabolic side which no compensatory feeding can counteract. The secret of successful dieting in ill health consists in the judicious restriction of food until health is restored and the swing of the pendulum is directed towards cell repair and anabolic reconstruction; ere this all attempts at building up the strength are futile.

In acute rheumatism the exhibition of fluids should not be restricted, partly for the reason that the dehydrating influences of acute sweating require compensation, and partly because the concentrated and acid condition of the urine requires adequate dilution. Alkalies of all kinds are urgently needed to neutralise the effects of the acidosis which invariably develops. Alkaline mineral waters, such as Vichy, are useful, but bicarbonate of sodium or citrate of sodium may be given freely, dissolved in barley water or other diluent. I make it a practice of giving very large quantities of alkalies in one or other of these forms to my rheumatic cases and do not hesitate to prescribe ½ oz. or more of alkaline salts in the 24 hours (see p. 486).

ACUTE COLI INFECTIONS

Coli infections are exceedingly common both in infants and young children, especially of the urinary passages in females owing to direct contamination of the urethra with fæcal matter. There is no conclusive evidence to explain why the coli bacilli, which are invariably present in the bowel, should, in some cases, invade the tissues and in other cases fail to do so. Although there is presumptive evidence that infection is due either to an exalted degree of virulence of the organisms themselves, to some condition, such as damage inflicted on the mucous membrane of the bowel, which facilitates invasion, or to some increased degree of acidity of the tissue juices, there is no actual proof of the influence of any of these etiological factors.

The successful treatment of coli infections with alkalies such as sodium or potassium citrate strongly suggests that the rational dietetic treatment in such cases should be designed to counteract the development of a condition of acidosis.

Acidosis, the causes which lead to it, and the means which may be employed to prevent it, have been thoroughly discussed in the section specially devoted to this condition, as also in the chapter on rickets, so that there is no necessity to reiterate what was said there further than to insist once more that all conditions of malnutrition lead, in the final issue, to an acidosis. As far then as diet is concerned it is necessary to see that it is physiologically adapted to the requirements of nutrition. Overfeeding is probably one of the commonest of all causes of malnutrition, and consequently of acidosis, while want of "balance" and deprivation of some essential accessory food factor come next in importance.

In view of the possibility that invasion of the tissues through some injured portion of the mucous membrane of the colon or appendix may be an important factor in the etiology, it is important that the diet itself should not be of such a nature as to irritate or injure the epithelial coating of the bowel. The mere fact that thread worms are so often associated with coli infections, or even the cause of them, suggests that the same unhealthy condition of the mucous membrane which permits of the presence of these parasites may also be a definite factor in the etiology of coli infections. Seeds, pips, stones or skins of fruit, and other hard and indigestible substances of a like character, should be rigorously excluded from the dietary, but not at the sacrifice of suitable fruits and vegetables which are free from these objections. The free administration of petroleum emulsion is, in my experience, of great value in chronic conditions of intestinal catarrh, not only as a lubricant and protective application to the damaged epithelial surfaces, but also in some degree as an insurance against excessive bacterial developments.

The essentials therefore for the diet in coli infections are:

(1) *The fulfilment of all the fundamental rules of physiological feeding, especially that one which concerns the avoidance of excess in quantity.*

(2) *The inclusion of a good proportion of fruits and vegetables.*

(3) *The avoidance of seeds, skins, stones and other hard and indigestible substances which can irritate or damage the mucous membrane of the bowel.*

THE ACUTE EXANTHEMATOUS INFECTIONS

General Remarks.—Among the acute infections the descriptions of which are included in this section are, first and foremost, the common exanthemata—measles, chickenpox, scarlet fever, etc.—to attacks of which all children are exposed. Most children also, at some time or other, have either mumps, whooping cough, diphtheria or influenza, while a small number have typhoid and septicæmia. Tropical diseases, such as cholera, malaria, relapsing, yellow and dengue fevers, are excluded from independent mention in this section, since they are not sufficiently common in this country to call for special description.

In much that follows in my general remarks on the dietetic treatment of the acute infections, I fear I shall find myself in conflict with orthodox opinion. The general view is that since in these acute fevers the metabolic processes proceed at an express rate and tissue destruction continues uninterruptedly until the pyrexia subsides, it is essential to support the patient's strength by generous feeding, while his own vital forces battle with the invader. As I have repeatedly stated already, in pyrexial conditions the catabolic processes exceed the anabolic, and hence there must be loss of weight and loss of tissue with or without generous feeding. There is no acute infection in which tissue waste is more rapid, or longer continued, than in typhoid fever, so that if the principle of generous feeding is of value in any pyrexial state, it certainly should be so in the case of this fever. The experience of the South African War in the treatment of typhoid fever, which occurred on a wholesale scale, proved, if anything can, that patients suffering from enteric fever have a better prospect of recovering on a very restricted ration than on the old generous, unlimited milk diet. I still adhere to this view, in spite of the more recent experiments of Benedict [1] in America and of the large following of American physicians [2] who believe in his so-called "high-calorie" feeding.

Although I agree with the second half of the old adage: "Feed a cold and starve a fever," the first half of this dictum appears to me to be just as irrational as it is to distinguish between colds and other kinds of fevers. I am firmly convinced that children suffering from colds as well as other fevers recover far more quickly, and are less seriously ill, when they are fed sparingly than when they are treated on the "high-calorie" principle. I have had a fairly extensive experience of the treatment of measles by both methods, the "high-calorie" and the "starvation," and in my opinion there is no comparison between the efficacy of the two methods. The overfed child develops a troublesome bronchitis at the time and tuberculosis later, especially when the generous-feeding principle is combined with the shut window and stuffy room, whereas when spare feeding is combined with the open window bronchitis is an exceedingly rare complication, and tuberculosis even more so. Another principle in common practice to which I take as much exception as to the "high-calorie" principle is that of adherence to a milk and sloppy diet. I can see no virtue in a fluid diet such as milk, which affords a very solid and tough curd as soon as it enters the stomach, over a solid diet such as bread and butter, which, if it is properly masticated, enters the stomach as a soft pulp which is immediately rendered still more liquid in the small intestine. The whole subject of invalid dietary labours under the curse of tradition and authority. If physicians would think clearly on these subjects and refuse to accept blindly old precedents, invalid dietaries would soon become much more practical and rational. I have seen people throw up their hands in horror at the thought of giving

[1] H. Benedict and N. Suranzi. *Ztschr. F. Klin. Med.*, 1903, vol. xlviii., p. 290.
[2] Fitch. *Dietotherapy*, vol. iii., pp. 399-424. Appleton.

ice creams to a typhoid patient, and yet view with approval large drinks of undiluted milk followed by pieces of ice to suck.

There is no necessity for invalid dietaries to be monotonous, sloppy or nasty as long as they fulfil the physiological indications. During the progress of acute fevers there is a tendency for the digestive secretions to become scanty. The mouth becomes dry from want of saliva, the gastric secretions tend to fail, while the activity of the pancreatic secretions is diminished. The food, therefore, should not only be reduced in quantity, but it should also be of such a character as to be easily digested. In this connection it is interesting to note that most of the invalid foods which have survived the test of time and are still popular are those which have the least food value, and require the least digestion, such as beef tea, calves' foot jelly, meat juice, grapes, oranges, brandy and champagne. Most of these can be absorbed without any preliminary digestion, and if their caloric value is examined by reference to the tables on pages 463-467 it will be found to be negligible or extremely small.

I cannot agree with the principle of small feeds at frequent intervals in acute fevers. I can see no reason why, when the functional activity of the digestive organs is seriously reduced, it should be expected that the processes of digestion should proceed more rapidly than usual. If anything, the intervals should be longer and not shorter than in conditions of health. On the other hand, owing to the requirements of the body for increased fluid, and the dryness of the mouth, sips of water or other simple liquids, such as barley water, lemonade, orangeade or imperial drink, are admissible.

In the majority of the infections dealt with in this section, the acute stages do not last more than a few days, although the periods of convalescence or quarantine may extend over many weary weeks, but during these times there is no necessity to keep the patient on a strict invalid dietary.

The chief indications for the dietetic treatment of children suffering from the acute exanthematous infections are as follows:—

(1) Fluids are required in full amount to compensate for the loss of water due to surface evaporation, rapid breathing and the concentrated condition of the urine; barley water, mineral water, orangeade, lemonade or imperial drink may be employed to satisfy these needs.

(2) The digestive secretions are scanty and of impaired activity, while the processes of absorption are often adversely affected, hence a restricted diet of easily digested food should be supplied.

(3) There is usually an instinctive disinclination to partake of fats of any kind. This fancy should be indulged, since, owing to liver incompetence, the digestion and absorption of fats are adversely affected.

(4) With reservations, sugars are preferable to starches, since they are more easily digested, and less liable to undergo undesirable fermentation in the bowel.

(5) Proteins are, as a rule, indicated in relatively full amount, since they are required for the elaboration of anti-bodies and for the building-up of phagocytes. Marmite may be useful to promote leucocytosis. Peptones are possibly more suitable than undigested proteins, since they can be absorbed directly into the blood, even though the proteolytic ferments in the intestinal tract are reduced to a minimum.

(6) Foods with an ample content of organic salts—such as grapes, oranges, lemons, peaches and melons—and various vegetable juices are urgently required to supply the alkaline bases which can neutralise the accession of acid bodies which are generated in the active catabolic processes due to the fever. Acidosis is the invariable accompaniment of acute infections, and in some cases, as in pneumonia, it is extreme.

(7) Stimulants, and especially cardiac stimulants, such as tea, coffee and beef tea, in reasonable amount are often of service, and they are usually highly appreciated by the sick child ; alcohol, however, is seldom required, except in conditions of extreme exhaustion.

(8) Cold or iced drinks are also a great comfort to the child with a high temperature, and there is no occasion to fear undesirable consequences, or so-called " chill," from their inbibition. Lemon or orange ice is often a great treat to a child with a parched mouth and high fever, while iced coffee is a useful and agreeable means of supplying food of good value in an acceptable form.

(9) Children in high fever and suffering from thirst often prefer

to take their food in a cold and solid form rather than as a hot liquid. This fancy may be indulged, and beef, chicken or orange jelly may be given cold, or milk stiffened with gelatine may be varied with curds and whey.

(10) Milk foods in large amount are not desirable in cases of acute fever; a little milk in weak tea is often readily taken, but whole milk is far too heavy a food to be well digested; whey or buttermilk are preferable, since they contain the much-needed mineral elements and possess a low caloric value. Malted milks are far less objectionable than pure milk, since they contain an almost completely digested carbohydrate (malt sugar), and such casein as may be present does not clot in a heavy coagulum in the stomach.

(11) Vegetables are not, as a rule, indicated in the acute stages of the infective fevers, since starch and cellulose are liable to undergo fermentation in the bowel, with the production of gas, but early in convalescence they are invaluable. Vegetable marrow, French artichokes and boiled onions are specially indicated; the tougher vegetables, with larger content of cellulose, such as cabbages, cauliflower, spinach, carrots and turnips, can only be given after the complete restoration of the digestive functions.

The above general directions are applicable in the majority of acute infections, but to make the management of the diet perfectly simple I append the details of a complete dietary for a child of 10 years suffering from one of the acute exanthemata.

During the acute stages of the fever there is usually almost complete anorexia, though thirst is often extreme. These promptings of nature should be indulged: food should not be forced on him, and fluids may be allowed almost *ad libitum*. The best kinds of liquid are weak barley water flavoured with lemon or orange juice, soda water, Vichy water or other mineral water.

The meals should be arranged at about the usual times, the frequent taking of small quantities of food is, under the circumstances, most undesirable. During these acute stages the caloric value of the food supply need not be seriously considered if at the end of the 24 hours it amounts to 30% or 50% of the normal allowance. No anxiety need be felt on the score of quantity. The following is a typical diet-sheet for use during stages of acute fever :—

Breakfast, 8-9 A.M.—Weak tea, 8 oz., with sugar and milk; 2 or 3 rusks, or a little dry toast and butter if the child fancies it.

Dinner, 1 P.M.—Chicken jelly, ½ oz., beef jelly, ½ oz., or calves'-foot jelly, 2 oz., junket, 2 oz., milk shape, 2 oz., or custard pudding, 2 oz.; with rusk, sponge cake or biscuit.

Tea, 5 P.M.—Weak tea, 8 oz., or Horlick's Malted Milk, 4 teaspoonfuls in 6 oz. of water; with biscuit or toast.

Supper, 8 P.M.—Veal tea or vegetable broth, 6 oz.

This most exiguous diet is quite sufficient during these early stages, especially if it is supplemented by fruit, or fruit juice, in between meals.

I do not regard it as wise to force food on the unwilling child at this period, but if he displays any inclination to take more food than is provided for in this programme there is no reason why his desires in this respect should be denied. After the temperature has come down, and the acute symptoms have subsided, the child becomes hungry, and expresses wishes for varieties of food which are hardly indicated so early in convalescence. The return to a normal dietary should be gradual, remembering always that so long as the child does not take exercise, and is confined to the house, the ration indicated for a healthy child is excessive and should not be allowed. From 60-70% is approximately the physiological allowance. During convalescence, when tissue repair and recovery of weight may be expected, a full allowance of protein foods of good biological value (see p. 356) should be afforded, but let it not be imagined that excess of carbohydrates or fats will promote tissue reconstruction. At this stage, as indeed under all other conditions of ill health, vegetables and fruits should supply a considerable proportion of the required calories.

In the following sections a few details will be given, and special requirements in individual fevers.

Measles.—During the acute stages—that is, during, the first 5 or 6 days—the dieting of measles should be conducted on the lines indicated above. As soon as convalescence sets in these restrictions may be relaxed, and a gradual return to normal allowed.

If, during or after the acute stage, there is any tendency to diarrhœa additional care must be exercised in arranging the dietary. Fruit and vegetables must be limited in amount, or omitted altogether, while malted milk and farinaceous food must temporarily constitute the chief part of the diet.

Secondary anorexia, or distaste for food, may persist for months after an attack of measles; this condition is less liable to develop if the policy of forced feeding and high-calorie dieting has not been pursued during the acute stages of the fever. The psychological aspects of suggestion in such matters must not be forgotten. If children have been forced to take food against their will when they are ill, a form of anorexia nervosa is apt to develop during convalescence. One of the chief dangers to be feared as a consequence of measles is the development of tuberculosis or the lighting-up of some old tuberculous focus, and in the hope of avoiding this catastrophe it has become a common practice to overfeed children during the period of convalescence. If, at any time, the diet ought to be thoroughly sound and physiological it is at this crisis in the child's life, and hence, at this time, it is especially unwise to commit the serious mistake of over-feeding.

Scarlet Fever.—There is little in the dietetic treatment of scarlet fever different from that of other acute infections. Any indiscretion calculated to lead to diarrhœa should be avoided, and a careful watch should be kept for the appearance of albumin in the urine. As in other fevers, during the period of high temperature, food of all kinds should be restricted in quantity. Meals should be arranged somewhat on the principle outlined on page 397, while barley water, whey, orangeade or mineral waters may be freely employed to assuage thirst during the intervals. The programme of the meals may be extended by the inclusion of water or cream ices, vegetable purées, cream soups and simple biscuits, if any desire is expressed for them. Such articles of diet are, as a rule, far more acceptable than the monotonous milk diets which are usually advocated in scarlet fever as a prophylactic against kidney complications. As will be again referred to in the section on nephritis, an exclusive milk diet is about the most irrational one which could be devised for conditions in which it is desired to relieve the kidney functions, for the reason that no food, with the exception of egg, meat, fish and poultry, contains a higher percentage of nitrogenous elements than milk. Nitrogenous foods should be reduced to a minimum if there is any reason to fear kidney complications, and the diet should consist mainly of farinaceous foods, vegetables and fruit, with only a very small allowance of milk.

During convalescence, which in uncomplicated cases usually commences at about the end of the first week, the gradual return to a normal diet is indicated, but a careful watch should be kept on the kidney functions, and the urine should be frequently tested for albumin.

Chickenpox.—Attacks of chickenpox are often so mild that but little alteration in the diet or habits of life are called for, but in those cases in which confinement to bed or to the house is necessitated, it must be remembered that the caloric value of the food must be reduced in conformity with the restricted output of energy. In severe cases, with high temperature, the diet must be constituted on the lines indicated on page 394. Convalescence, as a rule, gives but little trouble unless secondary anorexia develops. This complication is more likely to arise when the patient has been treated on the high-calorie system. Anorexia of this kind must be treated on the general principles described on page 425.

Mumps.—No special precautions are requisite in the dietetic treatment of this infection beyond seeing that the caloric value is restricted during the acute stages and indigestible varieties of food avoided. Since mastication is often painful, and the secretion of saliva reduced in quantity, solid foods are not appreciated, and they should be temporarily suspended.

Influenza.—In accordance with the old nostrum that a generous diet should be provided in the case of colds, a catarrhal condition such as influenza is often wrongly treated on this principle; as a matter of fact, at the commencement of influenza there is usually a marked distaste for food and the patient feels far more comfortable when this distaste is humoured. Most influenza patients experience considerable thirst, and in the case of babies the satisfying of this thirst often leads to the consumption of larger quantities of milk than usual; to avoid this the infant should be allowed to quench his thirst with barley water or very weak tea. It is a usual practice to supply very considerable quantities of stimulants during the early stages of the attack in order to counteract the depression which often results. I do not think there is much to recommend this form of treatment, but to those who approve of this kind of stimulation I would recommend the use of sherry whey for infants, and for older children weak tea, beef tea, oranges, grapes and calves' foot jelly in addition. I do not recommend milk or milk preparations, which have a high caloric value; these may be reserved until such time as the appetite returns and the temperature falls.

In severe cases of influenza, with pulmonary complications, or so-called septic pneumonia, I think the rule against alcohol should be relaxed, since it is important to counteract the severe cardiac depression which usually develops during the early days of the illness. Generally, recovery takes place or death ensues within six or seven days of the onset, and during this time it is quite possible to pursue the stimulant line of treatment. Under such circumstances, in my experience, the chances of recovery are adversely prejudiced by resort to the high-calorie method of feeding.

After severe attacks of influenza convalescence is often prolonged and tedious, and, as in the case of measles, there is a distinct danger of the development of tuberculosis. It is, therefore, extremely important that the patient should not have acquired a distaste for food by forced methods of feeding during the acute stages. The convalescent patient should be fed on the principle of adapting the caloric value of the food consumed to the output of energy; if he can take exercise or stand the open-air cure, he should have a correspondingly liberal diet; if he is immobilised in the house, or confined to the chair or sofa, the diet should be strictly limited.

Diphtheria.—The problem of feeding the breast-fed baby suffering from diphtheria is always a difficult one, owing to the possible infection of the mother. In the majority of cases the chances of the baby's recovery are enhanced if the milk is drawn off by a breast-pump and given by means of a bottle or spoon. In the case of infants who are already bottle-fed no change in the feeding is required so long as it fulfils the ordinary physiological requirements. In the case of older children, the dietary should be drawn up as in ordinary cases of fever (see p. 397), but the mistake of over-feeding or of giving indigestible varieties of food should be specially avoided, since vomiting may throw dangerous strains on a heart which is already debilitated. For this reason, however, it is not desirable to give small quantities at short intervals, vomiting is more likely to result from such procedure than by giving reasonably large quantities at longer intervals. To avoid overloading the stomach concentrated foods are to be commended, and for this purpose meat jellies and essences, peptonised "whole" milk or strong solutions of malted milk, are appropriate. Alcohol may be necessary in cases with much prostration; if so, sherry whey, champagne or brandy may be given in small quantities.

Diet after Tracheotomy.—This does not require any special modification, but after intubation it is sometimes difficult to feed the child successfully, since any escape of food down the side of the tube into the larynx may set up troublesome and painful coughing. Under ordinary circumstances of tracheotomy the child should be placed in a sitting position and encouraged in every way to swallow confidently and boldly, since timorous or feeble efforts are more likely to result in the passage of food into the larynx than when more energetic methods are employed. In extreme cases of dysphagia the use of an œsophageal tube may be necessary, but in order to avoid frightening the child this method should only be adopted as a last resort.

Feeding in Cases of Post-Diphtheritic Paralysis.—Paralysis of the soft palate or muscles of deglutition may complicate the feeding of infants and children during, or more frequently after, an attack of diphtheria. In mild cases it is well to remember that solids or boluses are more easily swallowed than fluids, which tend to regurgitate through the nose. In cases in which dysphagia is extreme the œsophageal tube must be employed; this is to my mind wholly preferable to nasal feeding, which is greatly resented by the majority of children. The only advantage of the latter method is that it is easier to pass a catheter up the nose than to force the mouth open and pass a tube down the back of the throat of a struggling child. It is, however, exceedingly easy and comparatively painless to pass an œsophageal tube into the stomach of a willing subject, but tact and experience are required to gain sufficient confidence in the child to ensure the voluntary opening of the mouth.

Diet in convalescence should be conducted in accordance with the general principles already enunciated in the section which deals with the treatment of fevers in general—that is to say, food should be physiologically adapted as regards quantity to the caloric requirements, and as regards quality to the ordinary balance of health. Careful watch should be kept for the development of early symptoms of paralysis of the soft palate.

Whooping Cough.—Owing to persistent vomiting and the prolonged course of the disease, dieting becomes in some cases extremely difficult. Fortunately vomiting is less common during the initial stages of the attack, when coughing is frequent, while the paroxysms become more widely separated when the vomiting becomes more severe. It is unusual for a child to vomit more than two or three times a day, and very rare indeed to meet with a case in which wasting develops as the result of the emesis.

The chief indications for the successful management of pertussis are (1) to select foods which pass rapidly out of the stomach; and (2) to so arrange the times of meals that they follow rather than precede the attacks of coughing. In many cases the paroxysms are quite regular in their periodicity, and when this is so it is easy to arrange the times of meals so that they fulfil the required conditions; but when the attacks are quite irregular we must be opportunists and seize the occasion for feeding as it presents itself.

When there is much vomiting foods like malted milk, peptonised cocoa, jellies, liquid custards, whey, purées, vegetable soups and other liquid articles of diet, which pass rapidly out of the stomach, should constitute the chief "standbys," seizing the opportunity at the termination of a severe paroxysm to give the more solid varieties of food.

Unless special reasons exist for doing otherwise I strongly advise adherence to regular times for meals: frequent small feeds are unphysiological, produce bad habits and are quite liable to set up gastric complications. It is claimed that when the food is too hot or too cold it is apt to excite a paroxysm. I cannot confirm this from my own experience; on the contrary, I have found iced drinks and ice creams greatly appreciated by children suffering from whooping cough. There is no particular diet indicated in whooping cough; there is no need to alter the balance or exclude particular varieties of food. Large quantities of meat or extractives such as beef tea have nothing to recommend them, while fruit and vegetables, as in most other conditions of ill health, are often of great service. Garlic has the reputation of possessing almost specific properties in the cure of the complaint, owing to the fact that the mustard oil to which its taste and smell are due is excreted by the mucous surfaces of the respiratory tract, in the substance of which the bacilli of whooping cough are located, and in so doing exercises a markedly bactericidal influence. For this reason garlic may be conveniently employed as a flavouring agent for the food. It is quite possible that fried onions have a somewhat similar therapeutic action.

Typhoid and Paratyphoid Fevers.—Enteric fever proper occurs so rarely in infancy, and paratyphoid conditions are so little distinguishable from simple cases of ileo colitis, that the description of the treatment of these infections will be confined to the case of children over 1 year of age subsisting on mixed diets.

It has been shown by Du Bois [1] that in typhoid fever digestion and assimilation are seldom more than 10% below the normal standard, while Warren Coleman,[2] of New York, in a most painstaking series of observations at the Bellevue Hospital, has helped to resurrect medical faith in the value of high feeding in enteric fever. Those who are interested in this subject are advised to read Dr W. E. Fitch's most admirable article on this subject in the third volume of his work on dietetics.[3] For my part I am quite unconvinced of the value of "high-calorie feeding" in cases of enteric fever, and I still pin my faith to the method of low feeding employed so successfully in the South African War. I entirely agree with Coleman, however, in his view that the old-fashioned system of adherence to a liquid diet is not only unnecessary but quite irrational.

As a rule typhoid fever persists for many weeks before the period of convalescence is reached, and during this time nutrition must be maintained at as high a level of efficiency as circumstances allow, in order that the material used up in the active combustion which prevails should, as largely as possible, be derived from the incoming food rather than from the body tissues. The time has long since passed when enteric fever is to be regarded merely as a local disease of the digestive tract, which requires local treatment for the purpose of protecting the ulcerated surfaces from injuries inflicted by unsuitable forms of food. It is true that the infective process exercises a very definite and specific influence on the lymphatic follicles of the intestinal tract, but, as a rule, the injuries inflicted are not sufficiently severe to interfere seriously with the processes of digestion or absorption, or, indeed, to warrant

[1] E. F. Du Bois. "The Absorption of Food in Typhoid Fever." *Arch. Int. Med.*, September, 1912, p. 177.

[2] Warren Coleman. *Jour. Amer. Med. Assoc.*, 3rd August 1912, p. 363.

[3] *Dietotherapy*. 1918. Appleton.

very severe dieting. In typhoid fever restricted dieting is required on the same grounds that similar treatment is required in all cases of fever rather than because there happen to be ulcerated areas in the intestine. Solid food, as long as it is adequately digested in the stomach and upper intestinal passages, is no more likely to damage the ulcerated surfaces of Peyer's patches than liquid or semi-liquid food, since the former is liquefied in the stomach before it has a chance of reaching the damaged areas of mucous membrane, whereas milk, the favourite form of fluid food employed, is converted into a solid in the stomach, and is only slowly reconverted into a liquid. The chief indication in the feeding of typhoid cases is to avoid supplying more food than can be completely digested and assimilated. The dangers attendant on the occurrence of fermentation or decomposition in superfluous food are so great when superimposed on the existing embarrassments due to the general toxæmia that the risks of under-feeding are infinitely preferable. There is always great tissue waste in enteric fever, no matter how adequate or inadequate may be the feeding, and it is quite impossible to make the anabolic processes keep pace with the catabolic, no matter how generous the diet.

The actual number of calories that can be usefully employed in any case of typhoid fever has been variously estimated by different authorities. It is probable, however, that in spite of the exaggerated activity of the metabolic processes in enteric fever the demand for food is less rather than more than that of a tuberculous patient confined to bed. As a matter of fact, the caloric requirements of a child suffering from uncomplicated typhoid are probably less than those of a normal child taking ordinary exercise. For instance, a child aged 10 years would require about 1750 calories in the 24 hours. If cow's milk is reckoned at the value of 400 calories per pint this would mean that the total requirements in the 24 hours would be represented by about 4 pints of milk, without any supplementary addition of any kind. For a child of this age suffering from typhoid fever 4 pints of milk should be considered an adequate allowance. As a matter of fact, it is questionable whether cow's milk is the best sort of food to afford the required number of calories.

Coleman includes in his dietaries eggs, custard, toast, butter, mashed potatoes, cream, lactose, apple sauce, cereals, chicken cream, coffee, junket, cocoa, and many other articles of diet which are usually excluded in cases of typhoid. While approving of all these articles of diet on general principles, I cannot help thinking that the tastes of patients should be very carefully studied during a prolonged illness of this kind, and that only such articles of diet should be pressed on them as may be acceptable. As I have already mentioned in my preliminary introduction to the subject of the treatment of acute infections, there is no logical reason why ice creams, iced coffee, cream crackers, meringues and protein biscuits should not be included in the list of permissible foods.

If constipation supervenes, I can see no reason why orange or grape juice should not be allowed, and on the same grounds there is no reason why lemon or orange ices should not be permitted. The monotony of an exclusive diet of milk may be relieved by giving milk thickened with gelatine, meringues filled with whipped cream, as well as ices made from other materials. The satisfactory feeding of children suffering from enteric fever is largely a matter of resourcefulness in combination with a knowledge of food values, food composition and gastronomics.

The first step to take in estimating the food requirements of a typhoid patient is to calculate the approximate value in calories of the total food requirements. Say, for instance, that the total value for the 24 hours is estimated at 1500 calories, this requirement may be supplied as follows :—

Milk	25 oz.	500 calories
Cream	1½ oz.	150 ,,
Eggs	1 oz.	80 ,,
Sugar	1 oz.	116 ,,
Toast	3 slices	224 ,,
Biscuits	1 oz.	100 ,,
Custard	1½ oz.	100 ,,
Cereals	1 oz.	116 ,,
Apple sauce	1 oz.	50 ,,
Chicken or fish	1 oz.	50 ,,
	Total	1486 calories

The meals or feedings can be arranged in various combinations of the above foods, and they can also be cooked in various manners, so long as the total quantity of food does not exceed the required limits and is not presented in such a form that it cannot be digested. The usual method is to give small feeds at frequent intervals. I cannot think that this is a rational proceeding, since the digestive processes are carried on at a slower rate than normal ; it is probably better to separate the feedings by intervals of three or four hours, although no such limitations need be placed on the consumption of simple fluids, such as barley water or lemonade. Should complications arise, modifications of the above instructions may become necessary.

In **Diarrhœa** the total amount of food should be restricted, and reliance should be placed on peptonised milk, the taste of which may be disguised with coffee or other flavouring matter.

In **Tympanites** it is important to legislate against excess, but there is no particular necessity to exclude all varieties of food except milk. In typhoid fever tympanites is usually attributable to nervous exhaustion and paralytic distension of the bowel rather than to the actual decomposition of food and the generation of gas.

Constipation.—A very common complication of typhoid fever is constipation, especially in those cases in which the diet is not excessive. It should be treated by the free exhibition of liquid petroleum, preferably in the form of Semprolin emulsion, which contains 50% of the oil.

Dry, Coated Tongue.—This complication is largely due to intestinal decompositions, which require the exhibition of intestinal antiseptics, such as Izal, Dimol or carbolic acid, rather than direct oral treatment.

Diet in Convalescence.—Many typhoid convalescents become fat and bloated as the result of the return of appetite after prolonged anorexia. Feeding up under such conditions is a great mistake: it does not expedite convalescence, but rather the reverse. It is of extreme importance to estimate approximately the caloric value of the food required, and not to exceed this amount in any appreciable degree. The caloric value under such conditions cannot possibly be much greater than that of a normal individual of the same weight and taking the same amount of exercise, in spite of the fact that tissue loss must be made good.

CHAPTER XII

THE RESPIRATORY SYSTEM

General Remarks—Bronchitis—Asthma—Pneumonia

General Remarks.—In the treatment of any damaged organ it is clear that the latter should be relieved of work as far as possible. This is particularly so in the case of the lungs. The chief function of the lungs is to provide oxygen for the blood, and to eliminate carbonic acid gas. The amount of oxygen to be absorbed and the amount of carbonic acid to be eliminated depends primarily on the quantity of food consumed; the latter in its turn will obviously depend on many independent factors, such as the amount of exercise taken, the temperature of the environment, and so on. Food and diet must therefore play a most important part both in the preventive and curative treatment of pulmonary diseases. Beyond the fact that excess of diet can throw undue strains on the respiratory system for the reasons above stated, I would add that superfluous nutritive material can be thrown off in the form of secretions from all mucous surfaces, not excluding those of the respiratory system. Overfed individuals often throw off vast quantities of mucus in the urine and fæces, and in the bronchial, pharyngeal and nasal secretions. Starvation reduces these losses immediately. Hence in the treatment of respiratory affections complicated with copious mucous secretions this should be remembered. These general remarks on the treatment of respiratory affections apply universally in all cases, but in special circumstances there are additional indications for treatment which will be given in the following sections.

Bronchitis.—In the acute bronchitis of infants it is particularly important that the attack should be quickly cured, for there is always a danger lest a prolonged cough at this time of life should become a habit even though the catarrhal condition may be completely cured.

Every attack of bronchitis passes through certain definite stages which cannot be circumvented or short-circuited, although the duration of each stage may be curtailed. These stages are as follows. In the first case there is a period of commencing inflammation, irritability and congestion without mucous secretion. This is followed by a short period in which there is a secretion of clear mucus, and finally there is a period of repair, in which the secretion is of a muco-purulent character. Each of these stages requires independent treatment both as regards drugs and diet.

During the first stage, even in infants, hot demulcent drinks are indicated in order to encourage the free secretion of mucus. From this point of view there is probably nothing better than the old-fashioned hot black-currant tea ; oranges, grapes or lemonade, by providing an ample supply of organic salts, can co-operate with drug treatment in promoting the liquefaction of the mucous secretions. Solid foods should be temporarily suspended during this stage, and in the case of infants the total supply of milk should be reduced in quantity. During the second stage, when there is a free secretion of mucus, these measures may be omitted. The need now is to encourage the free expectoration of such secretions as are formed rather than to increase the amount. In the case of infants the attainment of this object is difficult without resorting to emesis. An emetic at this stage is often the very best method of treatment, but as far as diet is concerned there are no special indications beyond complying with the ordinary physiological rules of feeding, with special avoidance of carbohydrate excess. In infants the total caloric value of the food should be reduced below the normal requirements, since confinement to the house is essential and the maintenance of an unduly high temperature in the atmosphere is required by the conditions. The same precautions are also necessary in the case of older children. In the case of the latter the milk ration is, as a rule, seriously overdone. It should be remembered (see p. 244) that 1 pint of milk in the 24 hours is the maximum amount required by any child in health, and consequently this amount should not be exceeded in the case of illness unless milk forms the exclusive food. In bronchitis, fruit, vegetables and cereals should form the main articles of diet, and they should be distributed among the various meals very much in the way indicated in the tables between pages 274-275 as applicable for healthy children. There is no need to rely exclusively on slops and so-called invalid foods during the second and third stages of an ordinary bronchitis. During the final stage, when there is a muco-purulent discharge, a full diet is indicated, if the child is well enough to go out of doors, and the weather is propitious, otherwise the diet must still be restricted as far as carbohydrates and fats are concerned, although a full ration of proteins may be permitted.

Chronic Bronchitis.—Chronic bronchitis is often associated in childhood with repeated attacks of asthma between which there is not sufficient time for recovery. This condition is sometimes associated with obesity, cardiac disease or syphilis; in such cases the diet must be regulated in accordance with the underlying condition.

Overeating must in all cases be avoided, and from this point of view the administration of cod-liver oil should be cautiously employed. Milk, fruit, vegetables and cereals should constitute the basis of the diet.

Asthma.—Asthma is a paroxysmal neurosis, and closely allied to hay fever, urticaria and eczema, with which it may alternate in the same individual. The asthmatic basis of certain cases of chronic bronchitis may be obscured by the persistence of the symptoms. It tends to develop as the result of very insignificant causes in neurotic individuals. Infants and children of the spasmophilic type may long escape an actual attack of asthma, but from the moment of the first attack they are extremely liable to recurrences owing to an acquired susceptibility to the original cause which precipitated the first attack; they become, in fact, hypersensitive or anaphylactic to some particular form of stimulus. The stimulus may be of almost any kind, but foreign proteins of various sorts are probably most frequently concerned in the etiology. These proteins may be attached to different varieties of food, such as pork, shell-fish or milk, to the seeds of plants, the hairs of animals or to the bodies of bacteria. From this point of view the whole etiology of asthma has been reconsidered, and tests are now commonly applied to the subjects of the disease in order that the special protein may be discovered to which the victim is hypersensitive. The test consists in scratching the skin with a sterile needle and rubbing in an aseptic solution of some animal or vegetable protein. If any one of them excites a violent reaction, as shown by a local urticaria, there are rational indications for avoiding the particular food from which the foreign protein is derived. It is often noticed that an asthmatic child is hypersensitive to more than one variety of protein.

Quite apart from this new and interesting side of the pathogenesis and rational treatment of asthma, food undoubtedly plays a most important part in the etiology of the disease. Long before this anaphylactic theory of asthma was mooted, it was almost universally recognised that a strict dietetic regimen was indicated in the treatment of this spasmodic neurosis. It is highly probable that hyperirritability of the central nervous system is one of the essential factors in all neuroses of this kind, and, as has been repeatedly explained already, this undue sensibility is one of the results of overfeeding or faulty feeding.

From this point of view a careful investigation should be made into all matters connected with the diet of the asthmatic child, and if any breach of the canons of physiological feeding is discovered it must be immediately rectified.

Acute attacks should be treated by complete suspension of the existing diet; the amount of food should be reduced until the severity of the symptoms has subsided, and after that point has been reached there should be a gradual return to a physiological dietary, with exclusion of all those articles of food which come under reasonable suspicion.

No general statements can be made with respect to the particular classes of foods or articles of diet which should be banned from the dietary. Many articles of food appear capable of exciting attacks in certain combinations, although when given alone, or in different combinations, they may be consumed with impunity; and in this connection it must be remembered that defects of digestion are very closely concerned with anaphylactic symptoms. Proteins, for instance, which in themselves have poisonous properties if absorbed unaltered into the system, are entirely free from objection when adequately digested. By common consent late meals must be forbidden in cases of asthma, and as far as possible food of any kind should be avoided after 6 P.M.; this is naturally a counsel of perfection in the case of infants, but even in the instance of the youngest infant, food should be restricted as far as possible during the hours which are devoted to the long night period of sleep. In view of the close connection between excitable states of the central nervous system and acidosis, the reader is strongly advised to read the chapter which is devoted to this subject (see p. 341).

PNEUMONIA

Lobar Pneumonia.—The dietetic principles to be observed in the treatment of lobar or croupous pneumonia are relatively simple, for in uncomplicated cases the disease runs its course within a comparatively short period, and during this time there is no need to feel anxiety on the score of the patient losing strength on the reduced dietary indicated by the conditions. Foods which cause indigestion or flatulence should be carefully avoided, since meteorism, or gaseous distension of the stomach and bowels, may cause embarrassment to the heart's action or to the diaphragmatic movements. Fluids are urgently required to meet the requirements of the high temperature usually developed and the excessive surface evaporation : they should be allowed to the extent of 3 pints or more in the 24 hours. Alkalies are strongly indicated, partly to counteract the acidosis which invariably develops and partly to keep the secretions in the pulmonary alveoli fluid and capable of being expectorated by coughing. Fruit and fruit juices clearly promote these objects. Weak tea is often appreciated by the patient, and on rational grounds may be permitted.

During the acute stages of the complaint the few calories that are required may be afforded by small quantities of milk, sugar, calves' foot jelly, oranges, grapes, vegetable and veal broth and beef tea with brandy or champagne if there are any indications of cardiac failure. It will be observed that all these articles of diet, which have established their claims by long experience, are of low caloric value. The total caloric value of the food during these acute stages and before the crisis should not, in my opinion, exceed a third of the estimated value during health. At the time of the crisis there is often need for stimulation by means of alcohol or cardiac tonics, such as digitalis, strophanthus or strychnine, but there is no indication for any increase in the food supply. After the crisis, however, and during convalescence the diet should be gradually amplified both as regards quantity and quality. The total amount of food should be about two-thirds of the estimated normal, and may consist of such ordinary varieties of diet as the patient can digest.

Broncho-Pneumonia.—Owing to the usually protracted course of this catarrhal condition the treatment cannot be conducted on the same " low calorie " diet which answers so excellently in the case of the lobar form. For the most part, the pneumonias of childhood consist of the bronchial type, and are seldom confined to one lobe or one lung, and hence, unless there is good evidence to the contrary, it may be wise in the case of a child in the early stages of a pneumonia to regard the condition as one of general broncho-pneumonia and not as one of croupous pneumonia. Although a pneumonia of this type cannot be treated on the starvation system it by no means follows that it should be treated on the " high calorie " system. It is difficult to assign the exact amount of food indicated, but if it consists of about two-thirds of the normal value it will not err on the side of deficiency.

There is no need to adhere to the old-fashioned monotonous dietary of milk and beef tea any more than there is in the case of typhoid fever (see p. 403). Solids are often preferred to fluids, and when this is the case there is no necessity to exclude them.

In my opinion there are advantages in the broncho-pneumonic patient taking small quantities of ordinary food at regular intervals. When this plan is successfully carried out the appetite is better maintained, and there is less dislike for food, than when small quantities are given at short intervals. Between meals the patient should be allowed to drink barley water, lemonade or Vichy water without restriction, in order that the thirst which usually exists may be assuaged.

Symptoms of indigestion or flatulence should be controlled by appropriate therapeutic and dietetic expedients.

CHAPTER XIII

THE CIRCULATORY SYSTEM

General Remarks—Congenital Heart Disease—Œdema—Cold Feet—High Blood Pressure—Low Blood Pressure

General Statement.—There are three definite indications in the treatment of children suffering from circulatory disturbances which should influence the diet. In the first place, hepatic or portal congestion may lead to dyspeptic symptoms and loss of appetite; in the second place, circulatory disturbances may interfere with the removal of waste products at the seat of production or at the seat of excretion; and in the third place, the enforced restriction of physical exercise reduces the caloric requirements for food.

There can be no greater mistake in the dieting of infants and children with congenital or acquired cardiac disabilities than to act on the principle that the strength of the patient must be kept up by generous feeding. The output of energy in heart disease must necessarily be low, and sometimes extremely so. Indeed, on occasions, it is reduced to a minimum, which is represented by the so-called "basal metabolism"—*i.e.* the irreducible output of energy associated with complete rest. The idea that strength can be increased or the output of work improved by generous dieting or by increments in the food supply above the physiological requirements shows a confusion of thought which is absolutely fatal to successful treatment. The optimum caloric value of the food, in cardiac as well as in other varieties of disease, is merely a matter of arithmetic, the more nearly the energy-value of the food consumed equalises the output of work the more justly will it deserve the epithet "optimum"; every calorie in excess of the optimum amount implies, in the case of the patient suffering from heart disease, so much additional circulatory embarrassment. The calorie requirements of a cardiac case are those of an individual taking restricted exercise, and the greater the restrictions imposed by the conditions the greater must be the limitation of the food supply. A great many cases of heart disease are hurried to their end by want of appreciation of this fundamental principle.

The first step, therefore, in drawing up a dietary for a child suffering from morbus cordis, or any other disability which interferes with the circulation, is to make as accurate an estimation of the output of energy as is possible under the circumstances; the total supply of food must then be made to equalise this output. This figure will naturally depend on the amount of exercise the child is allowed to take, or is capable of taking, without straining or damaging the heart. If the child is condemned to remain at complete rest in bed the caloric requirements will certainly not be more than 60% of those required by an active and healthy child of the same age and size (see p. 240); and further, if the patient is confined to a warm room the food requirements will be still less. If, on the other hand, while the child is immobilised in bed, metabolism is stimulated by the open-air treatment, heliotherapy, massage, etc., the caloric requirements may be raised in the same way as in the case of tuberculous patients (see p. 379), but in the majority of cases such attempts to raise the level of metabolism will assuredly impose more work on the heart, and thus defeat its own ends. The main secret of success in the dieting of cardiac patients is the reduction of food to the lowest possible level compatible with the physiological requirements.

The quality of the food is, in heart cases, of less moment than the actual quantity. As far as "balance" is concerned the protein ratio should be rather higher than under conditions in which normal amounts of exercise can be taken.

An ample proportion of the total proteins supplied should be afforded by milk, but meat, fish, eggs and poultry should not on this account be entirely prohibited, since variety is required from the psychological point of view. Such articles of food as kidneys, sweetbreads, liver, brains, and such-like varieties of "offal," are not indicated, for the reason that in proportion to their available energy they contain an unduly large content of purin bodies, which tend to increase blood pressure and throw additional strains on the circulatory and excretory organs.

As in all invalid dietaries, fruits, fresh as well as cooked, should afford no inconsiderable part of the required calories, while vegetables should be allowed to the extent that the digestive functions permit; flatulence due to the fermentation of vegetable cellulose, or diarrhœa are contra-indications to any undue pursuit of this vegetarian diet. There is no advantage in making the diet dull or monotonous ; so long as the total caloric needs are not exceeded the food may be as agreeable and appetising as is compatible with the circumstances.

Fluids.—Opinions differ as to the need for restricting the amount of fluid in heart disease. On the whole I incline to the view held by Œrtel that a large quantity of liquid must throw strains on the circulation, especially when, as is so often the case, water excretion by the kidneys is correspondingly defective. The total amount of fluid in bedridden cases should not exceed 36 oz. for a child 10 years of age, and the major portion of this quantity should be consumed between, rather than at, meals.

The above suggestions apply indiscriminately to all cases of cardiac disease, but in particular instances there are certain additional indications with respect to the dietetic treatment.

Congenital Heart Disease in Infants.—Infants suffering from any variety of congenital malformation of the heart should, if possible, be breast fed, since this method of feeding affords the best opportunity of avoiding many of the dangers inseparably connected with artificial feeding. In the case of such infants it is particularly necessary to control, not only the total amount of milk consumed in the 24 hours, but also the quantity obtained at each feed. Under-feeding is quite liable to occur owing to the feebleness of the infant, while over-feeding is equally objectionable owing to the strains it imposes on the circulation. The total caloric value of the food should be about 20% below the normal (see p. 8) owing to the reduced output of energy associated with the general feebleness. In artificial feeding attention should be specially directed to the adaptation of the food to the powers of digestion of each infant.

Œdema.—With anasarca due to cardiac failure the total intake of fluid should be still further restricted. Tea, coffee, lactose and most diuretic beverages may be given with advantage, while table salt should be restricted in quantity. Buttermilk, whey, barley water and mineral waters may be given with advantage. Regular massage is an invaluable expedient to promote circulation in the lymph and blood channels.

Blood Stasis in the Extremities.—Cyanosis of the extremities and cold feet are common complications of cardiac failure, but it must not be assumed that all such cases are due to this cause. Far more commonly they are to be referred to dislocations of the vaso-motor functions set up by undue exposure to cold during the early days of life. Cold feet or asphyxia of the lower extremities is often associated with portal congestion and dyspepsia. It is sometimes claimed that cold feet can be cured by treating the indigestion; although this view may be partially true there are frequent exceptions, for portal congestion and local asphyxia are both due to defects in the circulatory function, and may be cured by removal of some common cause. The re-education of the circulatory functions by graduated cold baths, exercise, massage and suitable clothing are more likely to bring about a cure than special attention to the diet; but, all the same, the latter is of some importance, since arterio-spasm, as well as other spasmodic conditions, is clearly connected with errors of diet and with the circulation of excess of waste products in the system. Speaking quite generally, an anti-gout diet is indicated under the circumstances.

High and Low Blood Pressure.—It is decidedly difficult to estimate with accuracy the blood pressure in infants, and by no means easy in the case of small children, but from such observations as I have been able to conduct for myself I have come to the conclusion that blood pressure undergoes far greater variations during the early years of life, and with far more serious results, than in adult individuals. These variations are quite understandable on the grounds of immaturity and want of education of the vaso-motor centres.

High Blood Pressure.—This may depend on a variety of subsidiary conditions which may themselves call for special dietetic treatment, such, for instance, as nephritis, cardiac over-action, nervous excitability, hyperthyroidism, hyperpituitarism and such-like conditions, and when they are discovered they must be appropriately dealt with as described under their respective sections. But apart from such special indications high blood pressure calls for a diet of low caloric value, especially with regard to proteins, which by their decomposition in the bowel and the supervention of the results of intestinal toxæmia tend to increase nervous excitability and vaso-constrictor action.

Low Blood Pressure.—Sudden falls in arterial tension are probably responsible for more collapses and deaths in early infancy than is commonly supposed, and in later childhood chronic conditions of low blood pressure may account for much apparent laziness and many adynamic states. Low blood pressure may, to some extent, be improved by generous dieting and stimulating foods, such as butcher's meat and meat extractives, while tea, coffee and other diffusible stimulants may be distinctly useful as temporary expedients.

CHAPTER XIV

THE NERVOUS SYSTEM

General Remarks—Convulsions—Epilepsy—Insomnia—Night Terrors—Nervous Irritability—Anorexia Nervosa—Nocturnal Enuresis—Spasmophilia (Myotonia Perstans—Tetany—Tetanoid Conditions—Respiratory Spasms, etc.)

General Account.—I have already indicated, in the sections on rickets (p. 334), acidosis (p. 341) and intestinal toxæmia (pp. 40 and 323), how closely many of the conditions included in this chapter are associated with degenerative changes in the nerve cells and their neuronic connections ; but in dealing with the subject of nervous symptoms and nervous diseases in a section of its own I regard it as all the more necessary to emphasise the close connection that exists between food and many of the pathological manifestations of the nervous system.

The nerve cell in its intimate structure probably represents the highest development of bioplasmic evolution, and in its functional manifestations affords the most delicate and highly differentiated expressions of metabolism. The nerve cell is, therefore, more susceptible to the changes and vicissitudes of the environment than the coarser fibred cells of the muscular, glandular and connective tissue systems. The presence of toxic substances in the blood and circulatory fluids, or abnormal variations in the amounts of the physiological constituents, will have wider-reaching results in the case of the nerve cell than in that of any other of the humbler tissues.

Nervousness, hyper-excitability and spasmophilic manifestations of all kinds are in large measure attributable to the presence in the circulation of toxic substances, due sometimes to the activities of living bacteria and at other times to quantitative or qualitative abnormalities of general metabolism.

Intestinal toxæmias, which are among the commonest of the pathological conditions which exist in infancy and childhood, are responsible for a very large share of the damage inflicted on nerve cells. So long as these poisons are deprived of their sting by the detoxicating influence of that extremely active crematorium the liver, few of them escape into the general circulation to the detriment of the delicate elements of the central and peripheral nervous system, but the moment the liver cells break down in function, owing to overwork or unusual duties, from that moment the nervous system begins to feel the influence of the circulating poisons, and to show abnormal response to the physiological stimuli of the environment, sometimes by over-excitability, sometimes by under-excitability.

The demineralisation of the system, especially as regards calcium and magnesium by acute or chronic conditions of acidosis, leads to certain very definite symptoms of spasmophilia, which have already been referred to as pathognomonic of the so-called "status calciprivus" (p. 335).

Most of the common nervous symptoms or nervous diseases of childhood, including convulsions, epilepsy, insomnia, hysteria, migraine, irritability of temper and night terrors, present in various combinations and in divers degrees the effects of nerve-cell degeneration due to the circulation of the noxious products of metabolism. I do not propose to deal with each of these individual conditions separately, but rather to give a few general suggestions for treatment which apply more or less accurately to all of them.

The diet in the vast majority of cases of functional nervous diseases should be arranged in accordance with the principles which have been invoked for the prevention of intestinal intoxication, acidosis and rickets—in other words, it must be constituted on sound physiological lines. In the first place, it must be adjusted to the caloric requirements, with special precautions against an excessive intake; in the second place, it must be of the correct "balance"; in the third place, it must lack no essential accessory factor; and, finally, it must be adequately digestible.

However well adapted a diet may be to the physiological requirements, if it is not presented in a form capable of being digested it will undergo abnormal decomposition in the bowel, with the production of those toxic bodies which have been shown to be so seriously damaging to the delicate elements of the nerve cell and the whole neuronic system. Although in the final issue the majority of circulating poisons which bring about nerve degenerations are of bacterial origin, and produced either in the bowel or in the tissues, it must be remembered that bacterial activities can be kept under reasonable control in well-regulated and healthy intestines, provided that the diet is neither excessive nor unduly indigestible. There are difficulties in many of the worst cases in finding dietaries which can be completely digested owing to unhealthy conditions of the bowel, and to functional disturbances of the digestive organs. So long as the motions are offensive no other evidence is required to prove that decompositions are occurring in the colon and that toxins are being absorbed into the system. If these do not immediately give rise to nervous symptoms it is not because damage is not being inflicted, but rather because the liver is able, for the time being, to neutralise the more obvious effects by efficient detoxicating activities.

It is impossible to insist too emphatically that the one obvious complication to combat in all cases of functional nervous disorder is intestinal intoxication, and from this point of view diet is all-important.

In infancy functional and organic disturbances of the digestive organs are very easily set up by indiscretions in the feeding, and when once the damage has been inflicted diets which would under normal circumstances be absolutely suitable become relatively pathological. Under such circumstances the diet must be adjusted to the digestive capacities. In the case of infants up to the time of weaning, predigestion of the food is the great standby, but in relying on artificial means of this kind it is essential to remember that by such expedients the further development of the digestive functions is hindered, if not arrested, and secondly, that nutrition cannot flourish unless all the other conditions of physiological feeding, including the supply of accessory factors, are provided. For instance, the mistake is often made of omitting the anti-scorbutic vitamines in order that diarrhœa and other disturbances of the bowel may not be set up by the usually laxative properties of the foods which contain these necessary accessory factors.

All infants who are kept for any considerable period on peptonised milk should invariably receive in addition a small modicum of fruit juice and vegetable broth (see p. 476). The prevention of intestinal intoxication in older children is less simple than in the case of infants, for they are supposed to be incapable of maintaining sound nutrition on the exclusive milk diet on which infants can thrive perfectly well. For further particulars with respect to the management of intestinal toxæmias see page 323.

Apart from the direct treatment of intestinal intoxications the question of acidosis and mineral depletion must always be remembered in dealing with cases of functional nervous disturbance, and from these points of view an adequate supply of alkaline salts, as afforded by vegetables and fruits, must always be provided. But in all such cases our attention must be directed to the discovery of any chronic infection due to syphilitic, malarial, rheumatic, colonic, septic, catarrhal or staphylococcic organisms, and in as far as such conditions are amenable to dietetic treatment every prophylactic and curative precaution should be taken. Apart from these general instructions, which are more or less applicable in the treatment of all functional nervous disturbance, certain additional precautions must be taken in the individual conditions which will be independently dealt with in the following sections.

Convulsions.—It is often difficult to distinguish between isolated convulsions due to digestive or other reflex causes and ordinary epilepsy. Independent eclamptic attacks are liable to occur in spasmophilic infants from insignificant causes without actual epilepsy resulting. In young infants the usual cause is reflex irritation of intestinal origin, but irritation of the urinary system by concretions or sand are quite liable to have the same effect. In older children convulsions are especially liable to occur when the excitability of the whole nervous sphere is raised during the period of dentition, this being the last straw which breaks the camel's back in cases in which the degree of excitability has been progressively elevated by errors of diet or intestinal toxæmia.

In isolated attacks of convulsions all milk or solid food should be temporarily omitted, and barley water, veal broth or some other simple fluid of low caloric value substituted. If the fits are repeated in spite of the withholding of food this method of starvation must be discontinued and a suitable diet provided. If the underlying cause is connected with indigestion, a complete revision of the diet becomes necessary. If the convulsions are found to be associated with acidosis, "status calciprivus" or spasmophilia, these conditions must receive independent treatment, special care being taken to make good any existing depletion of the alkaline reserves of the blood by fruit juices and vegetable soups.

If dentition is an associated or underlying cause it may be treated by appropriate means. In spasmophilic cases, with raised excitability of the peripheral nervous system to electrical and other forms of stimulation, phosphorus dissolved in cod-liver oil seems to be almost a specific, but in all cases the diet must be very thoroughly revised as well.

Dentition and Troublesome Teething.—There can be no possible doubt that dentition is one of the most prolific causes of convulsions in infants over 6 months of age. The eruption of the teeth causes irritation of the central nervous system, the effects of which may be reflected in various directions, most commonly in those which have been the seat of previous disturbances. Serious results do not occur unless the excitability of the central nervous sphere is already high owing to inherent tendencies or injuries inflicted by faulty feeding or other forms of bad management. Minor degrees of acidosis and reduced alkaline reserves in the blood are, in my experience, the chief predisposing causes of serious troubles during teething. The treatment consists in adjusting the diet to the physiological requirements, by the methods of remineralisation already referred to, and by the administration of small quantities of phosphorated cod-liver oil.

Epilepsy.—There can be no possible doubt that, with or without hereditary predisposition, diet plays an enormous part in the aggravation and in the cure of epileptic tendencies. Although in the majority of instances of inveterate epilepsy there is some organic basis, any intercurrent event which raises the general level of excitability of the central nervous system inevitably tends to precipitate the development of an attack. From this point of view intestinal toxæmias, acidosis and the "status calciprivus" must be regarded as important etiological factors. A diet based on physiological lines, with strict limitation of decomposable proteins, such as are contained in meat, fish, eggs and milk, often effects an extraordinary improvement in the frequency of, and in the tendency to, epileptic seizures which are quite definitely due to organic causes, while in cases which are commonly regarded as idiopathic a cure may at times be effected by dietetic measures alone. In infants strict attention to the modification of the milk in the case of artificial feeding, or of the diet of the mother in cases of breast feeding, are practically the only dietetic measures that are practical, but in older children wider scope is available for alterations in the food. Milk must be reduced to physiological proportions—that is to say, to a maximum of 1 pint in the 24 hours ; and meat, fish and eggs must be given in strict moderation. The greater part of the diet must be made to consist of vegetables, cereals and fruits, while a careful watch must be kept on the condition of the bowels for evidence of intestinal decompositions or constipation. In addition to the above dietetic measures there is probably no more efficacious expedient than the daily administration of liquid paraffin or petroleum emulsion.

Insomnia, Night Terrors and Restlessness at Night.—Insomnia in infants is often associated with the establishment of a habit of waking up during the night owing to the encouragement of night feedings. It may also persist as a habit due to various causes which have long since ceased to exist. On the other hand, night terrors and restlessness during sleep are constantly caused, in older children, by gastric or intestinal indigestion. For this reason there should be a careful inquiry into the nature and character of the food, and especially into the character and quantity of the food consumed at the last meal before going to sleep. Since intestinal toxæmias and acidosis are common causes of nervous irritability the possibility of these conditions being at the basis of the trouble must not be overlooked. It is a common belief that children keep awake because they are hungry. This is a most fatal opinion to hold, for it almost certainly leads to the very measures which aggravate the primary trouble.

Chronic insomnia cannot be cured in a few days by dietetic means, but if inveterate sleeplessness is due to or is aggravated by the absorption of intestinal toxins a cure may be eventually effected or facilitated by controlling the decomposition of food in the bowel by dietetic restrictions.

NERVOUS IRRITABILITY, HYSTERIA, NIGHT TERRORS, NIGHTMARES, SOMNAMBULISM, SICK HEADACHES, MIGRAINE, ETC.

In this class of nervous affection is grouped together a number of conditions which are so closely related in etiology and pathology, and of which the dietetic treatment is so similar, that a single description will cover all.

In the chapter on Rickets (p. 333) the association between the "status calciprivus" and nervous irritability was referred to, and in the treatment of the special conditions mentioned at the head of this section this connection must not be forgotten, since without doubt the same preventive and remedial measures apply in both cases. The aim of treatment should be so to arrange the dietary that, while there is a good supply of calcium, magnesium and other alkaline bases in the food in organic combinations, all unnecessary and excessive calls upon these supplies by acid bodies of large molecular size, themselves the products of defective metabolism, should be reduced to a minimum. In this connection over-feeding of any kind must be avoided, but an ill-balanced dietary, or one that lacks vitamines, or one in any way indigestible, will contribute to the same undesirable results.

To avoid disappointments in treatment it must not be overlooked that essential instability of the nervous system from hereditary, congenital or antenatal causes is a factor which greatly interferes with the attainment of a cure. But, all the same, in the worst cases of innate nervous irritability dietetic means often mitigate the severity of the symptoms.

In arranging the dietary the first step to take is to make as accurate an estimate of the caloric requirements of the child as is possible under the circumstances, remembering that the output of energy or the amount of exercise taken outweighs all other requirements taken together. The average caloric requirements will be found in the table between pages 240 and 241. If the child takes more than the average amount of exercise he will be entitled to food of greater caloric value than the average, whereas if he takes less exercise than the average the supply must be correspondingly reduced. Neither heredity, appetite nor personal idiosyncrasies can defy the operation of the law of the conservation of energy. The amount of food required is the amount of food which, by reason of its intrinsic caloric value, affords the required number of units of energy.

The "balance" must be arranged on the same basis as that required under ordinary conditions of health (see pp. 18 and 243)—that is to say, about 1 part of protein by weight to 5 parts of combined carbohydrate and fat, also by weight. If, for instance, the estimated requirement of the child is 1500 calories per diem these can be provided by 2 oz. (50 grammes) of protein; 1 oz. (28 grammes) of fat and 9 oz. (250 grammes) of carbohydrate for—

2 oz. of protein affords	232 calories
1 oz. of fat affords	263 ,,
9 oz. of carbohydrate affords . . .	1044 ,,
Total .	1539 calories

These requirements must be provided by the most appropriate varieties of food combined at the several meals in the most suitable manner possible. The articles of food selected must be of such a character as to conform to the digestive capacities and the tastes of the child; there is no reason why a correctly adjusted diet should be monotonous or unappetising.

The drawing up of satisfactory diet tables will be greatly assisted by the careful reading of Chapter XIV., Part II., but the diet sheets included in this chapter need not be strictly followed.

The fat content of the dietary need not be a fixed quantity: the proportion of 1 part of fat by weight to 10 parts of carbohydrate by weight may be unnecessarily low in certain cases.

In breast milk, which may be regarded as of the correct standard for babies, the ratio is 3·5 to 7, or as 1 is to 2. As the child grows older the proportion of carbohydrates to that of fat becomes considerably larger, until it approaches the ratio of 8 to 1. It must be remembered, however, that, if fat is substituted for carbohydrate, for every part of the latter omitted only half a part of fat must be substituted, since the caloric value of fat is 263 and that of carbohydrate only 116.

It is seldom desirable to increase the protein ration beyond the amount already mentioned—*i.e.* 2 oz. in the 24 hours—provided it is of full biological value (see p. 355); if vegetable protein is substituted for animal protein, since it is of lower biological value, a correspondingly larger ration must be allowed.

Since in these cases it is particularly desirable to avoid the development of an acidosis, fruits and vegetables with a good mineral content must be supplied in full amount, and for the reason that in no other way can an adequate intake of organic salts be provided to maintain the alkaline reserves of the blood.

A diet which consists largely of white bread, milk, butter, meat, fish and eggs is an acidosis diet, besides being a badly balanced diet, and to this sort of diet a large number of children suffering from various forms of nervous irritability will be found to owe their troubles.

Anorexia Nervosa.—This neurosis is very common in self-centred and pampered children; it is far more common in only children than in those who are members of large families.

The hysterical refusal of food and occasional emesis, which are the characteristic symptoms of the condition, are generally due to tactlessness and anxiety on the part of fussy mothers or nurses, and may be said to be psychopathic symptoms due to "suggestion," in the case of neurotic children.

The extent to which innate defects in the nervous system are factors in the condition must always be estimated, but all the same the symptoms are eminently curable by management and tact.

When a child presents symptoms of sitophobia, the one essential for cure is that he should be removed from his psychopathic environment and placed in healthy surroundings, with sensible people and healthy children. The symptoms rapidly disappear when no notice is taken of the child, and he falls under the mass influence of a number of hungry children clamouring for their food. At the Nursery Training School at Golders Green we occasionally have these cases, and it is seldom we fail to effect a cure in two or three days. The children tend, however, to prove to be recidivists if they return home too soon to their old associations. Since this neurosis is due to over-sensitiveness of the central nervous system, and is a manifestation of hysteria, the same dietetic measures must be taken, both prophylactic and remedial, that were described in the previous group—that is to say, strict attention to caloric requirements, balance, digestibility and content of organic salts in the food.

Nocturnal Enuresis or Bed-Wetting.—This extremely common symptom in neurotic children is not invariably included among the functional disturbances of the nervous system, but from many points of view it is more appropriately classified as a neurosis than as a genuine genito-urinary symptom. It occurs chiefly among children of innately unstable nervous systems, and is often associated with, or is the precursor of, night terrors, somnambulism or spermatorrhœa. It is specially liable to occur in children who have been untrained, or badly trained, with respect to the control of the function of micturition, and the symptom is apt to undergo exacerbations during teething or after illness.

The condition is undoubtedly influenced by diet, both favourably and unfavourably, and in this connection it is interesting to read the views of different physicians who have had success in the dietetic management. Some doctors advise a restriction of proteins, some of carbohydrates, and yet, again, others recommend the exclusion of all rich or highly flavoured foods. As a matter of fact, any error of diet, either as regards quantity or quality, which leads to intestinal toxæmia or acidosis, will lead to raised excitability of the central nervous system, and predispose to the manifestation of neurotic symptoms of this kind.

In one case a cure may be effected by restricting one kind of food, in another by excluding some particular article of diet, and in another by adding some required element or by correcting the balance in some other way. In a certain proportion of cases thyroid or pituitary treatment has a beneficial influence, so too has hypnotic suggestion, and there is no reason why these expedients should not be applied, in appropriate cases, in addition to regulation of the dietary.

The main indications in the dietetic treatment are to prevent intestinal intoxication, acidosis or the accumulation in the blood of waste products owing to defective excretion by the kidneys, intestine or skin. The diet should be adjusted quantitatively and qualitatively to the physiological requirements. Late suppers should be forbidden, the digestive functions should be regulated and fluid should be somewhat restricted towards evening.

In my opinion it is quite unnecessary to interdict any particular article of diet, such as meat, sweets or pastry ; the mistake to avoid is the giving of any one of these in excess, or to provide a badly balanced dietary. A diet including rational proportions of milk, meat, poultry and fish, combined with a considerable quantity of fruit, vegetables and cereals, is the one to advise, never forgetting that the total caloric value must not exceed the physiological limits, that the balance must be correct, that no accessory factors must be omitted, and that the whole of the food must be presented in a digestible form.

SPASMOPHILIA, HYPEREXCITABILITY OF THE NERVOUS SYSTEM, MYOTONIA PERSTANS, TETANY, TETANOID CONDITIONS, RESPIRATORY SPASMS, ETC.

The term spasmophilia, which covers all the above conditions, as well as certain others in addition, has already been referred to in the section on Convulsions (p. 421), and in that on Rickets (p. 334). It is one of extreme interest.

There appears to be a condition of nervous hyper-irritability which is inborn, as well as one which is acquired, and which gives rise to the so-called idiopathic convulsions of infants and other spasmodic manifestations before errors of diet have had time to be effective. This idiopathic condition is probably identical with the so-called congenital "status calciprivus" of Theemann, and further it must be remembered that all new-born infants are in a condition of acidosis, which implies a raised condition of nervous excitability, immediately after birth.

This condition is quite probably dependent on blood states in the mother during pregnancy. The acquired form is far more common, and is usually regarded as one of the evidences of rickets. It seems to me to be more reasonable to regard both as due to the same cause or causes. One of the chief manifestations of the congenital form is myotonia perstans, a chronic condition of rigidity of the muscles not altogether unlike that of Little's disease. In later infancy there is a tendency to intermittent respiratory spasms, such as crowing, holding the breath and spasmodic closure of the glottis.

The causes of the acquired forms of spasmophilia have been variously ascribed by different authors to gastro-intestinal auto-intoxication (Comby and D'Espine), or to special elements in the food, such as starch, sugar, or other constituents of whey. Although nearly all authorities regard unsuitability in the food as the chief factor in the etiology, no two appear to agree as to the particular element which is the specific exciting cause. For my part, I regard this over-excitable condition of the nervous system as partly dependent on hereditary qualities of the nervous system, and partly no environmental factors, both antenatal and postnatal. The chief determining factor is, however, calcium depletion, from whatsoever cause arising. Since both food causes and other hygienic factors, such as want of fresh air and want of exercise, are contributory factors in mineral depletion, all of them must be regarded indirectly as factors in spasmophilia. I cannot agree with Thiemich that breast feeding is a specific cure for spasmophilia because it frequently occurs in nurslings who have never had anything but breast milk, and partly because there are many possible faults in breast feeding which can give rise to a condition of acidosis and mineral depletion, and which are direct causes of the "status calciprivus" and of nervous hyper-irritability. To prevent disturbances of digestion or of general metabolism which may lead to acidosis all the laws of physiological feeding must be observed. The food must be adapted quantitatively to the caloric requirements, the "balance" must be correct, no accessory factors must be wanting, it must be adequately digestible and free from bacterial contamination. If all these precautions are observed symptoms of spasmophilia are not likely to develop, even in children with strong inborn tendencies to nervous instability. A breach of any one of them, however, or any combination of them, may, in the total absence of inborn tendency, finally result in a spasmophilic condition. In combination with correct feeding, certain accessory expedients are distinctly useful in the curative treatment. For instance, phosphorated cod-liver oil (p. 479) appears to be almost a specific in certain cases, while the administration of alkalies, such as sodium citrate or carbonate or saccharated lime water, are useful in preventing alkali depletion, while antiseptics or other means which control intestinal decompositions are most rational therapeutic standbys, since they attack directly one of the commonest causes of acidosis.

CHAPTER XV

THE URINARY SYSTEM

Introductory Remarks—Acute Nephritis—Chronic Nephritis

Introductory Remarks.—The renal functions consist in eliminating waste products from the blood and certain of its normal constituents which are present in excess.

When the kidneys are damaged or diseased, waste products accumulate in the blood, and normal constituents sometimes reach a high degree of concentration, with the result that certain pathological symptoms, such as œdema, uræmia or acidosis, ensue. Since both waste products and the normal constituents of blood owe their origin to food ingested it is perfectly clear that we can, to some extent at least, compensate for defective excretion by controlling the intake—in other words, by dieting. Although it is obviously the duty of the physician to relieve the damaged kidney of all unnecessary work, it is still more obviously his duty to prevent damage being inflicted on originally healthy kidneys. There can be no possible doubt that the majority of cases of chronic interstitial nephritis, and probably many other forms of kidney disease, are caused by the long-continued abuse of the renal functions owing to dietetic indiscretions.

The main task of the kidney is to remove urea, uric acid and other products of nitrogenous metabolism, and the main troubles connected with renal insufficiency are associated with the accumulation of these substances in the blood and tissues. It is, therefore, obviously desirable to limit the intake of protein and other nitrogenous foods to the lowest physiological limits in all those cases in which there is any renal insufficiency. To a certain extent we can assess the efficiency of the kidneys before actual declaration of renal disease by the following means :—

(1) By estimating the total amount of urine passed in the 24 hours.

(2) By measuring the specific gravity of the urine.

(3) By applying the urea test.[1]

[1] M'Lean's *Index of Urea Excretion.*

But in infants and young children these tests are not easily applied, owing to the difficulty of collecting the urine.

The capacity of the kidneys to excrete various substances such as creatinin, lactose, potassium iodide, sugar and dyes (phenosulphonaphthalein, methylene blue, indigo carmine, etc.) can be tested clinically, but not without very considerable trouble.

In order that cases of kidney disease may be rationally treated it is important to have some knowledge of the character of the damage inflicted and of the degree of impairment of function. If, for instance, the kidneys can excrete water but not urea this is a good indication for limiting the amount of nitrogenous food; if, on the other hand, the kidneys can excrete urea well but at the same time allow the passage of albumin into the urine, this loss may require compensation by nitrogenous foods being given in full amount. In the following pages a short account of the dietetic treatment of the more common varieties of kidney disease will be given in separate sections.

Acute Nephritis.—In acute conditions of inflammation of the kidneys, in which there is proliferation of the cells of the glomerular tuft associated with degenerative changes, the clinical symptoms are scanty urine of high specific gravity with much albumin and with varying quantities of blood. As a rule there is considerable reduction in the elimination of urea and sodium chloride. Corresponding with this defective excretion there is an accumulation of waste products in the blood. The indications for treatment are:

(1) The prevention of toxæmias due to the retention of waste products.

(2) The prevention of œdema, ascites, etc., due to the accumulation of fluid in the tissues.

(3) To relieve the kidneys as far as possible of unnecessary strain.

We may attempt to fulfil these indications by the following means.

To some extent we can mitigate the degree of intoxication by keeping the child on a minimum diet and, temporarily at least, suspending the intake of all nitrogenous foods. Further, we can bring into active co-operation the accessory mechanisms of excretion by (1) free purgation and (2) free diaphoresis. Secondly, we can in some degree prevent œdema by restricting the intake of fluids, by the exclusion or limitation of salt, and by the withdrawal of water by free purgation and sweating. Thirdly, we may relieve the congestion of the kidneys by measures which are calculated to reduce arterial hypertension and by "cupping" the loins. Although these measures do not come strictly within the scope of this work it is desirable to mention them, since dietetic means by themselves are of little avail.

The dietetic treatment during the acute stage and at the commencement of an attack consists in reducing the intake of food to a minimum. This line of treatment, as a rule, falls in with the wishes of the patient, who suffers from complete anorexia. If, however, the attack is not so severe as to necessitate the exclusion of all food, a selection must be made from such articles of diet as contain the least possible proportion of nitrogenous elements, are most easily digested and possess the highest possible content of organic salts. In the case of breast-fed infants it is difficult to carry out these requirements without temporarily weaning the child. Artificially fed infants should, for the time being, be placed on whey and cream mixtures, while older children should be provided with a diet of barley water, oranges, grapes, peaches and other fruits. The length of time occupied by the acute stage differs in various cases, but as long as the acute symptoms persist there can be no advantage in attempting to keep up the strength of the patient by milk or other foods with a high protein content. With respect to fluids, I would emphasise the fact that during the acute stage, with oliguria and an ingravescent condition of œdema, there is no possibility of washing out waste products by the free inhibition of barley water, Imperial drink or other reputed diuretic fluids. Under the waterlogged conditions which obtain the indication is to withhold water and bring about its loss by all available means, and not to add to the existing excess.

As improvement takes place the diet may be increased and expanded in parallel-wise with the subsidence of the symptoms. It must be remembered, however, that conservatism at this stage is very necessary, since it is of supreme importance to avoid an acute stage passing over into a chronic one. When a child is suffering from acute heart disease every effort is made to keep the child at rest and relieve the heart in order that the acute stage may not develop into a chronic one. It is, however, seldom that the same method is applied in dealing with acute nephritis; it would appear as if, in the majority of cases, the chief object were to return to a normal diet at the earliest opportunity. If the kidney is to return to a normal condition of health after an acute attack of inflammation it must be spared unnecessary work of every kind as far as possible. The urea output must be reduced to the lowest physiological limits by a corresponding reduction in the intake of nitrogenous foods, while the intake of sodium chloride, as well as water, must be kept as low as possible for the whole period of convalescence.

It is very desirable to have some sort of knowledge with respect to the permissible reduction in the intake of protein food. The normal protein requirements of an average adult in health are about 100 grammes, or $3\frac{1}{2}$ oz., in the 24 hours. For a child of 5 years, weighing about 40 lb., the requirement is about 32 grammes, or $1\frac{1}{4}$ oz., and for a baby one year old about 22 grammes, or $\frac{3}{5}$ oz. In cases of recovering nephritis these quantities should not be exceeded; indeed, it is in many cases very desirable that they should not be reached. In drawing up dietaries for kidney cases it is necessary to know the protein content of the various foods in common use, in order that these amounts may not be exceeded. For instance, it should be remembered that the protein content of cow's milk is 1 part of protein in every 25 of milk; in bread 1 part in every 11, and in meat 1 part in every 7. The proportion of protein contained in other varieties of food can be learnt by reference to Table 89, page 463.

The total caloric value of the food that should be supplied to infants and children suffering or recovering from nephritis must be made to depend on the total output of energy in the form of heat, and muscular work. If the infant is kept warm and at rest in bed the total caloric requirements—*i.e.* the basal metabolism—need not be more than about two-thirds of the normal (see p. 240), possibly less. From these data diet sheets can be constructed so that the total caloric value of the day's food is kept within the above limits, and so that the total protein supply does not exceed $\frac{3}{5}$ oz. for a baby of 1 year, or $1\frac{1}{4}$ oz. for a child of 5 years of age. The remaining caloric requirements must be provided by carbohydrates and fats in the proportion of about 1 part of fat by weight to about 6 parts by weight of carbohydrate. To take an example. Let us suppose we are required to draw up a dietary for a child of 5 years of age, recovering from an attack of acute nephritis, with albumin still in the urine and with a defective excretory capacity for urea, salt and water. The total caloric value of the food required for such a child whilst still kept at rest in bed will not be more than 1000 calories—*i.e.* two-thirds of the normal requirement of 1500.

The daily allowance of food may be budgeted for as follows:—

TABLE 82

Food Ration for 24 Hours for a Child 5 Years of Age suffering from Nephritis, in Convalescent Stage

Articles of Food	Protein Content in oz.	Caloric Value
Milk, $\frac{3}{4}$ pint (15 oz.) .	0·6	300
Bread, $3\frac{1}{2}$ oz. . . .	0·27	228
Sugar and other carbohydrates, such as rice, tapioca, Benger's Food, etc., 2 oz. . . .	0·01	232
Potato, $1\frac{1}{2}$ oz. . . .	0·03	36
Green vegetables, $1\frac{1}{2}$ oz. .	0·028	16
Grapes, 2 oz. . . .	0·01	32
Orange juice, 2 oz. . .	0·01	16
Apple, 2 oz. . . .	0·008	32
Butter, $\frac{1}{4}$ oz. . . .	. .	65
Cream, $\frac{1}{2}$ oz. . . .	0·02	65
Chicken, 1 oz. . . .	0·16	40
Total .	1·146	1062

The various meals may be arranged according to taste out of the above articles of food, but the amount for the 24 hours should not exceed the permissible quantities, either as regards caloric value or protein content. The transition from the non-nitrogenous diet required at the commencement of an attack to the restricted diet enjoined for convalescence, and again from this latter to the careful diet indicated for a child who has recovered from an attack, should be gradual and deliberate.

In carrying out these measures there is endless opportunity for ingenuity and resource. The diets to which kidney patients are usually condemned are generally dull and uninteresting. The belief in milk as a suitable food is very widely held: it should be most sparingly used owing to its high protein content. The prejudice against butcher's meat and poultry dies hard. Owing to the high biological value of these forms of protein—*i.e.* 104, as compared to milk protein, 100, and vegetable proteins mostly under 50—they are specially indicated for providing part, at least, of the daily requirement of this element, and they are, as a rule, immensely appreciated.

Chronic Nephritis.—This condition in children is generally the result of an acute nephritis which has passed insensibly into the chronic stage and which clinically and pathologically is of the large white kidney type.

Children suffering from chronic kidney disease are always in danger of a breakdown owing to their limited reserve powers. They may be able to get along fairly well provided they do not strain the renal functions, but the moment they exceed the normal capacity serious symptoms supervene owing to the accumulation of waste products in the system which fail to be eliminated. Children suffering from repeated attacks of this kind need not necessarily be treated as invalids who must be kept continuously in bed, but they must always be kept on a low nitrogenous diet. They must not be allowed to take much exercise, and they must be kept warm. These measures will minimise nitrogenous metabolism and obviate unnecessary strains on the kidney. In these cases, also, the daily allowance of table salt must be strictly limited and the total amount of fluid consumed must be reduced below the normal. A high blood pressure, with all its attendant dangers and inconveniences, is one of the complications to be feared in chronic renal disease, and consequently all those articles of diet which are known to raise arterial tension must be forbidden or greatly restricted in quantity. Meat extractives and purin bodies have the reputation of being harmful in this respect, and for this reason should be excluded as far as possible from the dietary, although Von Noorden claims that they are well excreted even by damaged kidneys.

In order that a careful watch may be kept on the blood pressure of children afflicted with chronic kidney disease, it is well to remember that under 1 year of age the normal systolic pressure is 70 mm. of mercury; under 2 years, 80 mm.; under 9 years, 90 mm., and from 9 to 12 years, 100 to 105 mm.

The precautions to be taken in the management of chronic nephritis in childhood may be summarised as follows :—

(1) Restriction of caloric value of food.

(2) Restriction of protein content.

(3) Restriction of salt.

(4) Exclusion of purin bodies.

(5) Limitation of fluids.

The rigour with which these restrictions must be enforced will naturally depend on the degree of damage already inflicted. It is a mistake to rely too exclusively on the amount of albumin present in the urine as a guide to the degree of renal inefficiency. There may be no albumin when efficiency is reduced to a minimum, and there may be a large quantity when the functional efficiency is good. The most reliable test is that of urea excretion (the urea concentration test, see p. 430), although a study of the total non-protein nitrogen content of the blood would no doubt give still more valuable indications. The real danger in nephritis is the accumulation in the blood of nitrogenous waste of all kinds, in addition to urea itself. If we had any clinical test of easy application to show when the danger limit was being approached we should see far fewer relapses in cases of chronic renal disease.

In order that a satisfactory diet may be devised, the following special points must be borne in mind :—

(1) That foods with a high protein content should be excluded or limited.

(2) That foods with a high purin content should be strictly limited.

(3) That foods with excess of salt should be excluded.

In order that these objects may be secured the following tables should be consulted.

TABLE 83

Foods with a High Protein Content

Food	Protein Content
Milk	3·5%
Meat (average)	14·5%
Fish (average)	10·9%
Egg	11·9%
Cheese	25·0%
Bread	9·2%
Semolina	12·0%
Dry beans, lentils, peas	23·0%
Oatmeal	14·2%

The following foods[1] contain less than 0·5% of protein:

[1] See *Dietotherapy* (Fitch), vol. iii., p. 338.

arrowroot starch, corn starch, sugar, honey, cotton-seed oil; the following between 0·5% and 1%: arrowroot, sago, tapioca, apples, pears, plums, rhubarb, tomatoes, turnips, oranges, lemons, raspberries, gooseberries, strawberries; and the following from 1% to 1·5%: grapes, leeks, onions, bananas, celery, cabbage, cauliflower.

In the following table[1] is given a list of foods with a high purin content.

TABLE 84

Food with High Purin Content

Varieties of Food	Percentage of Purins
Asparagus	0·021%
Beef (average)	0·200%
Chicken	0·129%
Cocoa (theobromine)	1·00%
Codfish	0·058%
Coffee (caffein)	1·00%
Halibut	0·102%
Ham	0·115%
Haricot beans	0·063%
Lager beer	0·012%
Liver	0·275%
Mutton	0·096%
Oatmeal	0·053%
Onions	0·009%
Pale ale	0·014%
Plaice	0·079%
Pork	0·121%
Porter	0·015%
Potatoes	0·002%
Rabbit	0·097%
Salmon	0·116%
Sweetbread	1·006%
Tea (caffein)	1·00%
Tripe	0·056%
Turkey	0·126%
Veal	0·116%

As regards the reduction of table salt in the food. If it is not taken as a condiment, and if salted foods—such as bacon, dried herrings, kippers, haddock and salmon—be avoided, there is little danger of excess. Nor is it desirable that it should be excluded altogether, since NaCl is one of the necessary mineral elements. In the following table[2] (see p. 438) is given the average salt content of certain common foods.

[1] Taken from *Dietotherapy* (Fitch), vol. iii., p. 339. [2] *Ibid.*, p. 337.

TABLE 85

Sodium Chloride Content of Certain Common Foods

Raw Foods	Percentage of Salt	Raw Foods	Percentage of Salt
Asparagus (cooked) .	2·7–3·5	Cheese . . .	1·5–2·5
Beef steak . .	0·10	Egg (yolk) . .	0·02
Brown bread . .	0·75	Egg (white) . .	0·19
Cabbage (cooked) .	0·5–0·9	Fruit (average) .	0·05
Cauliflower (cooked) .	0·5–0·9	Meat (uncooked) .	0·1
Caviare . . .	6·7	Milk . . .	0·15
Cereals . . .	0·01–0·1		

The following is a sample diet sheet, drawn up in conformity with the special requirements. Such a table would be suitable for a child 10 years of age requiring a restricted diet of 1500 calories with a total protein content of $1\frac{3}{4}$ oz. The total food may be distributed as required at the different meals, and naturally scope must be allowed for ingenuity in making the meals appetising so as to conform with the special tastes of the child. The total quantity of fluid should be restricted to 30 oz., or less, in accordance with the atmospheric temperature and the surface evaporation.

TABLE 86

Diet Sheet for a Child 10 Years of Age suffering from Chronic Renal Disease

Article of Food	Protein Content in Oz.	Caloric Value
Milk, 1 pint	0·8	400
Meat, 2 oz.	0·28	114
(Or Egg, 2 oz.	0·23	76)
(Or Poultry, $1\frac{1}{2}$ oz.	0·3	57)
(Or Fish, 2 oz.	0·19	34)
Bread, 5 oz.	0·36	320
Potato, 3 oz.	0·045	69
Vegetables (various), 2 oz. .	0·028	18
Fruit (oranges, apples, grapes, etc.), 4 oz.	0·006	44
Jam, 1 oz.	0·003	81
Butter, $\frac{1}{2}$ oz.	. .	130
Cream, 1 oz.	0·04	130
Sugar, 1 oz.	. .	116
Carbohydrates (various, tapioca, rice, sago, etc.), $\frac{1}{2}$ oz. .	0·10	58
	Total protein, about 1·75	Total caloric value, about 1500

CHAPTER XVI

THE LIVER

Introductory Remarks—Biliousness—Jaundice—Cirrhosis—Colelithiasis—Obliteration of the Bile Ducts—Acute Yellow Atrophy

Introductory Remarks.—When we speak of diseases of the liver our thoughts naturally turn to jaundice, cirrhosis, gallstones, acute yellow atrophy, and so on. It should be borne in mind, however, that the minor affections of this organ are far more important, because they are so far more common. I mean such minor symptoms as "biliousness," chills on the liver, sick headaches, and so-called liverishness, which, though generally regarded with some incredulity and contempt by the medical profession, are very real and serious troubles to those who suffer from them. For this reason I propose to give what may be considered somewhat disproportionate attention to these conditions.

Biliousness.—This condition, which is synonymous with so-called torpid liver or hepatic inadequacy, represents one of the commonest ills of human flesh. There are few people who have not suffered from this condition at some time or another. The liver has most important duties to perform, on which health and comfort depend, and when these functions are in abeyance or poorly performed we feel bad-tempered and out of sorts. It is a very common condition with children, but it seldom receives the sympathy and treatment it deserves. The liver is the great filter and crematorium of the body of waste and toxic bodies absorbed into the circulation from the alimentary canal. Before these substances are allowed to pass into the general circulation, to the detriment of the delicate nerve cells of the brain, spinal cord and peripheral ganglia, they are submitted to the detoxicating influences of the liver cell. One of the chief duties of the liver cell is the de-amination of all superfluous amino-acids and their conversion into urea or ammonium salts. When it fails in this function the blood is flooded with nitrogenous bodies of greater or less toxicity, and for their removal the body is dependent on the kidneys and other excretory organs. It is the accumulation in the blood of nitrogenous bodies other than its normal constituents—serum albumin and globulin—which gives rise to the various forms of biliousness. Among the more obvious results of hepatic insufficiency, due to exhaustion, overwork or other causes, are headache, vertigo, nausea, muscæ volitantes, constipation, furred tongue, anorexia, offensive breath and a sense of fatigue, which in various combinations and in various degrees of severity make up the clinical picture of biliousness.

The endurance of the liver naturally differs very materially in different cases, while the degree to which its detoxicating functions are taxed will depend on a variety of circumstances, including the following :—(1) the total amount of food consumed ; (2) the physiological demands for food ; (3) the character of the food ; and (4) the extent to which decompositions occur in the bowel.

The prevention of biliousness depends therefore on the adaptation of the quantity of food to the physiological requirements, on the prevention of intestinal intoxications, and on the cooperation and team-work of the excretory organs.

Children are often encouraged to exceed the physiological requirements for food by being allowed to partake of sweets, condiments and rich foods when their appetites for simple articles of diet begin to fail. Except in cases of anorexia nervosa there is no danger whatsoever of any child not taking enough food to satisfy the physiological requirements. It does, however, occasionally happen that a child's digestive functions are so disturbed that no food taken into the system is digested or absorbed. Under such conditions no advantage ensues by tempting the patient against his will to consume food, which only undergoes decomposition in the bowel and adds to the anorexia and general condition of intoxication. On the contrary, there is every reason why food should be withheld until the digestive functions have recovered some degree of efficiency, or why predigested food should be supplied.

In cases of chronic biliousness the diet should be of the simplest. The caloric value should be most carefully adjusted to the estimated requirements and particular care should be exercised to exclude excess of nitrogenous foods. If the digestive functions are too feeble to digest all the food required for the general purposes of the body, the demand for food must be temporarily reduced by curtailing exercise and, if need be, by keeping the child in bed. Although excess of nitrogenous food directly taxes the de-aminating and de-toxicating functions of the liver, excess of carbohydrates is not without influence, in the sense that one of the duties of the liver cell is to store excess of glycogen, and when its constituent cells are overloaded with glycogen there is some danger lest mere pressure and distension should interfere with its other functions. If the dietaries of "bilious" and irritable children are carefully examined from the point of view of caloric value and "balance" they will almost invariably be found to be not only excessive, but also overweighted with protein, derived from milk, meat and eggs.

The treatment of biliousness should not consist exclusively in stimulating the liver, by grey powders, rhubarb, colchicum and other cholagogues, to do more work, but rather to relieve it of some of the duties it can ill perform. For this reason attention should be directed to the digestive and excretory organs, as well as to the precise constitution of the diet.

Jaundice.—Obstructive jaundice is characterised by pale-coloured stools, by bile-coloured urine and by an icteric tinge of the skin and mucous membranes. In addition to all these symptoms there are also secondary results, due to want of bile in the intestines and excess of bile and other toxic bodies in the blood—the natural consequences of failure of liver function.

One of the most obvious of these secondary results is the suspension of fat absorption and the presence of excess of fat and soaps in the fæces.

A further result of the decomposition of neutral fat, which inevitably occurs in the bowel under such conditions, is the withdrawal of calcium and magnesium from the body, as well as other valuable alkaline salts. The limitation of fats in the diet is, therefore, a clear indication in the treatment; carbohydrates are, as a rule, well digested and absorbed; proteins are also fairly well digested, but they should not be given in excess, owing to the generally impaired functions of the liver.

Alkaline salts, and especially organic salts, are urgently required to compensate for the withdrawal of alkaline bases in the fæces. The indications, therefore, for feeding in cases of obstructive jaundice may be summarised as follows:—

(1) Strict limitation, or even exclusion, of fat.

(2) Avoidance of excess of protein foods.

(3) Reliance on carbohydrate foods as chief sources of energy.

(4) The provision of foods which are rich in organic salts—*i.e.* fruits and vegetables.

It is obvious that a diet which consists chiefly of fruits and vegetables will fulfil the above requirements. On the other hand, if these contain large proportions of cellulose, flatulence and other inconveniences may ensue.

Fat-free milk, whey or buttermilk are perhaps safer sources of protein than fish, meat or eggs, which contain in addition considerable quantities of fat.

The following is offered as an appropriate dietary for a child of 10 years of age, suffering from acute catarrhal jaundice and confined to bed (see Table 87).

The caloric requirements of a child of this age, under normal conditions of health and moving freely about, are approximately 1750 calories in the 24 hours (see p. 240).

Making allowance for the restricted requirements due to illness and immobilisation in bed we may estimate that the outside requirements are 1200 calories in the 24 hours.

At first, if the symptoms are severe, and accompanied with vomiting, nothing but whey or buttermilk should be given, and all attempts to provide a diet of adequate caloric value should be temporarily abandoned. As the symptoms begin to improve there may be an advance to peptonised milk, skimmed milk, or to Benger's Food prepared from skimmed milk, with the addition of veal broth and grapes. If progress towards recovery is made there may be a gradual transition to the diet indicated in the following table (see p. 443).

As convalescence approaches, and the child begins to take outdoor exercise, the diet may be gradually expanded so as to include ordinary articles of diet; a careful watch being kept on the condition of the stools and the urine in order that fat may be reintroduced as soon as the obstruction to the passage of bile into the intestines has been relieved.

Cirrhosis.—Cirrhosis of the liver is by no means unknown in childhood. The indications for diet are quite clear. The functional efficiency of the organ is reduced, and consequently, as far as possible, its duties must be relieved. This can be done in two ways: (1) by preventing or reducing the degree of intestinal intoxication; (2) by reducing the total intake of protein foods to the lowest physiological minimum.

In arranging the diet, the first step to take is to make as accurate an estimation of the caloric requirements as is possible under the circumstances. The next step to take is to determine to what extent the nitrogenous elements of the food can be safely reduced.

TABLE 87

Diet Sheet suitable for a Child 10 Years of Age and suffering from an Attack of Catarrhal or Obstructive Jaundice

		Caloric Value
7 A.M.	The juice of 1 orange (1 oz.) or about 10 grapes	12
Breakfast, 8.30 A.M.	Weak tea, made with skimmed milk and sugar	25
	Bread, toasted or plain, 2½ oz.	190
	Honey, ½ oz.	45
	Stewed prunes or baked apple (2 oz.), with sugar	90
Dinner, 1 P.M.	Boiled fish (cod or whiting), 1½–2 oz. . .	30–40
	Potatoes, 1½ oz.	30
	Vegetables (various), green and otherwise, 2 oz.	20–40
	Milk pudding (skimmed milk), 2 oz. . .	60
	Bread or biscuits (water)	76
Tea, 5 P.M.	Cocoa made from skimmed milk, 8 oz. . .	100
	Bread, cake (plain), biscuit (water), 2½ oz. .	250
	Jam, ½ oz.	30
Supper, 8.30 P.M.	Fruit jelly (sweetened), 2 oz. . . .	56
	Biscuits or toast, 1½ oz.	150
	Total .	1164–1194

NOTE.—In addition to the above, raw fruit, such as apples, pears, bananas, greengages, as well as barley water, may be allowed between meals, thus bringing up the caloric value of the diet to over 1200 calories.

Fruits, vegetables, milk and farinaceous foods must constitute the basis of the diet, any deficiency in the protein content being made up with animal proteins of high biological value rather than by proteins of vegetable origin, which from this point of view are less valuable and must be consumed in larger quantity.

It is better to keep children suffering from cirrhosis on a very low diet, in bed and at rest, than on a high diet with much exercise.

Diseases of the Gall Bladder and Bile Ducts.—Colelithiasis or gallstones are so uncommon in children that they hardly require special mention. In the rare instances in which these conditions occur the main object of dietetic treatment is to keep the bile as fluid as possible and flowing freely. It is claimed that the entry of food into the stomach acts as a reflex stimulus for the flow of bile into the intestine and, consequently, that no children suffering from any form of this complaint should be kept from food longer than four hours. The restriction of fat is usually advised, but some authorities recommend the free exhibition of olive oil to effect the solution of retained gallstones. If a rich diet, containing an excess of fat, is considered to be one of the causes of gallstones, and to be contra-indicated after they have been formed, it is difficult to understand the rationale of treatment by huge doses of oil. Personally, I have never seen any other than harmful results from this line of treatment. On the other hand, there are no valid grounds for excluding fat altogether from the dietary. There are no objections to the provision of a full supply of carbohydrates; indeed, this class of food seems most suitable. Proteins or nitrogenous foods must be kept within physiological limits, but meat is probably a better form of protein than any other, since it certainly promotes the flow of bile. Alkalies, whether given independently or combined in the food, tend to keep the biliary secretions fluid, and hence must be provided in full amount.

Obliteration or Atresia of the Bile Ducts.—Since these congenital or neo-natal conditions are generally fatal within a few months the only diet that need be considered is that of the newborn infant. Every attempt should be made to continue breast feeding, in spite of inevitable failure of nutrition. If for any reason this is impossible the artificial food must be modified strictly to breast standard, and at first very completely predigested. The administration of ox bile and lecithin, to promote the digestion of fat and its absorption, certainly appears to have a favourable influence.

Acute Yellow Atrophy.—This is a rare but by no means unknown condition in children, or even in infants. The dietetic treatment is much the same as that recommended for acute catarrhal conditions of the bile ducts—namely, the provision of fruit, vegetables, cereals, veal broth and whey. Much milk is not indicated—1 pint of cow's milk in the 24 hours should be considered the outside limit for any infant or child suffering from this disease.

CHAPTER XVII

DISEASES OF THE SKIN

General Remarks—Urticaria—Eczema—Acne—Seborrhœa—Eczema Seborrhœicum—Boils—Furunculosis—Carbuncles—Psoriasis

General Remarks.—The relationship of diet to skin diseases is one of the most debatable subjects in medicine. Some authorities regard the association as extremely close, while others declare themselves entirely sceptical of any connection. The view that certain direct relationships do actually exist has been greatly strengthened of recent years by discoveries in connection with anaphylactic phenomena arising in the skin and elsewhere in the body as the result of the ingestion of foreign proteins; these reactions take the form of erythema, eczema, urticaria, œdema, etc. Minute traces of the foreign proteins existing in milk, meat, fish, poultry, pollen seeds, fruits, animal hairs, etc., may excite violent reactions in susceptible individuals, not only when they are eaten and swallowed, but sometimes by mere contact with the skin or mucous surfaces.

Asthma, hay fever, eczema and various other conditions which were formerly described as spasmodic neuroses are now regarded as possibly due to anaphylactic reactions in specially sensitive or sensitised individuals. In this regard, therefore, food undoubtedly has a direct relationship with skin diseases. Indirectly also food must play an important rôle in the pathology of the skin, since the latter is closely concerned with the elimination of waste products and with certain unchanged materials consumed with the food and assimilated into the blood stream. Sweat at times contains a number of soluble and aromatic bodies produced in the metabolism of the body or consumed as food. Arsenic and sulphur are two elements which are intimately associated with the metabolism of the epithelial cells, and appear to exercise a considerable influence on their functional activities.

Skin diseases as a rule, or perhaps always, represent disturbances of dermatological functions, and are generally due to overwork or to unusual or unsuitable duties. Skin diseases, especially those connected with the sebaceous or sweat glands, may be due to the imposition of excessive work necessitated by the presence of some substance in the blood which, though a normal constituent, is excreted by the skin when present in excess. Overactivity of any of the glands of the skin, or of its constituent epithelial elements, may lead to such pathological conditions as eczema, seborrhœa, bromidrosis, acne, etc. Owing to the team work of all the excretory organs increased work may be thrown on the skin by breakdowns of any of its functional associates, such as the kidneys, the bowels or the lungs. Eczema is extremely common in kidney disease, and so is acne in constipation. Excessive sweating is a frequent cause of eczematous inflammation of the skin, and since the former is itself often due to overfeeding it is quite clear that indirectly diet may be closely concerned with one of the most common of dermatological affections.

Infection undoubtedly plays a most important part in the production of skin disease, such as furunculosis, impetigo, eczema, boils, carbuncles, etc., but to what extent this part is primarily or to what extent secondarily due to this cause it is impossible to say. But, from either point of view, diet must exercise an important influence, since susceptibility to, or immunity from, infectious disease is definitely connected with dietetic habits. Over-feeding with sugar or carbohydrates renders the consumer peculiarly susceptible to infections of all sorts ; in the extreme case of total failure of carbohydrate metabolism—viz. in diabetes—the patient is notoriously liable to develop eczema, boils or carbuncles. It is quite possible also that want of certain of the accessory factors may directly predispose, not only to infections of all kinds, but to such skin reactions as are common in pellagra, beri-beri, scurvy and xerophthalmia, which are admittedly due to food defects.

Finally we come to the trophic influences of the nervous system on the skin and its appendages and the effects of reflex stimulation. Some skins are very susceptible to reflex stimulation of all sorts, and show weals and other markings on slight provocation or insignificant mechanical irritation. This condition of vulnerability or dermographia, as it is called, is probably caused by extreme sensitiveness or irritability of the central nervous system, which reflects in an exaggerated manner the results of surface stimulation.

All conditions, therefore, which tend to increase the excitability of the central nervous system predispose also to skin affections, and it is in this connection that food may be regarded as playing an important though indirect part in the pathology of the skin. Food, therefore, may directly or indirectly lead to disease of the skin in any one of the following ways :—

(1) It may produce anaphylactic reactions, such as urticaria, erythema or eczema, through the presence of foreign proteins.

(2) It may impose unusual or severe tasks on the excretory organs of the skin, leading to hyperidrosis, seborrhœa, miliaria, acne, etc.

(3) It may increase the excitability of the central nervous system and lead to exaggerated reactions to surface stimulation, dermagraphia, etc.

(4) It may predispose to bacterial infections, such as furunculosis or carbuncles, in diabetic or hyperglycæmic states.

An understanding of these intimate associations between food and skin diseases will help in the prevention as well as in the cure of many of the common varieties that are met with in infancy and childhood. In the following pages a few special directions are given for treating individual diseases which are not included in the foregoing general account.

Urticaria.—In one form or another urticaria is exceedingly common in infants and children. Sometimes it takes the form of "hives" or "gum rash," sometimes that of strophulus, and at others that of angio-neurotic œdema, lichen urticatus or erythema toxicum. In the majority of cases these skin lesions appear to be anaphylactic in character, and to be predisposed to by excitable states of the central nervous system, an association which perhaps explains the prevalence of urticarial rashes in infants who are teething. The anaphylactic basis of so many of these rashes emphasises the necessity for seeking in some food cause the essential etiological factor. It is often difficult, however, to discover the particular protein substance which is the source of the trouble, for the rashes occasionally appear when no changes have been made in the food. In other cases it may appear justifiable to incriminate fish, eggs, cow's milk or certain fruits, such as strawberries. When such is the case the treatment is simple. In quite a large number of instances indigestion appears to be the exciting cause, and this explanation is quite in harmony with the anaphylactic theory, since in indigestion foreign proteins may fail to become resolved into their constituent amino-acid elements, and consequently may be absorbed in an unchanged and still poisonous form.

The dietetic treatment, therefore, involves not only the exclusion of doubtful articles of diet and foods which are known to exercise an anaphylactic action, but also the selection of foods which are easily digestible and unlikely to cause dyspeptic symptoms.

The foods specially to avoid, in cases in which there is a tendency to urticarial rashes, are shellfish, eggs, pork, fruits with seeds, such as strawberries and raspberries, and porridge, although there are many others which in special cases have toxic properties.

In connection with the etiology of this group of skin rashes it must be remembered that the toxins of bacteria are also largely concerned in the development of anaphylactic phenomena, and when this is the cause of the trouble we should in vain search for a food cause.

Eczema.—Eczema, which at all times is a most troublesome affection of the skin, is one of the most distressing conditions that can affect a baby, and unfortunately it is exceedingly common. Owing to these reasons I propose to deal with this subject at some length.

It is a great mistake to regard eczema as a disease which is exclusively caused by food. Food undoubtedly plays a part, possibly a predominating part, in the etiology, but in nearly all cases in which eczema becomes chronic or intractable to treatment there will be found to be an underlying element of extreme vulnerability of the skin to external stimulation, a condition which presupposes, as has already been mentioned, an overexcitable state of the central nervous system. In such cases, therefore, the epidermis must be protected as far as possible from injurious stimuli, such as result from rough handling, coarse clothing, undue exposure to the sun, to the heat of a fire, to cold winds, to soap, to hard water and to such-like sources of irritation.

An injury inflicted on the skin by any excessive form of stimulation soon becomes the seat of a bacterial infection, the effects of which may mask the primary characteristics. Although this underlying vulnerability of the skin and the undue excitability of the central nervous system should receive due attention on the lines already referred to, every effort should be made to protect the skin from injurious external irritation, or, when such is inevitable, from secondary bacterial infections.

In the first place, the child suffering from eczema should be washed as seldom as is compatible with cleanliness. Soap should be dispensed with or most carefully selected, and drying should be most gently conducted with the softest available towel. The child further should not be exposed to the direct rays of the sun nor to those of a bright fire, his clothing should be soft and he should not be exposed to cold or strong winds.

With regard to feeding. In my experience eczema is more common in breast-fed infants than it is in those bottle-fed, or at least it more commonly commences during breast feeding than after the substitution of the bottle. The question, therefore, naturally arises, should breast feeding be relinquished if a severe attack of eczema develops while the baby is still at the breast? In my opinion every effort should be made to avoid weaning unnecessarily and to take every step short of this to improve the conditions of feeding.

In the first place, since the quantity of the food has a very important bearing on the excretory functions imposed on the skin, the total amount of breast milk consumed by the child should be carefully estimated by the "test-feed," and if found to be excessive must be reduced.

In the second place, the quality of the milk should receive due attention and the mother's diet should be examined. Nursing mothers are almost invariably overfed, and, for quite mistaken notions, too often deprived of fruits and vegetables which are so essential for pure blood and a healthy milk supply. It is extremely important that nursing mothers should not partake of excessive quantities of protein foods, since these tend to produce intestinal toxæmias and thus impair the purity of the milk. Unfortunately a chemical analysis of the mother's milk does not help matters, for such examinations do not reveal the presence of those subtle poisons which exercise a toxic influence on the child, while information with respect to small variations in the fat or protein content of the milk are practically valueless.

In the case of bottle-fed infants the whole method of feeding must be subjected to the closest scrutiny and any departures from physiological standards with respect to quantity or quality noted and adjusted. If any gross errors are discovered these may possibly be responsible for the condition, but too much reliance must not be placed on the therapeutic value of an entire change of food. Infants with eczema are often changed from one food to another—from cow's milk to dried milk, from dried milk to condensed milk, and from condensed milk to patent foods—without any rational plan or policy, in the somewhat unjustifiable belief that the right food will be hit upon by accident. If a food cause is at the root of the matter it will be generally found to be one of quantity, balance, absence of vitamine or contamination, and as a rule nothing further is needed than to adjust the quantity, the balance or other faulty detail, without making any radical change in the particular variety of the food employed.

In older children the relationship of food to eczema is more difficult to recognise and to control, since on a mixed diet the opportunities for anaphylactic reactions are vastly increased; none the less a patient attempt should be made to discover special food idiosyncrasies by ordinary observation or by applying the skin inoculation tests.

Apart from anaphylactic complications the dieting must be conducted on ordinary lines. It is quite unjustifiable to exclude any particular class of food, such as sugars or fruits or meats, although special articles may be omitted with advantage, such as shellfish, strawberries, porridge, pork, cheese. The one essential is to control quantity: the total caloric value of the food must be very strictly regulated. The balance is also of importance, and so is the inclusion of an adequate supply of vegetable food and vitamines. The total quantity of cow's milk should not exceed 20 oz. in the 24 hours, including such quantities as may be used for making milk puddings; and in this connection I would draw attention to the irrational restrictions which are often imposed on pastry and biscuits. Exactly the same materials can be employed for making pastry or biscuits as are used in making the highly valued milk pudding, and yet the former are often entirely excluded from the list of permissible foods, while puddings are ordered wholesale. As far as my experience goes, biscuits and pastry which are made from the ordinary materials used in making milk puddings are no more indigestible or harmful in cases of eczema than are the puddings themselves, nay, rather, they have the advantage that they demand mastication and cannot be swallowed whole.

ACNE, SEBORRHŒA AND ECZEMA SEBORRHŒICUM

These troublesome skin affections are due to overactivity of the sebaceous glands, accompanied with distension of the follicles and secondary infections—usually by the staphylococcus albus.

In infants the sebaceous glands of the scalp are extremely liable to become the seat of this unsightly form of inflammation, and to give rise to the familiar mouse-coloured crusts.

This predilection as regards site is probably due to the fact that the scalp is exposed to damage during and after birth, injuries which set up irritation in predisposed individuals and reduce resistance to bacterial infections.

The period of puberty is another stage of life at which overactivity of the sebaceous glands is liable to occur, an event which is closely associated with the establishment of the sexual functions and the development of certain secondary sexual characteristics, including the growth of hair. This activity of the skin and its appendages may lead to excessive functioning on the part of the sebaceous glands, and finally to the inflammatory reactions which result in acne. There may be some truth in the common belief that acne spots in boys are due to abuse of the sexual functions, the latter may lead to the liberation into the circulation of an excess of those testicular hormones which stimulate the growth of hair and the activities of the sebaceous glands.

The diet in cases of acne and seborrhœa may not be without significance, although its influence may be indirect. It is commonly believed that " intestinal stasis " is closely associated with the development of acne spots, but it is somewhat difficult to find any actual evidence in support of this view. There is, for instance, no proof that any of the products of intestinal decomposition due to stasis are eliminated by the sebaceous glands. On the other hand, there is some evidence for assuming that excess of fat and other normal food products absorbed into the system may be eliminated in the sebaceous excretions. The skin becomes demonstrably greasier after a heavy meal, but mere greasiness of the skin and overactivity of the sebaceous glands does not constitute the whole picture of acne, we have still to explain the hyperkeratosis of the ducts and the plugging of the follicles with dirt and the subsequent infection. Perhaps there is some such explanation for these events, as will be mentioned later in discussing the problem of hyperkeratosis in psoriasis. Possibly there is some connection between food and a lowered resistance to the staphylococcal organism, and in this regard the adverse influence of carbohydrate excess should be remembered as well as the debilitating influences of intestinal intoxications due to protein excess. Practical experience as well as theoretical considerations suggest the following measures in the prophylactic as well as in the curative treatment of acne :—

(1) A physiological diet with avoidance of excess.
(2) Avoidance of all foods that may lead to intestinal intoxications.
(3) Avoidance of all rich and stimulating articles of diet which may increase the sexual appetite.
(4) Avoidance of all those foods which tend to lower resistance to bacterial invasion, or which can raise the virulence of bacteria already existing in the system.

BOILS, FURUNCULOSIS AND CARBUNCLES

The development of a single boil or a succession of boils is a very tiresome condition in childhood. They are generally due to the staphylococcus aureus, which is enabled to gain a foothold owing to increased virulence on the part of the parasite or to lowered resistance on the part of the host. During the first few weeks of life multiple pustules are exceedingly common, partly owing to damage inflicted on the delicate epidermic structures of the child and partly to the undeveloped bactericidal qualities of the blood and tissue juices. In later infancy and childhood furunculosis is apt to develop in conditions of hyperglycæmia or diabetes, as shown by Schwartz and Heimann.[1]

Pilo-sebaceous infections appear to be predisposed to by all those conditions which promote undue activity of the cutaneous glands. Over-feeding, and especially over-feeding with carbohydrate foods, must be avoided and a full amount of exercise taken daily. All those indiscretions of diet which lead to intestinal toxæmias also promote these inflammatory conditions of the skin. Apart from dietetic treatment a condition of furun-

[1] "Sugar Content of the Blood in Various Diseases of the Skin." *Jour. Cut. Dis.*, 1916, xxxiv., p. 159.

culosis is favourably influenced by the exhibition of one of the many preparations of yeast which are available. The virtue of yeast in such conditions may be due to its fermentative influence on sugar, an effect which produces much the same result as an actual restriction of carbohydrate food. On the other hand, yeast has a valuable vitamine and nucleo-protein content which may favourably influence nutrition and raise the powers of resistance to infection. In any case, some such preparation of yeast as Furunculine, Levuline, Zymine or Ceredine is well worth trying in intractable cases of furunculosis. Some authorities recommend fresh yeast as obtained from the brewery in half-drachm doses at meal-time; Marmite is also useful. When carbuncles arise as a complication of diabetes the latter condition must receive appropriate treatment in addition to the special treatment indicated for this skin infection.

PSORIASIS

The treatment of psoriasis, both dietetic and otherwise, is distinctly disappointing, but a more rational cue for treatment is beginning to emerge from the accumulation of evidence that this skin condition is related to the inefficient metabolism of protein. This dermatological weakness clearly runs in families, a coincidence which may possibly be more closely related to the perpetuation of dietetic habits than to any direct transmission of a metabolic dyscrasia. The disease presents itself on those parts of the body which are especially exposed to cold and where the circulation is poor, as on the knees and elbows; it tends to improve under the influence of warmth and sunlight, it is rare in the tropics and among dark-skinned people, and is especially liable to develop in the persons of those who are large consumers of protein food in which sulphur in organic combination exists in large amount, as, for instance, in egg albumin, fibrin, casein and the albumins of turnips, cabbage, cauliflower, asparagus, apples, pears, gooseberries, onions, celery and potatoes.

The interesting suggestion[1] has been made that psoriasis represents some defect in the keratinisation or vulcanisation of the corneal layer of the epidermis. In the commercial vulcanisation of rubber, if too much or too little sulphur is used in the process

[1] "Variability in Vulcanisation the Cause of Psoriasis." George Elliott, M.D. *Medical Press*, 26th November 1919, p. 420.

the rubber becomes brittle; there may be some parallelism between failure of vulcanisation of rubber and defects in keratinisation of the corneal cells of the epidermis—in other words, psoriasis may be due to some defect in the quantity of sulphur which reaches the epidermal structures. It has been suggested that the results of psoriasis represent an effort on the part of the prickle cells of the rete to deal with an excess of sulphur. It is also possible that the silvery colour of the corneal squames in psoriasis is due to the bleaching action of sulphurous acid. Experience certainly supports the theoretical hypothesis that a restriction of the amount of the protein intake has a favourable therapeutic influence on the course of psoriasis. Be the explanation what it may, I have had personal experience of the remarkable improvement which results in this skin condition when the decomposition of food in the large bowel is controlled by the combined action of petroleum and some such effective intestinal antiseptic as Dimol.

CHAPTER XVIII

DISEASES OF THE BLOOD

Introductory Remarks—Anæmia—Chlorosis—Leukæmia—Purpura—Hæmophilia

Introductory Remarks.—Since the blood stream is not only the highway along which travel all supplies of material for the physiological activities of the organs, but also the drainage system through which pass all waste products on their way to the excretory organs for elimination, abnormalities in the physical and chemical qualities of the blood itself frequently occur which can be recognised by clinical means. Crude and inexact terms which no doubt will undergo considerable modification as the science of hæmatology advances are, at the present time, employed to designate the grosser changes which occur. Anæmia, for instance, is a generic term applied to that condition of the blood in which the colouring matter or hæmoglobin is deficient in amount, but this deficiency, since it may be due to a great number of different causes, will probably in the future be distinguished by descriptive epithets in conformity with the precise etiology. The treatment of different kinds of anæmia will be based on more rational and scientific grounds when we are able to distinguish the particular causes which lead to the condition. At the present time as soon as a disease of the blood is labelled anæmia it is immediately treated with iron quite irrespective of the causes to which the condition may be due. Quite apart from anæmia there are a number of abnormalities of the white cells and of the plasma which deserve to be included among the diseases of the blood. Some of these conditions, in accordance with accepted custom, are included in this section, while others, such as acidosis and uræmia, which equally deserve to be included in the same category, are discussed in other sections.

Anæmia.—The various conditions included under this heading are very rarely due to a deficiency of iron in the food. As a rule they are attributable to causes which bring about an unusually great destruction of blood cells or which create large demands for iron. Although the deficiency of iron can generally be cured by the administration of ferruginous preparations, the rational treatment is obviously to deal with the cause which is primarily responsible for the anæmia.

Apart from anæmia due to actual losses of blood the more common varieties of simple anæmia are due to :

(1) Intestinal intoxications with or without constipation.
(2) General infections due to rheumatic, septic, tuberculous, syphilitic, malarial, catarrhal or coli organisms.
(3) Conditions of acidosis.

The treatment of each of these underlying conditions is described separately under its appropriate section, but speaking quite generally, in cases of anæmia the chief therapeutic indications are :

(1) To secure a healthy condition of the alimentary tract and to prevent decompositions of its contents by correct dieting, and to clean up the mucous membrane of the bowel by saline aperients and by the regular use of petroleum emulsion so as to allow adequate absorption.
(2) To deal with any possible condition of acidosis by the administration of alkaline salts and by the inclusion in the diet of an adequate proportion of those foods which contain a full amount of mineral elements in organic combination—viz. green vegetables and fruits.

The treatment of anæmia in infants cannot readily be conducted on dietetic principles alone, since the iron content of their normal food—viz. breast milk or cow's milk—is exceptionally low. Cow's milk at no time contains a very rich proportion of iron, but when it is diluted with water, in order that it may be modified to breast standard, its iron content may be dangerously low. To provide against the defective supplies of iron contained in their natural food, infants are born with a reserve of iron in the liver which, according to Bunge, is five times as much as that present in the liver of adults, so that if young infants have not exactly an inexhaustible supply of iron to fall back upon, they have at least some reserves on which they can depend until such time as their digestive functions are sufficiently developed to enable them to subsist on a mixed dietary in which the proportion of iron is higher than it is in milk. For this reason there are advantages in supplying quite young infants with small quantities of foods, other than milk, which are known to contain a good proportion of iron—as, for instance, yolk of egg, raw meat juice and beef tea. Nursing mothers should also take care to provide themselves with foods which contain a good percentage of iron, or if they show symptoms of anæmia they may take some medicinal preparation of iron. It occasionally happens that infants become extremely anæmic owing to the fact that, although there may be plenty of iron in their food, they are unable to absorb it owing to catarrhal or atrophic conditions of the mucous membrane of the bowel; under such conditions the subcutaneous injection of colloidal iron gives rapid and most satisfactory results.

In children, after weaning has been completed, the chief dietetic cause of anæmia appears to be a too exclusive diet of bread and butter, milk, potatoes and meat. A dietary of this kind, especially when it is excessive in caloric value, is pre-eminently an acidosis diet. By the addition of an adequate supply of fruit and vegetables its faulty composition can be easily rectified, remembering always that no diet, however correct from the point of view of quantity or "balance," can be physiologically correct unless it is adequately digested, hence in the treatment, as well as in the prevention of anæmia, the digestibility of the food should be taken into careful consideration.

Chlorosis.—This is a special form of anæmia which is almost exclusively confined to the female sex, and which, for the most part, occurs at or about the time of puberty. The chief indications in the treatment of this condition are:

(1) The correction, by alkalies, of the hyperchlorhydria, which almost invariably forms part of the syndrome, by the limitation of table salt, and by the avoidance of condiments and other stimulating articles of diet.

(2) The correction of constipation and intestinal toxæmia.

(3) The correction of acidosis.

(4) The supply of foods with an adequate iron content.

(5) The restriction of fluids.

It is comparatively easy to arrange a dietary which fulfils these conditions by a few simple modifications of Tables 72, 73 and 74, given between pages 274 and 275. One of the chief alterations that is necessary is the inclusion of a somewhat more liberal allowance of raw fruits, such as oranges, grapes and apples, and of leguminous vegetables, such as peas and beans.

In the following table is given the iron content of some of the more common varieties of food:—

TABLE 88

To show the Average Percentage of Iron contained in certain Common Varieties of Food

White of egg	a trace	Strawberries	0·00086–0·00093
Yolk of egg	0·005	Apples	0·0003
Barley	0·0014–0·0015	Asparagus	0·0008
Flour (wheat)	0·0016	Spinach	0·0033–0·0039
Milk (cow)	0·0023	Grapes	0·0023
Milk (human)	0·0023–0·0031	Oranges	0·0002
Cabbage (inner leaves)	0·0045	Meat (protein)	0·015
Potatoes	0·0072	Fish (protein)	0·005
Bread	0·001	Peas (green)	0·0015

The symptomatic treatment of chlorosis by iron is so satisfactory that our ignorance of the essential pathology is comparatively unimportant, but all the same I would once again call attention to the great value of colloidal iron administered hypodermically in this as well as in all other forms of anæmia in addition to the usual hygienic measures advisable in conditions of malnutrition.

Leukæmia.—Avoiding the vexed questions of the pathology, relationships and classification of the various forms of leukæmia, it may be said in general terms that the dietetic treatment has so far been established on no rational basis. A "generous" diet is the favourite recommendation given by most authorities. It is difficult to believe that the physiological incentive to the development of leucocytes lent by this method of treatment can do otherwise than aggravate the trouble. In my opinion no encouragement should be given to the uncontrolled and excessive proliferation of the white cells of the blood by protein over-feeding. The diet should be adjusted to the ordinary physiological requirements as estimated by the output of energy without regard to the pathological requirements of excessive leucocyte multiplication. With excessive leucocytosis, and consequently with a large production of phosphoric acid due to the breakdown of the nuclear elements of the white cells, it is obvious that there must be a great demand for alkaline bases in order that the acid-alkaline "balance" of the blood may be maintained ; for this reason alkaline salts in natural vegetable combinations or in their pure form should be supplied in full amount (see p. 486).

Purpura.—Purpura may be considered a symptom rather than a disease. It appears to be associated with hæmolytic phenomena which are possibly anaphylactic in character—that is to say, red-blood corpuscles are broken down owing to the presence in the blood of some toxic and foreign proteid ; whether the protein responsible for this reaction is of food or bacterial origin is at present undetermined. One of the most constant and remarkable concomitants of the hæmolytic phenomena of purpura is a universal reduction in the number of the blood platelets. As a rule, in purpura, the red-blood corpuscles show a great tendency to undergo dissolution, and the clot when it is formed does not contract in the usual manner. What these phenomena may portend from the point of view of dietetic treatment it is difficult to say. The anaphylactic element in many, if not in all, forms of purpura would appear to justify a very careful revision of the dietary from the point of view of excluding toxic proteins. On the other hand, it is possible that failure of the digestive processes may lead to the absorption of protein bodies which would not excite anaphylactic phenomena [1] were they more completely digested. In favour of the bacterial origin of the foreign proteids which may possibly excite purpuric symptoms is the fact that powerful antiseptics, such as thymol or Dimol, given in large doses appear to delay or mitigate the severity of the attacks. As far as I know there are no rational indications for the dietetic treatment beyond the exclusion or limitation of meat, egg and milk proteins which predispose to intestinal decompositions. The diet must, in all cases, be regulated with due regard to caloric value, " balance," vitamine content and digestibility.

Hæmophilia.—The pathology of this condition, like that of purpura, with which it is closely associated, is extremely obscure. There appears, however, to be some connection with want of prothrombin or some other element essential for the formation of blood clot. The fact that the administration of one or other of the various hæmostatic sera affords good though temporary results is an argument in favour of the belief that hæmophilia is definitely

[1] Discussion on Cutaneous Sensitisation at B.M.A. Annual Meeting, 1921. *B. M. J.*, 8th October 1921, p. 554.

connected with some deficiency of important blood elements. The experimental evidence available with respect to the influence of diet on this condition points to the fact that an exclusive milk diet favourably influences this blood dyscrasia. I cannot believe, however, that so ill-balanced a diet as one consisting exclusively of cow's milk can be right in this or any other condition, since it must introduce troubles of its own even if it temporarily benefits an existing pathological condition. The only suggestions that I have to make for the dieting of hæmophilic patients is that the diet should be arranged in accordance with all the ordinary principles of physiological feeding and that it should contain articles of food which possess a good calcium and mineral content. Green vegetables and fruit have been specially recommended from this point of view.

APPENDIX

APPENDIX

Table of Caloric Values.—Farinaceous Foods—Fish—Fruits—Jam—Jellies—Meat and Poultry—Milk and Milk Products—Miscellaneous Foods—Nuts—Soups—Sugars—Vegetables

Recipes for preparing Certain Foods.—Barley Water from Pearl Barley—Barley Water from Prepared Barley—Oatmeal Water—Barley Jelly—Oatmeal Jelly—Bread Jelly—Whey—Whey prepared from Separated or Skimmed Milk—Whey prepared from Commercial Whey Powder—Sherry Whey—Buttermilk—Peptonised Milk—Egg Water—Raw Meat Juice—Commercial Meat Products—Commercial Peptone Preparations—Beef Tea—Veal Broth—Vegetable Broth (Bouillon de Légumes de Méry)—Vegetable and Bone Soup (author's)

Tables of Vitamine Content of Various Foods.—Common Foodstuffs containing no Accessory Food Factors—Common Foodstuffs rich in Fat-Soluble "A"—Common Foodstuffs rich in Water-Soluble "B"—Common Foodstuffs rich in Water-Soluble "C"—Common Foodstuffs containing all three Accessory Factors

Fats and Fat Emulsions.—Phosphorated Cod-Liver Oil—Phosphorus in Oil of Almonds—Substitutes for Dairy Cream—Formulæ for preparing Emulsions of various Percentages—Table of Weights and Measures

TABLE OF CALORIC VALUES OF COMMON FOODS[1]

The caloric value of 1 oz. of protein is 116
" " " " " " fat is 263
" " " " " " carbohydrate is 116

TABLE 89

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Farinaceous Foods						
Oatmeal .	16·1	7·2	67·5	1·9	115	
Biscuits .	8·30	9·0	75·0	..	120	Average (M'Killop)
Bread (brown)	9·9	..	42·3	1·2	60	Hovis (Hutchison)
Bread (white)	7·2	0·2	48·1	0·9	64·8	Average (Plimmer)

[1] For further details see (1) *Food Values.* Margaret M'Killop. George Routledge & Sons; (2) *Analyses and Energy Values of Foods.* R. H. A. Plimmer. His Majesty's Stationery Office, 1921; (3) *Dietotherapy*, vol. i., p. 703. Fitch. Appleton.

TABLE OF CALORIC VALUES OF COMMON FOODS—*continued*

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Cakes . .	6·3	9·0	63·3	..	104	Average (M'Killop)
Flour . .	10·1	1·6	75·5	0·8	103·9	Average (Plimmer)
Macaroni .	10·9	0·6	75·9	..	102	
Rice . .	7·4	0·4	79·2	0·2	102	
Sago .	0·2	0·2	86·7	..	101	
Semolina .	12·0	0·7	76·0	..	104	
Tapioca .	0·3	0·2	88·0	0·1	105	
Fish—						
Cod . .	16·5	0·4	..	1·2	20	
Halibut .	18·6	5·2	..	1·0	35	
Herring (fresh)	19·5	7·1	..	1·5	41	
Sole . .	18·8	1·8	..	1·1	26	
Turbot .	14·8	14·4	..	1·3	55	
Whiting .	17·7	0·2	..	0·2	21	
Fruits, Fresh—						
Apples .	0·3	0·2	9·8	0·3	12	Much cellulose
Apricots .	1·1	..	12·4	0·5	15	
Bananas .	1·2	0·1	12·5	0·9	30	Plimmer
Cherries .	0·8	0·1	11·2	0·4	14·2	
Currants .	1·2	0·1	6·4	0·7	91	Average (Plimmer)
Grapes (juice)	0·6	0·1	13·9	0·5	16	Average (Plimmer)
Orange (juice)	0·6	..	6·6	0·4	8	
Pineapple .	0·3	0·1	8·0	0·4	10·4	
Plums . .	0·5	0·3	7·8	0·4	10	Average (Plimmer)
Strawberries	1·0	0·5	6·3	0·7	10	
Fruits, Dried—						
Currants .	1·7	0·3	42·0	2·6	51	Much cellulose
Dates . .	1·6	0·1	69·7	2·0	83	Much fibre
Figs . .	2·0	0·5	53·2	2·3	69	
Plums . .	3·0	0·3	40·0	1·9	51	
Raisins .	2·2	0·3	61·0	2·5	74	Much fibre
Jam . .	0·3	..	69·4	0·40	81	Average (Plimmer)
Jellies, etc.—						
Calves' foot jelly	4·3	..	17·4	0·7	28	
Gelatine (dry)	91·4	0·1	..	2·1	108	A protein sparer
Isinglass (dry)	89·3	1·6	..	2·0	109	Ditto
Meat—						
Beef (average)	15·2	15·5	..	0·9	58	
,, (best cuts)	16·4	16·9	..	0·81	63	
,, (rump, medium fat)	17·4	25·5	..	0·9	87	

TABLE OF CALORIC VALUES OF COMMON FOODS—*continued*

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Mutton, leg (medium fat)	18·5	18·0	..	1·0	68	
Pork, breast	13·3	8·6	..	0·8	40	
Pork cutlets	20·1	7·5	..	1·0	43	
Poultry, etc.—						
Chicken .	17·8	7·2	..	0·9	39	
Duck . .	15·4	16·0	..	1·1	60	
Pheasant .	13·7	7·35	..	0·75	35·4	
Turkey .	19·0	16·2	..	1·0	64	
Hare . .	20·5	6·2	..	..	40·2	
Rabbit .	21·5	2·5	..	0·9	31	

MILK AND MILK PRODUCTS[1]

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Milks—						
Ass's Milk .	1·9	1·4	6·2	..	14	
Buttermilk .	3·0	0·5	48·0	..	10	
Condensed Milk:						
Sweetened	9·0	13·5	51·5	..	106	
Unsweetened	9·6	9·3	11·2	..	49	
Cow's milk	4·0	3·70	4·8	0·7	20	
Dried ,,	25·2	23·4	34·4	6·0	141	Good full cream
Goat's ,,	3·8	4·00	4·30	0·8	20	
Human ,,	1·5	3·74	6·37	0·3	20	
Mare's ,,	2·5	1·14	5·87	0·36	13	
Skimmed ,,	3·4	0·3	5·1	0·6	11	
Butter .	1·0	83·0	..	..	219	
Cheese .	25·2	33·4	..	2·6	121	English cheddar
Margarine .	0·2	84·0	..	..	223	Mean value
Creams—						
Rich . .	1·6	50·0	2·2	..	138	Thick centrifugalised
Medium .	2·7	26·7	2·8	0·18	70	
Poor . .	2·8	18·5	4·5	..	56	Obtained by skimming

[1] See also pages 154 and 229.

MISCELLANEOUS FOODS

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Chocolate .	4·8	31·1	49·9	1·4	151	
Cocoa . .	18·0	26·8	40·3	6·3	138	
Egg—						
White . .	10·7	0·1	..	0·6	14	
Yolk . .	15·5	33·3	..	2·0	108	
Nuts—						
Almonds .	18·8	55·0	16·0	..	186	Indigestible
Brazil . .	13·0	70·0	8·0	3·3	210	
Chestnuts .	9·0	8·0	48·0	0·9	64	
Cocoanuts .	4·2	48·5	30·0	0·8	141	Flesh
Filberts .	14·3	51·0	17·0	2·7	173	
Walnuts .	15·8	58·0	11·1	1·8	186	Fresh
Soups—						
Beef tea .	1·2	1·5	..	0·3	5	
Consommé .	2·5	..	0·4	1·1	3	
Julienne .	2·7	..	0·5	0·9	4	
Ox-tail .	4·0	1·3	4·3	1·6	13	
Pea . .	3·6	0·7	7·6	1·2	14	
Stock (good)	4·6	4·3	..	1·1	10	
Vegetable .	2·9	..	3·6	1·0	3	Analysis approximate only (see p. 476)
Sugars—						
Brown sugar.	..	..	98	..	113	Demerara (Plimmer)
Lump sugar .	..	..	100·0	..	116	
Honey .	0·4	..	71·4	..	80·6	
Treacle .	4·20	..	59·9	0·30	69·9	
Vegetables—						
Roots & Tubers:						
Artichokes (Jerusalem)	2·5	0·2	17·5	1·1	23	
Beetroot .	1·6	0·1	8·8	1·1	13	
Carrots .	1·1	0·4	8·2	1·0	13	
Onions. .	1·6	0·3	9·1	0·6	13	
Parsnips .	1·6	0·5	11·0	1·4	15	
Potatoes .	2·2	0·1	18·4	1·0	23	
Turnips (white)	1·3	0·2	6·8	1·1	10	
Green:						
Asparagus .	[2·2]	0·2	3·0	0·2	4	Doubtful analysis
Brussels sprouts	1·5	0·1	3·4	1·3	6	Much cellulose (5%)
Cabbage (raw)	1·8	0·4	5·8	1·3	10	Good vitamine content, and valuable in soups
,, (cooked)	0·5	0·02	0·7	0·2	10·5	

MISCELLANEOUS FOODS—*continued*

Articles of Food	Protein Per Cent.	Fat Per Cent.	Carbo-hydrate Per Cent.	Ash Per Cent.	Caloric Value Per Ounce	Notes
Cauliflower .	2·2	0·4	4·7	0·8	9	
Spinach .	2·5	0·5	3·8	1·7	7	
Vegetable marrow .	0·06	0·2	2·6	0·5	3	
Pulses and Leguminous:						
Peas (green)	4·0	0·5	16·0	0·9	24	
Peas (dried)	21·0	1·8	55·0	2·6	83	
Scarlet runners	1·7	1·7	3·7	0·3	7	Much cellulose

RECIPES FOR PREPARING CERTAIN FOODS FOR INFANTS

Barley Water

Take two tablespoonfuls of washed pearl barley and boil slowly in 1 pint of water for about 1 hour. At the end of this period the volume of water will have been reduced to about 14 oz. Strain and keep covered in cool place.

The percentage composition is approximately:

Proteids	0·09
Fat	0·05
Starch	1·63
Caloric value per oz. about	2

Barley water is a good diluent of milk in spite of its low caloric value: it promotes the formation of a lighter clot, and develops the starch-digesting functions in the young baby.

Barley water may be more expeditiously prepared from Robinson's Prepared Barley. It may be made of any strength according to the amount of prepared barley used in making the decoction. It should not at first be used in greater strength than is provided for in the following recipe.

Another Method of Preparation

Robinson's Prepared Barley, 2 teaspoonfuls. Water to 1 pint. Boil for 10 to 20 minutes.

Such a decoction contains about 0·75% of starch. Caloric value per oz., about 1.

Oatmeal Water

Add 2 teaspoonfuls of fine oatmeal to 1 pint of water. Simmer for 40 minutes, make up to 1 pint and strain.

This decoction contains about 0·5% of starch. Caloric value under 1 per oz.

Barley Jelly

Add 3 (level) tablespoonfuls of prepared barley to 1 pint of water. Boil for 40 minutes. Make up to 1 pint and strain hot. When cold sets as firm jelly.

The percentage composition is:

Proteins	0·68
Fat	0·03
Starch	4·43
Ash	0·04
Caloric value	5 per oz.

Oatmeal Jelly

Add 3 (level) tablespoonfuls of fine oatmeal to 1 pint of water. Boil for 40 minutes. Make up to 1 pint and strain hot. When cold this decoction will set into a firm jelly.

The percentage composition of this jelly is:

Proteins	0·47
Fat	0·11
Starch	4·58
Ash	0·50
Caloric value	5 per oz.

Bread Jelly

Take 4 oz. of stale bread (best seconds, if possible). Soak in cold water for 8 hours. Squeeze and rewash. The pulp is to be boiled for 1½ hours with 1 pint of water in a double saucepan to prevent burning. Make up to 1 pint and rub through fine hair sieve. When cold decoction sets into firm jelly.

Percentage composition:

Proteins	2·7
Fat	0·5
Carbohydrates	15·2
Caloric value	18 per oz.

THE USES OF BREAD AND OTHER CEREAL JELLIES

Cereal decoctions or jellies such as the above are useful additions to milk mixtures after the infant has learned how to digest starch. They serve as rational intermediaries between barley water and solid forms of starch, such as crusts or rusks.

In certain cases of atrophy in infants due to enteritis or colitis a mixture made from bread jelly, meat juice and cream—Dr W. B. Cheadle's famous mixture—gives surprisingly good results. These ingredients may be combined in the following proportions :—

Raw meat juice . .	2 oz.
Bread jelly . . .	$2\frac{1}{2}$ oz.
Cream (moderately thick)	$1\frac{1}{2}$ oz.

Rub up in mortar and gradually stir in sufficient water to make 1 pint.
Percentage composition :

Proteins . . .	1·3
Fat	2·0
Carbohydrates . .	1·2

To this sugar of milk may be added if thought desirable. Caloric value about 8 per oz.

Whey

To prepare whey add to 1 pint of fresh milk one junket tablet, one teaspoonful of Fairchild's Pepsencia, or about one dessertspoonful of rennet. Warm gently to blood-heat. When the curd has become quite solid beat it with a fork, and keep warm until the curds have shrunk considerably; strain through muslin.

The approximate percentage composition of whey prepared in this manner is :

Proteins . . .	0.9
Fat	0·34
Sugar	4·7

Whey should not be boiled, nor should the milk from which it is prepared be subjected to a higher temperature than 165° F., since the whey proteids are slowly coagulated when the temperature rises above this point.

If whey is used in the preparation of cream mixtures the activity of the rennet contained in it must be destroyed by heat, otherwise the ferment will coagulate the caseinogen contained in the added cream, and spoil the mixture. If used, therefore, for this purpose, whey must be heated at a temperature of about 150° F. for about forty minutes; the ferment rennin will then be completely destroyed.

Whey prepared as above from whole milk is comparatively expensive. It can, however, be prepared inexpensively from separated or skimmed milk, which can usually be purchased at the price of one penny per pint.

Caloric value about 8 per oz.

Whey Prepared from Separated or Skimmed Milk

The percentage composition of whey prepared from separated milk is as follows:—

Proteins	1·17
Fat	0·04
Sugar	5·36 (ADRIANCE)

The possibility of being able to prepare whey so cheaply is of great advantage in treating the delicate infants of poor people. The only difference of importance between the whey made from whole milk and that prepared from fat-free milk is that the fat content in the latter is less than in the former.

Caloric value about 6 per oz.

Whey prepared from Whey Powder (Sec-Wa.)

Whey can be very cheaply and conveniently prepared by dissolving dried whey powder in water. Such a powder is produced by Casein Ltd. and sold under the name of Sec-Wa (see p. 218).

The composition of the powder is:

Whey proteins	14·25%
Fat	0·27%
Milk-sugar	74·45%
Mineral matter	9·80%
Water	1·20%
Caloric value about	100 per oz.

If 1 drachm of this powder is dissolved in 1 oz. of water the resulting fluid has a composition of:

Whey proteins	1·77%
Fat	0·13%
Milk-sugar	9·30%
Mineral matter	1·22%
Water about	88·0 %
Caloric value about	12 per oz.

Sherry Whey

To ½ pint of boiling milk add one wineglassful of sherry. Allow to simmer at 150° F. for 10 minutes and strain through muslin.

Whey prepared in this way contains about 2% of alcohol. During the boiling, part of the whey proteids are coagulated, hence sherry whey is less nutritious than ordinary whey.

It should only be given to infants as a temporary food in cases of great debility or exhaustion.

Caloric value about 6 per oz.

Buttermilk

Buttermilk is occasionally employed for the purposes of infant feeding, especially by the Germans. It contains all the constituents of milk, but with only a trace of butter fat. According to Atwater its percentage composition is as follows :—

Proteids . . .	3·0
Fat	0·5
Sugar	4·8
Caloric value about .	10 per oz.

It will be noticed that the almost complete absence of fat renders it highly unsuitable as a permanent food for infants. The protein percentage is high, but the caseinogen does not appear to clot in quite such a heavy coagulum as in the case of fresh milk ; in this respect it has advantages when gastric digestion is feeble.

The sour taste is due to lactic acid, which is the result of fermentative changes in the milk-sugar.

Buttermilk contains an enormous number of bacteria, mostly of an innocuous kind—*i.e.* lactic acid bacilli ; from this point of view alone, it is a food which should only be used in those cases in which gastric digestion is active ; hence the very class of case is excluded which would be likely to derive benefit from the digestible character of the fluid. It is more suitable for those cases in which the sour-milk treatment (Professor Metchnikoff's lacto-bacilline) is indicated—that is to say, in conditions of diarrhœa with offensive stools.

THE PEPTONISATION OF MILK

Milk must be peptonised for a much longer time than is generally supposed to be necessary for the conversion of its complex constituents into the simple products of digestion which are required for absorption.

For the complete resolution of caseinogen into simple amino-acids many hours of digestion are required. Some authorities say 20 hours, but for practical purposes it is unnecessary to proceed so far with the artificial digestion. In those cases in which it is necessary to predigest milk very thoroughly, the process should be allowed to continue for about 3 hours. In the majority of cases in which peptonised milk is required it is sufficient if the artificial digestion is pursued for 1½ to 3 hours.

The best artificial digestants are:

Fairchild's peptonising powder (in tubes).
Liquor pancreatis (B.P.).
Or liquor pancreaticus (Benger's).

It is much easier to predigest milk dilutions than it is to peptonise whole milk, since the latter often clots early in the process and leaves a solid, flaky residium of curd unless the predigestion is carried to the final stages.

It is, therefore, better to prepare the required milk dilution first and peptonise it afterwards than to peptonise the whole milk first and modify it afterwards to the required standard.

It is, however, possible to peptonise whole milk without preliminary clotting if enough citrate of sodium is first added. Two grains of citrate of sodium to each ounce of milk is usually sufficient to ensure smooth peptonisation without clotting of the casein.

The best temperature to peptonise milk is 117° F. The process proceeds more slowly at lower temperature but does not cease altogether even when the milk is kept in an ice-safe.

After the process has continued as far as is required the milk should be brought rapidly to the temperature of boiling water and cooled down quickly so as to stop further peptonisation and to sterilise the milk, which is, as a rule, richly charged with bacteria owing to the prolonged incubation.

The Details of Preparation are as follows :—

To peptonise 1 pint of milk or milk dilution.

Boil milk, cool down to 117° F. or below, place in jug with paper cap, through which projects the handle of a spoon.

Add (1) One Fairchild's peptonising powder (with or without citrate of sodium, 20 to 40 grains).

(2) Two teaspoonfuls of liquor pancreatis (B.P.) and 15 grains bicarbonate of sodium.

or (3) Two teaspoonfuls of liquor pancreaticus (Benger's).

Stand the jug in a basin of water at the temperature of about 117° F. Stir occasionally with the spoon without lifting the paper cap.

Continue the peptonisation for the required length at time—that is to say, for any period up to 3 hours—and then bring to the boil. Cool down quickly and keep on ice, or in the coolest available place.

Egg Water

Egg water is prepared from the white of egg (egg albumin) as follows :—

Take 1 part of white of egg and 2 parts of cold water. Thoroughly shake in a clean bottle, and strain through muslin. The resulting solution contains about 3·5% of coagulable proteids.

Egg water thus prepared and further diluted with water, whey or beef tea, constitutes a good nitrogenous food for delicate infants; it is to be recommended in place of the commercial meat juices.

Egg water is non-stimulating; it consequently has advantages for use in cases of nervous excitement or irritability, and especially in meningitis. It is also recommended for cases of persistent vomiting and diarrhœa. Egg albumin should not be given in greater strength than 2·0%—that is to say, egg water as prepared above should be combined with an equal part of some diluent, such as whey.

Egg water must not be boiled or mixed with very hot water, otherwise the proteids will be coagulated.

Approximate composition of egg water prepared as above and diluted with equal part of water:

Proteins, gelatine etc. .	1·8
Fat	A trace
Sugar	A trace
Extractives . . .	2·0
Approximate caloric value	2 per oz.

Raw Meat Juice

Take 4 oz. of prime rump steak, remove fat, mince finely and mix with 1 oz. cold water, place between two plates and stand for ½ an hour in cool place and then squeeze through muslin.

The percentage composition is as follows :—

Proteins	5·0
Fat and sugar	A trace
Extractives	A trace
Mineral matter	0·75
Caloric value about	6 per oz.

Raw meat juice can also be made in a more expeditious manner by using a special press such as that illustrated on this page.

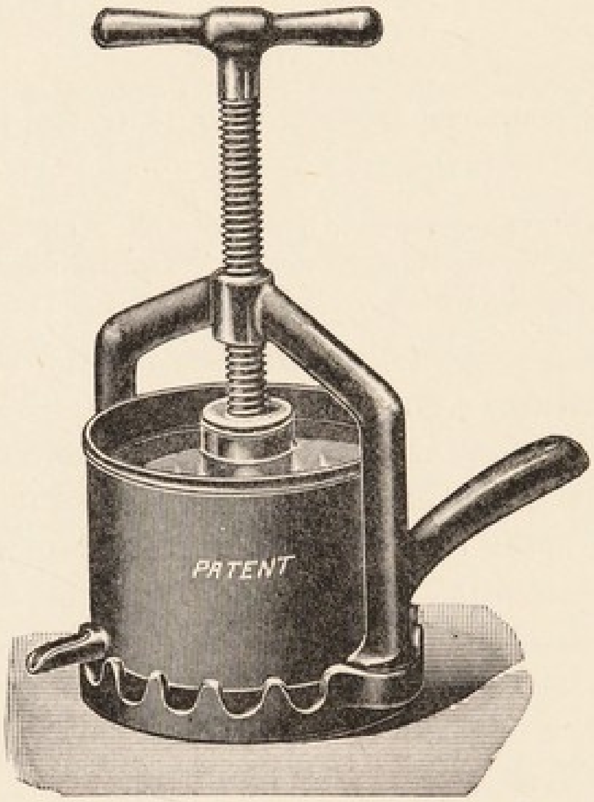


Fig. 90.—The "Hercules" Meat Juice Press

Raw meat juice in small quantities (not more than 1 oz. in the 24 hours) is a valuable addition to milk mixtures owing to its stimulating qualities, its iron content and to the high biological value of its proteins (see p. 356). It should not be heated above 100° F. It has been known to contain the cysts of tape worms. From this point of view commercial meat juices are safer.

COMMERCIAL MEAT PRODUCTS[1]

Percentage Composition

TABLE 91

Name	Water	Soluble Albumin	Insoluble Protein Matter	Fat	Total Protein Matter available as Nutriment
Liebig's Extract of Beef . . .	20·06	0·06	9·52	0·91	0·06
Armour's Extract of Beef . . .	14·03	0·68	8·80	1·27	0·68
Valentine's Meat Juice	60·31	0·55	2·68	0·78	0·55
Wyeth's Beef Juice .	57·88	0·47	3·25	0·85	0·47
Bovinine . . .	81·09	13·98	2·43	1·49	13·98

[1] From *Dietotherapy* (Fitch), vol. i.

COMMERCIAL PEPTONE PREPARATIONS[1]

Percentage Composition

TABLE 92

Name	Water	Total Nitrogen	Insoluble Protein	Albumoses	Peptones	Extractives	Carbohydrates	Fat	Ash	Authority
Benger's peptonized beef jelly . .	89·68	1·55	...	2·41	4·75	2·27	...	...	0·89	Konig
Brand's essence of beef . . .	89·19	1·48	2·25	...	6·05	0·15	...	...	1·31	Stutzer
Brand's beef peptone	84·60	...	...	7·00	...	...	...	...	1·40	Hutchison
Carnrick's peptonoids (solid) . . .	6·75	10·49	56·25	...	6·93	0·10	13·41	10·67	5·50	Stutzer
Carnrick's peptonoids (liquid) . . .	5·50	...	...	24·00	...	65·40	...	...	5·20	...
Fairchild's panopeptone . . .	81·00	...	...	...	3·00	15·00	...	...	1·00	...
Valentine's meat juice	59·07	2·50	...	1·81	4·87	22·73	...	...	11·52	Konig

[1] From *Dietotherapy* (Fitch), vol. i.

BEEF TEA

Take 1 lb. of lean beef, mince finely, mix thoroughly with $1\frac{1}{2}$ pints of cold water. Stand for 1 hour. Simmer down to 1 pint. Strain, cool and remove fat.

Percentage composition :

Proteins	1·0
Fat	A trace
Sugar	A trace
Extractives	2·0
Caloric value about .	2 per oz.

Beef tea can hardly be regarded as a food. It is, however, a good stimulant, and in combination with bread jelly, peptonised milk or milk dilutions it is of service in stimulating metabolism.

Veal Broth

Take 1 lb. of lean veal, cut small, add a few small pieces of shin or knuckle bone and 1 pint of cold water. Simmer gently for 4 hours. Make up to 1 pint, and cool and remove fat. Should set in jelly when cold.

Méry's Vegetable Soup (Bouillon de Légumes de Méry)

Take 2 oz. potatoes, 2 oz. carrots, 1 oz. turnips, ½ oz. dried peas, ½ oz. haricot beans and allow to simmer gently with 1 quart of water for 4 hours in an earthenware pot. Strain and add a level teaspoonful of salt. If thought desirable, 2 oz. of rice or barley may be added to the ingredients.

This vegetable soup is at times useful for infants during convalescence from acute illnesses, such as pneumonia, bronchitis, influenza and colitis. I have chiefly used it myself in cases of scurvy, and for this purpose I consider it of great service when combined with fresh meat juice.

Vegetable soup should be given as a diluent of milk and in quantities of 2 oz. for an infant of three months, and in proportionately larger quantities for older children.

Author's Vegetable and Bone Soup

Take 1 lb. of shin of veal or bone of some other young animal (chicken, lamb, etc.), chop up so as to expose marrow, and simmer gently for about 8 hours with 1½ pints of water and one tablespoonful of malt vinegar but no salt. Add a small handful of mixed vegetables and again simmer for 1 hour. Strain, make up to 1 pint and allow to set into jelly.

The object of adding the vinegar is to decalcify the bone and thus allow better solution of the colloid substances of the matrix and at the same time to enrich the mineral constituents of the soup. After a few hours' cooking the vinegar is neutralised by the bone salts and, as a rule, the reaction becomes actually alkaline before the vegetables are added.

The vegetables to be added should include some $\frac{1}{4}$ lb of the following:—cabbage, spinach, Brussels sprouts, turnip tops, carrots, parsnips, turnips, onions, fresh or dried peas and beans, mixed in varying proportions. A few sprigs of Irish moss [1] may also be added with advantage, since this sea-weed contains a rich content of organised iodine and other marine mineral elements which are absent or deficient in amount in inland vegetables.

Soup made in this way contains a rich proportion of animal and vegetable mineral matter. It also contains a great variety of meat and vegetable extractives, including those of red and white marrow. It is possible also that it contains vitamines from the fat of the bone and from the green vegetables.

From time to time other odds and ends may be added to this soup with advantage. For instance, one day a small piece of liver; another a little sheeps' brain; another half-a-teaspoonful of Marmite, and so on. In the building up of the human body a vast number of accessory food factors are required in addition to the so-called vitamines, and although these are probably present in breast milk they may not always be present in adequate amount, or may be altogether absent from cow's milk and its dilutions. For this reason a small quantity of soup made as above, and with various occasional additions, may be of the greatest advantage in supplying absent elements or elements present in deficient amount but necessary for complete development.

From a wide experience of the use of this soup as an addition to the ordinary food of infants I can confidently testify to its wonderful influence on nutrition. It can be given to babies of any age. I have frequently given it to infants under one week old, when even peptonised milk could not be tolerated. When used in such cases without milk it may be fortified with milk-sugar and cod-liver-oil emulsion, and should be well diluted with water. For ordinary healthy infants I generally order 2–4 oz. to be given in the 24 hours. It may also be given to breast-fed infants as a supplementary food.

The percentage composition of this soup is approximately as follows :—

Gelatine and colloid substances	5%
Extractives	3%
Mineral Matter	4%

[1] See p. 372

TABLES OF THE VITAMINE CONTENT OF VARIOUS FOODS

The following tables give lists of foods in which the various vitamines are present or absent (from Dr R. H. A. Plimmer's *Analyses and Energy Values of Foods*).

Table 93

Common Foodstuffs containing no Accessory Food Factors

Fats and Oils	Meats, etc.	Cereals, etc.
Lard	Tinned meats	White wheaten flour
Olive oil	Fish, white	Pure cornflour
Cotton-seed oil	Cheese (skim-milk)	Polished rice
Cocoanut oil	Meat extracts	Pea flour, kilned
Cocoanut butter	Malt extracts	Oatmeal, kilned
Linseed oil	Preserved lime juice	Custard powders
Margarine from vegetable fats	Beer, wine	Egg substitutes

Table 94

Common Foodstuffs rich in Fat-Soluble "A"

Butter	+++	Heart	++
Cod-liver oil . .	++++	Herring	++
Cream	++	Mackerel	++
Egg yolk	++	Salmon	++
Wheat germ . . .	++	Cabbage, raw	++
Beef or mutton fat . .	++	Lettuce	++
Fish oil . . .	++	Spinach	++
Liver	++	Carrots	+

Table 95

Foodstuffs rich in Water-Soluble "B" (Anti-Neuritic)

Eggs, fresh and dried. .	+++	Fish roe	++
Wheat germ . . .	+++	Linseed and millet . .	++
Dried yeast	+++	Dried pulses . . .	++
Yeast extract and autolysed "Marmite"	+++	Germinated pulses . .	++
Liver, brain, sweetbread .	++	Nuts	++

TABLE 96

COMMON FOODSTUFFS RICH IN WATER-SOLUBLE "C" (ANTI-SCORBUTIC)

Cabbage, raw	++++	Beetroot	—+
Lemon juice, fresh	++++	Tomatoes, canned	++
Orange juice, fresh	++++	Germinated pulses	++
Tomatoes	++++	Cabbage (cook ½ hour at 100° C.)	++
Runner beans, raw pods	+++	Lemon juice, preserved	++
Swede juice, fresh	+++	Lime juice, fresh	++
Raspberries, fresh	++	Carrot	+
Cloudberries, fresh	++	Onion	+
Salads, cresses, etc.	++	Rhubarb	+
Cooked potatoes	+	Apples	—+
Lean meat	—+	Bananas	—+
Raw milk	—+	Grapes	—+

TABLE 97

COMMON FOODSTUFFS CONTAINING ALL THREE ACCESSORY FACTORS

Foodstuff	Fat-Soluble "A"	Water-Soluble "B" or Anti-Neuritic	Water-Soluble "C" or Anti-Scorbutic
Cabbage, fresh	++	+	+++
Cabbage, cooked	+	+	+
Pulses, germinated	+	++	++
Cereals, germinated	+	++	++
Liver	++	++	+
Milk, cow's whole (raw)	++	+	+
Milk, cow's whole (dried)	++	+	—+ *
Milk, cow's whole (boiled)	++	+	—+
Milk, sweetened condensed	+	+	+
Meat, lean	+	+	+
Carrots	+	+	+
Potatoes	+	+	+

* Signifies less than +

FATS AND FAT EMULSIONS

PHOSPHORATED COD-LIVER OIL

Dissolve one part of dry phosphorus in 10,000 parts of cod-liver oil which has been freed from air and moisture by heating at a low temperature.

PHOSPHORUS IN OIL OF ALMONDS

℞ Phosphori (1 in 10,000 ol. amygd. dulc.) . ℥ss
Pulv. acaciæ . . . . . . ʒi
Syrup simplicis . . . . . . ʒi
Aquam ad . . . . ℥i.

FATS AND FAT EMULSIONS AS SUBSTITUTES FOR DAIRY CREAM

In order that cow's milk may be modified to the physiological standard of breast milk it is necessary, unless the "top-milk" method is employed, to supplement with additional fat. Dairy cream is naturally the best form of fat to use, but it is expensive and not always available. Ordinary fats or oils in their natural condition do not mix readily with milk, but float at the top, and hence it is necessary to use them in the form of emulsions, which can be prepared by any of the usual means. For many years I have used emulsions of various oils, or combinations of oils, in my Welfare Centre, with the greatest benefit to the infants. In preparing these it is desirable to obtain an emulsion which is as similar as possible to human cream—that is to say, one in which the relative proportions of the various neutral fats, fatty acids, etc., which make up the combination, should be the same as those which exist in human butter fat itself (see p. 106). It is not very easy to arrange a suitable combination of this kind, but if oleo-fat and nut oil are combined in equal proportion with a small addition of cocoanut oil, an emulsion can be obtained which fulfils these conditions fairly satisfactorily. The following formula may be used for preparing a 33% fat emulsion :—

Oleo fat	3 oz.
Nut oil	3 oz.
Cocoanut oil	2 drachms
Benzoic acid	5 grs.
Decoction of Irish moss to make	20 oz.
Caloric value . . .	88 per oz.

FORMULÆ

For making 1 Pint of Emulsion of Cod Liver Oil, Olive Oil, or any liquid fixed Oil of any required Percentage up to 48, and of Butter Fat (melted) of any Percentage up to 33

(1) 48 per cent.

℞ Olei	℥ixss
Pulv. acaciæ . . .	℥iiss
Glusidi	gr. ii
Ol. amygd. amar. . .	♏v
Aquam ad . . .	℥xx

(2) 40 per cent.

℞ Olei	℥viii
Pulv. acaciæ	℥ii
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Aquam ad	℥xx

(3) 33 per cent.

℞ Olei	℥vi, ʒv, ♏xx
Pulv. acaciæ	℥i, ʒv, gr. xx
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Aquam ad	℥xx

(4) 25 per cent.

℞ Olei	℥v
Pulv. acaciæ	℥i, ʒii
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Aquam ad	℥xx

(5) 20 per cent.

℞ Olei	℥iv
Pulv. acaciæ	℥i
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Aquam ad	℥xx

(6) 33 per cent. butter fat

℞ Butter fat (melted)	℥vi, ʒv, gr. xx
Pulv. acaciæ	℥i, ʒv, gr. xx
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Aquam ad	℥xx

These emulsions to be made by means of mortar and pestle.

FORMULÆ

For preparing Fat Emulsions in Large Quantity

When large quantities of emulsions of liquid fats are required, decoction of Irish moss (Chondrus Crispus) may be used in place of acacia, the formula then being :—

Olei (any required percentage)	
Glusidi	gr. ii
Ol. amygd. amar.	♏v
Decoct. Chondri Crispi	℥x
Aquam ad	℥xx

Decoction of Irish Moss

Irish moss	4 oz.
Water	1 gallon

Boil for 15 minutes, strain while hot and make up to 1 gallon, if necessary, with water.

When Irish moss is used as the emulsifying agent a mortar and pestle cannot be employed with satisfactory results. A good emulsifying machine for "moss" emulsions is made in various sizes by Joseph Baker Sons & Perkins Limited, Kingsway House, Kingsway, W.C.2.

Vitoleum Cream [1]

This is a finely homogenised cream containing 50% of fats rich in fat-soluble "A" vitamine (growth factor). The approximate analysis of the fats contained in Vitoleum Cream is given as:

Saponification number	199·02
Iodine number	82·00
Reichert-Meissl number	2·88
Polenske number	1·59

These analytical figures, with the exception of the iodine number, are closely identical with those of human milk fat.

Arnold in his work, *Ueber Frauenmilchfett*, gives the following figures for human milk fat:—

Saponification number	206·08
Iodine number	46·25
Reichert-Meissl number	2·65
Polenske number	1·65

The higher iodine number and the lower saponification number in Vitoleum Cream results from having to use certain amounts of liquid fats to make a 50% emulsion possible. A moderately high iodine number is not considered of importance, but it is generally recognised that the Reichert-Meissl and Polenske numbers must closely approximate to human milk fat figures if nutritional disturbances are to be avoided.

[1] Messrs Marylebone Preparations, 2 Great Barlow St., Marylebone, W.1. Agents:—Messrs Sangers, 278 Euston Road, N.W.1.

It is interesting to compare the above figures with those of an emulsion of cod-liver oil. They are as follows :—

Saponification number . . .	180
Iodine number	160
Reichert-Meissl number . . .	*nil*, or negligible
Polenske number	*nil*, or negligible

The objection to giving large quantities of butter fat in the form of ordinary dairy cream or butter-fat emulsion is that the Reichert-Meissl number, or volatile fatty-acid content, is far too high. The objection to cod-liver-oil emulsion as a substitute for cream is that the iodine number is too high, and, as experience proves, such emulsion, given in full amounts, almost invariably causes vomiting in infants.

It appears to be of some importance to nutrition and digestion that, when a substitute fat emulsion is used in place of human butter fat, the relative proportions of the various fatty acids should not deviate greatly from the ratio in which they are present in breast milk. Too much oleic or palmitic or stearic acid interferes with good physiological results. The nearer the similarity of the combination the better the result (see p. 106).

FORMULÆ

For preparing Creams of any Required Percentage Composition

The fat content in dairy cream is very varied, ranging from 20% to 50%, the usual strength being about 33%. The precise percentage of fat can be ascertained from the dairy.

It is quite easy to reduce the percentage of fat to any required degree by the addition of cow's milk which contains 3·5% of fat. The exact quantities of the two constituents to be employed is merely a question of arithmetic: how much milk containing 3·5% of fat must be added to a cream of known percentage composition to reduce it to the required percentage composition ?

For instance, to reduce a 36% cream to 25% we should have to add, roughly, one-third part of cow's milk.

To take the concrete example of preparing 4 oz. of 25% cream from a 36% cream in one's possession :

	1 fl. oz.,	3 fl. dr.	of cow's milk
	2 ,,	5 ,,	of 36% cream
=	4 fl. oz.		of 25% cream

To avoid troublesome calculations the following formulæ are supplied for converting creams of various percentage composition into creams of commonly required percentages. The figures in each case are for preparing 4 oz. of cream.

50% to 48% =	..	ʒi	♏22	milk
	℥iii	ʒvi	♏38	cream
50% to 45% =	..	ʒiii	♏26	milk
	℥iii	ʒiv	♏34	cream
50% to 40% =	..	ʒvi	♏52	milk
	℥iii	ʒi	♏8	cream
50% to 36% =	℥i	ʒi	♏38	milk
	℥ii	ʒvi	♏22	cream
50% to 33% =	℥i	ʒiii	♏48	milk
	℥ii	ʒiv	♏12	cream
50% to 30% =	℥i	ʒv	♏46	milk
	℥ii	ʒii	♏14	cream
50% to 25% =	℥ii	ʒi	♏12	milk
	℥i	ʒvi	♏48	cream
50% to 20% =	℥ii	ʒiv	♏38	milk
	℥i	ʒiii	♏22	cream
50% to 16% =	℥ii	ʒvii	♏24	milk
	℥i	..	♏36	cream
48% to 45% =	..	ʒii	♏10	milk
	℥iii	ʒv	♏50	cream
48% to 40% =	..	ʒv	♏46	milk
	℥iii	ʒii	♏14	cream
48% to 36% =	℥i	..	♏37	milk
	℥ii	ʒvii	♏23	cream
48% to 33% =	℥i	ʒii	♏47	milk
	℥ii	ʒv	♏13	cream
48% to 30% =	℥i	ʒiv	♏56	milk
	℥ii	ʒiii	♏4	cream
48% to 25% =	℥ii	..	♏32	milk
	℥i	ʒvii	♏28	cream

8% to 20% =	℥ii	ʒiv	♏8	milk
	℥i	ʒiii	♏52	cream
8% to 16% =	℥ii	ʒvii	..	milk
	℥i	ʒi	..	cream
45% to 40% =	..	ʒiii	♏51	milk
	℥iii	ʒiv	♏9	cream
45% to 36% =	..	ʒvi	♏56	milk
	℥iii	ʒi	♏4	cream
45% to 33% =	℥i	ʒi	♏15	milk
	℥ii	ʒvi	♏45	cream
45% to 30% =	℥i	ʒiii	♏34	milk
	℥ii	ʒiv	♏26	cream
45% to 25% =	℥i	ʒvii	♏25	milk
	℥ii	..	♏35	cream
45% to 20% =	℥ii	ʒiii	♏17	milk
	℥i	ʒiv	♏43	cream
45% to 16% =	℥ii	ʒvi	♏22	milk
	℥i	ʒi	♏38	cream
40% to 36% =	..	ʒiii	♏30	milk
	℥iii	ʒiv	♏30	cream
40% to 33% =	..	ʒvi	♏8	milk
	℥iii	ʒi	♏52	cream
40% to 30% =	℥i	..	♏46	milk
	℥ii	ʒvii	♏14	cream
40% to 25% =	℥i	ʒv	♏9	milk
	℥ii	ʒii	♏51	cream
40% to 20% =	℥ii	ʒi	♏32	milk
	℥i	ʒvi	♏28	cream
40% to 16% =	℥ii	ʒv	♏2	milk
	℥i	ʒii	♏58	cream
36% to 33% =	..	ʒii	♏57	milk
	℥iii	ʒv	♏3	cream
36% to 30% =	..	ʒv	♏54	milk
	℥iii	ʒii	♏6	cream
36% to 25% =	℥i	ʒii	♏50	milk
	℥ii	ʒv	♏10	cream
36% to 20% =	℥i	ʒvii	♏45	milk
	℥ii	..	♏15	cream
36% to 16% =	℥ii	ʒiii	♏42	milk
	℥i	ʒiv	♏18	cream

33% to 30% =	..	ʒiii	♏15	milk
	℥iii	ʒiv	♏45	cream
33% to 25% =	℥i	..	♏40	milk
	℥ii	ʒvii	♏20	cream
33% to 20% =	℥i	ʒvi	♏6	milk
	℥ii	ʒi	♏54	cream
33% to 16% =	℥ii	ʒii	♏27	milk
	℥i	ʒv	♏33	cream
30% to 25% =	..	ʒvi	♏2	milk
	℥iii	ʒi	♏58	cream
30% to 20% =	℥i	ʒiv	♏4	milk
	℥ii	ʒiii	♏56	cream
30% to 16% =	℥ii	..	♏54	milk
	℥i	ʒvii	♏6	cream
25% to 20% =	..	ʒvii	♏26	milk
	℥iii	..	♏34	cream
25% to 16% =	℥i	ʒiv	♏48	milk
	℥ii	ʒiii	♏12	cream
20% to 16% =	..	ʒvii	♏45	milk
	℥iii	..	♏15	cream

Mixed Salts

℞ Sodii bicarb.	℥i
Pot. citratis	℥ss
Mag. carb pond. . . .	℥ss
Calcii lactatis	ʒiii

Dosage.—One teaspoonful or less in water every morning.

Table 98

TABLES OF WEIGHTS AND MEASURES

Mass

Equivalents of Imperial and Metric Measures

1 pound avoirdupois = 453·592 grammes
1 ounce avoirdupois = 28·35 grammes
1 grain = 0·0648 gramme or 64·8 milligrams
1 mgm. (milligram) = 0·01543 grains (or approx. $\frac{1}{64}$ grain)
1 gm. (gramme) = 15·432 grains
1 kgm. ("kilo" or kilogram) = 2 lb. 3¼ oz. avoirdupois

Table 99

Capacity

Equivalents of Imperial and Metric Measures

1 fl. ounce, Imperial measure = 28·42 cubic centimetres
1 pint, Imperial measure = 568·34 cubic centimetres
1 gallon, Imperial measure = 4·546 litres, or 10 lb. avoirdupois of pure water at 62° F. and under an atmospheric pressure of 30 inches of mercury
1 centimil = 0·17 minim (approx.), Imperial measure
1 decimil = 1·7 minims (approx.), Imperial measure
1 c.c. (cubic centimetre) or one mil = 16·9 minims, Imperial measure
1 L. (litre) = 35·196 fluid ounces (35 fl. oz., 1 fl. dr., 34 min.), Imperial measure

Table 100

SCALE OF WEIGHTS AND HEIGHT

Imperial and Metric Equivalents

Weights

12 st.	76·203 kgm.
11 st.	69·853 kgm.
10 st.	63·503 kgm.
9 st.	57·153 kgm.
8 st.	50·802 kgm.
7 st.	44·452 kgm.
6 st.	38·102 kgm.
5 st.	31·751 kgm.
4 st.	25·401 kgm.
3 st.	19·051 kgm.
2 st.	12·701 kgm.
1 st.	6·350 kgm.
13 lb.	5·897 kgm.
12 lb.	5·443 kgm.
11 lb.	4·990 kgm.
10 lb.	4·536 kgm.
9 lb.	4·082 kgm.
8 lb.	3·629 kgm.
7 lb.	3·175 kgm.
6 lb.	2·722 kgm.
5 lb.	2·268 kgm.
4 lb.	1·814 kgm.
3 lb.	1·361 kgm.
2 lb.	0·907 kgm.
1 lb.	0·454 kgm.

Heights

6 ft.	1828·8 mm.
5 ft.	1524·0 mm.
4 ft.	1219·2 mm.
3 ft.	914·4 mm.
2 ft.	609·6 mm.
1 ft.	304·8 mm.
11 in.	279·4 mm.
10 in.	254·0 mm.
9 in.	228·6 mm.
8 in.	203·2 mm.
7 in.	177·8 mm.
6 in.	152·4 mm.
5 in.	127·0 mm.
4 in.	101·6 mm.
3 in.	76·2 mm.
2 in.	50·8 mm.
1 in.	25·4 mm.
$\frac{3}{4}$ in.	19·0 mm.
$\frac{1}{2}$ in.	12·7 mm.
$\frac{1}{4}$ in.	6·4 mm.

To calculate the metric equivalent of any weight up to 12 stone, or any height to 6 feet—find the metric equivalent of number of complete stones or feet at head of column, then the equivalent of remaining pounds or inches and fractions of an inch at the foot of column, and add the results together.

Table 101

Factors for converting Metric into Imperial Scale and Vice Versâ

To convert	grammes into grains	×	15·432
,,	grammes into ounces, avoirdupois	×	0·03527
,,	kilogrammes into pounds	×	2·2046
,,	grains into grammes	×	0·0648
,,	avoirdupois ounces into grammes	×	28·35
,,	troy ounces into grammes	×	31·104
,,	cubic centimetres into fluid ounces, Imperial	×	0·0352
,,	litres into fluid ounces, Imperial	×	35·2
,,	fluid ounces into cubic centimetres	×	28·42
,,	pints into litres	×	0·568
,,	metres into inches	×	39·37
,,	inches into metres	×	0·0254

INDEX

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HENRY KIMPTON, 263 HIGH HOLBORN, LONDON, W.C.1

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