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FOOD
AND
HEALTH

A. B. CALLOW

THE WORLD'S MANUALS

FOOD & HEALTH

An Introduction to

The Study of DIET

by

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LONDON
OXFORD UNIVERSITY PRESS
HUMPHREY MILFORD

1928

OXFORD UNIVERSITY PRESS
Edinburgh Glasgow Leipzig Copenhagen
New York Toronto Melbourne Capetown
Bombay Calcutta Madras Shanghai
LONDON: HUMPHREY MILFORD
Publisher to the University

Printed in Great Britain

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Introduction

EDMUND KEAN, the famous actor, is said to have altered his diet according to the part he had to play: pork for tyrants, beef for murderers, mutton for lovers. Crude as this principle is, it implies more thought than most of us trouble to give to the question of diet. We eat meals that are chosen by some one who may (or may not) know how to cook, but who knows little or nothing about the relative values of different types of food. We do not seriously believe that it matters. Why should we trouble ourselves with what scientists say about food? Our grandparents knew nothing about calories or vitamins, yet they were fine, healthy folk. But, although it is true that in the past many people have been perfectly hale and hearty without having any clear ideas about the science of nutrition, we must not overlook the further truth that in the good old days many others died of diseases that developed simply because of deficient or unsuitable diets—diseases that are now being rapidly stamped out. Moreover, the people who retained their strength in former generations had food that was very different from that generally eaten nowadays. The old-fashioned wholesome diet of fresh meat, milk, butter, eggs, fruit, vegetables, and wholemeal bread is now often replaced by tinned or dried foods, margarine, egg substitutes, and white bread. Since these alterations are mainly for the worse, it is to-day more than ever necessary to have sound knowledge to guide us in our choice of food.

It might be argued that the scientist should work out a list of menus suitable for various occasions, and submit it to the public without any tiresome preliminaries about the chemistry of food-stuffs, or the physiology of digestion. Against this method of procedure is the fact that many of us have special peculiarities of digestion. There is certainly some truth in the saying that what is one man's food is another man's poison. We must therefore to some extent work out our own salvation in the matter of diet; and in

order to do this we must have some idea of the chemical nature of foodstuffs, and the changes that take place during digestion. It is not enough to be told that we must eat more vitamins, and that white bread should be abolished. Intelligent people have a right to know wherein lies the magical power of vitamins, and what, if anything, is wrong with bread that is white. We shall see later that, although on the whole brown bread is preferable, there are special cases in which the despised white bread is actually better than the much-boomed brown. It is important to understand that the various substances that we eat do not all serve the same purpose in the body, and the science of diet has to show how each purpose can be fulfilled. Metallurgists devise alloys for different uses, and what is useless for one purpose may be valuable for another. A metal which melts in hot water is not to be recommended for making tea-spoons, but will make a capital electric fuse. In the same way some foods have only a limited value, but need not on that account be banished from a mixed diet. Our task is to show how this complex problem can be simplified by the application of scientific knowledge.

The Chemical Nature of Foodstuffs

THE most necessary of all foods, the first we ever consume, and that which we take most constantly throughout our lives is one which few of us think of as a food at all. It is the oxygen of the air. Like practically all other living organisms, we breathe or respire, that is to say we take up oxygen from the air and give out carbon dioxide.

In oxygen, members of the animal and the vegetable kingdoms have at least one foodstuff in common. Speaking generally, however, animals and plants obtain their nourishment from very different sources. The difference lies chiefly in the fact that animals cannot support life unless they are supplied with carbon in the form of complex organic substances, whereas green plants obtain the carbon they require in the simple form of carbon dioxide from the air. With the aid of their green colouring matter, chlorophyll, green plants are able to elaborate this carbon dioxide into complex organic compounds, the necessary energy being derived from sunlight. Thus the green leaves of plants contain the most valuable of the world's food factories. The carbon dioxide, which is given off as a waste product by both animals and plants during respiration, is only present in very small amounts in the air, but it is seized by green plants, and forms the basis for the manufacture of organic compounds essential for the life of animals and man. Plants obtain their other foodstuffs in the form of water and dissolved salts, such as nitrates, phosphates, &c., from the soil. From these simple materials green plants are able to build up the substances necessary for the formation of roots, leaves, flowers, &c. But the higher animals are quite unable to live on such a diet. They must have their carbon in the form of complex organic compounds, and they also require a good many special substances which they cannot manufacture in their own bodies, and yet which are necessary for their vital processes.

In both animals and plants the most obvious function of food is to supply the new material that is required for growth. There can be no increase in weight unless some food substance has entered the body. Even when the adult stage is reached in man and growth ceases, the tissues of the body continually undergo slight changes, the old fabric breaking down and being replaced by new. This building up of body-tissue goes on without interruption throughout life, but it is much more marked during convalescence after an illness.

This is, as we have said, the most obvious function of food; but tissue repairs use up only a very small proportion of what is eaten. Another small proportion of the food is excreted as waste material. The bulk of the food still remains to be accounted for. Large meals are eaten frequently, and yet adults usually show no increase in weight. As a matter of fact, by far the greater portion of the food that we eat is used as fuel to keep the body temperature to what we call 'blood heat', and to provide the energy for muscular movements. In cold-blooded creatures, such as fishes and reptiles, the body temperature varies with the temperature of the surrounding water or air; but man and other warm-blooded animals have elaborate mechanisms for controlling the temperature of the body so that it is kept constant, regardless of changes in the environment. The human body is kept at a tropical heat (98° F., or 37° C.) and, since the surrounding air is generally much cooler than this, heat is continually being lost by the body. In order to keep up this constant supply of heat, food is burnt, that is oxidized, in the body just as coal is burnt to keep our houses warm. In the same way, the food that we need to supply the energy necessary for our muscular movements may be compared with the fuel burnt to drive a train. Every muscular movement, whether involuntary like the beating of the heart, or voluntary like walking or lifting, uses up a certain amount of energy, and this energy is obtained by burning an equivalent amount of the body's supply of fuel. The body fuel consists of carbon-containing compounds which are oxidized by

the oxygen taken in by the lungs. Just as coal, coke, and wood have different values as fuel for household fires, the various foodstuffs that we eat have different values as fuel for the human body.

The main constituents of human food are proteins, carbohydrates, fats, mineral salts, and water, although in addition to these substances ordinary foods generally contain various other substances of known or unknown chemical constitution. Proteins, carbohydrates, and fats are all carbon-containing (organic) compounds, capable of being used by the body as fuel; but for tissue repairs and growth, fats and carbohydrates, since they contain no nitrogen, are not of direct value. On the other hand, proteins are essential for building up tissues because they enter into the composition of all the cells in the body, and in fact of all living cells.

As we have already explained, plants are able to build up their own proteins from simple materials, but animals cannot do this, and hence require a supply of proteins in their food. Since proteins can also be used as fuel for the human body, it might be thought that they are the ideal food. This might indeed have been the case if it had not been for the misfortune that our digestive system cannot cope with a diet of proteins alone. It is interesting to notice that dogs are made of sterner stuff, and are able to live on a diet of lean meat, which contains a relatively high proportion of proteins.

There are large numbers of different proteins in different animals and plants, but they have certain features in common, and show remarkable resemblances whether found in elephant or amoeba, oak tree or diatom. Each protein consists of a collection of simpler bodies, called amino-acids, that are held together in a special way. The amino-acids are built up of the elements carbon, hydrogen, oxygen, nitrogen, and sometimes sulphur. Some of them are comparatively simple compounds in which the atoms are arranged within the molecule in a more or less straight chain. Others contain, in addition to a chain, complex rings of atoms such as the well-known benzene ring, which is present in several amino-acids. At present we know of over twenty different amino-acids,

and there are probably others that have not yet been isolated. The amino-acids are present in varying amounts in different proteins. Sometimes one amino-acid occurs several times in one protein, while others may be completely absent. There are simple proteins that contain only a few amino-acids, while others are very complex and contain large numbers. Thus it can readily be imagined how it is that there are such an immense number of different proteins. Not only are the proteins from different animals and plants different, but there are always several different proteins in any one animal or plant. For example, in the human body there are several distinct muscle proteins, four other proteins in the blood, and so on.

The proteins that we eat are not all equally valuable as food, because they do not all contain the amino-acids that we require. Some amino-acids, like glycine, can be manufactured in the human body, and so need not be present in our food proteins; but there are at least six amino-acids which the body cannot synthesize. Since they are necessary for the formation of body-tissues, &c., it is essential that these six amino-acids should be present in our food, or serious consequences will follow. Experiments have shown, for instance, that an inadequate supply of the amino-acid tryptophane has a bad effect on the growth of rats in the laboratory, and it is highly probable that a similar deficiency would cause severe illness in human beings.

Any protein that lacks one or more of the six essential amino-acids is thus less valuable as a foodstuff than one that contains them all, so that in choosing our proteins quality must be considered as well as quantity. As might be expected, proteins from animals resemble human proteins more closely than do those from plants, and hence plant proteins are not so good for human food as animal proteins. If we consider it solely from the point of view of the protein value of the diet, there is something to be said for the otherwise shocking practice of cannibalism. The victorious warrior may not, as was formerly supposed, gain an extra supply of courage by eating the heart of his fallen foe, but he certainly obtains in this

way a supply of very useful proteins. Cannibalism is certainly more desirable as regards proteins than is a strict diet of vegetarianism. The cannibal gets all the necessary amino-acids in the exact proportions required, but the vegetarian is in serious danger of missing some essential. Vegetarianism has the added disadvantage that huge quantities of fruit and vegetables have to be eaten in order to obtain an adequate supply of protein, and moreover the protein may be difficult to digest. By 'vegetarian' I mean some one who lives entirely on fruit and vegetables, and eats no food of animal origin. The so-called vegetarians who eat milk, butter, eggs, and cheese have a much better-regulated diet.

In an ordinary mixed diet we obtain our proteins from a number of different sources. Some foods contain protein as their chief constituent, for example white of egg, lean chicken, and certain fish (whiting, cod, halibut, &c.). Other fish (herring, mackerel, salmon, &c.), most meats, cheese, and egg-yolk contain protein together with fat. Fruit, vegetables, and most cereals contain protein (usually a very small amount in fruits and vegetables) in conjunction with carbohydrate, while oatmeal, nuts, milk, and chocolate are examples of foodstuffs that contain protein and both fats and carbohydrates. The percentages of protein, carbohydrate, and fat in the edible portion of most common foodstuffs are given in the tables on pages 89-93. Dried peas, beans, and lentils (pulse) contain a high percentage of protein (about 20 per cent.), but it must be remembered that the quality of vegetable protein is inferior to that of animal protein. Fruits and vegetables (other than pulse) contain only small quantities of protein, for example there is 1.4 per cent. in the cabbage, and 0.9 per cent. in the orange. On the other hand, cheese contains 20-30 per cent. of first-class protein, meat and fish about 15-20 per cent., eggs 12 per cent., and milk 3 per cent.

Besides the proteins that we have been considering, there are, in living organisms, several complex compounds known as conjugated proteins, whose molecules contain not only protein but also

non-protein groups. The nucleoproteins, which are found in cell nuclei, are examples of these conjugated proteins. Here the non-protein group contains, amongst other things, purine derivatives, so-called because they contain a special double-ring structure called the purine ring. The physiological importance of the purine derivatives in our food is that they become converted in the body into uric acid, which has a bad habit of accumulating in tissues and joints and giving rise to gout and certain types of arthritis. Patients suffering from these complaints are sometimes treated with drugs which tend to remove the deposits of uric acid. But it is clearly more satisfactory to try to prevent the formation of uric acid in the body. The only known way of doing this is to adopt a diet that is free from purine derivatives, for certainly most of the uric acid of the body is formed from these substances. It is not altogether an easy matter to avoid all purine derivatives, since they are present in all food materials which contain cells with nuclei. All forms of meat contain purine derivatives, especially sweetbreads, liver, and kidney. Other foods which contain them are beans, oatmeal, tea, coffee, cocoa, &c. (see pp. 82-3).

Having discussed the protein content of our food, we can now turn to the carbohydrates and fats, both of which contain no nitrogen, and which are therefore useful as fuel rather than for purposes of growth or tissue repair. The term carbohydrate implies that these substances contain the elements carbon, hydrogen, and oxygen, the two latter being in the same proportion as in water, that is two atoms of hydrogen to one of oxygen. The group of carbohydrates consists chiefly of starches and sugars including, for instance, cane sugar, milk sugar, glucose, and starch. The simplest carbohydrates that are of importance as food are glucose and fructose. These two sugars are very similar in chemical constitution, and both have the chemical formula $C_6H_{12}O_6$. The more complex sugars are made up of two, three, or more simple sugars like glucose, in much the same way as the proteins are made up of amino-acids. But there is this great difference. The individual

amino-acids show a great variety of chemical structure, while the simple sugars are all very much alike. Also, there are large numbers of different amino-acids that assist in the formation of proteins, whereas there are only a few different simple sugars that take part in the constitution of the complex carbohydrates. Any one of these simple sugars may occur several times in the same complex carbohydrate, and quite often only one or two of them are present.

The best known of the moderately complex carbohydrates is ordinary table sugar, which is known to chemists as cane sugar, saccharose, or sucrose. Each molecule of saccharose is composed of one atom of glucose (also called dextrose or grape sugar), and one atom of fructose (also called laevulose or fruit sugar). Similarly, each molecule of maltose (malt sugar) contains two atoms of glucose; and each molecule of lactose (milk sugar) contains one atom of glucose, and one atom of a simple sugar called galactose. An example of a more complicated carbohydrate is pectin, which is present in most fruits. Starch is a complex carbohydrate which contains large numbers of glucose groups, as is also cellulose, the material that forms the walls of plant-cells. Fruits, seeds, and vegetables provide us with considerable quantities of cellulose, which cannot be digested to any appreciable extent, but passes through the body unchanged. Although this undigested cellulose has no direct nutritive value, we shall see later that it is important as 'roughage', which serves to keep the digestive system in proper working order.

With the exception of cellulose, the different carbohydrates are all more or less equally valuable as foodstuffs (except for infants and dyspeptics). They are present in a large variety of foods, especially fruits, seeds, and vegetables. Starch is the chief constituent of cereals, peas, potatoes, tapioca, &c.; cane sugar is found in the beet, the sugar cane, the sugar palm, the maple, &c.; glucose is present in nearly all fruits, many of which also contain fructose; honey consists chiefly of invert sugar, which is a mixture of glucose and fructose in definite proportions. Animal foods containing

carbohydrates are not common, but milk contains a sugar called lactose, and there is an animal starch called glycogen, present in lobsters, oysters, &c. Traces of glycogen may be present in meat, especially liver, and it is said that the sweet flavour of horse meat is due to its relatively high glycogen content (about 0.5-1 per cent.). The percentage of carbohydrate in the edible portion of some common foodstuffs is given in the tables on pages 89-93.

Like the carbohydrates, the fats also contain the elements carbon, hydrogen, and oxygen, but here the proportions and arrangement are quite different. The fat molecule consists of two portions, one of which is glycerol, the other being one or another of a collection of chemical compounds called fatty acids. It may be mentioned that chemists include as fats some substances that we generally call oils, for example olive oil and cod-liver oil. True fats form about 80-100 per cent. of the fatty substances that we eat, like butter and lard. Meat, cheese, eggs, and most nuts have a high percentage of fats, but fruit and vegetables contain only minute quantities. Fish can be divided into two classes according to its fat content. Herring, salmon, mackerel, and sardines all contain quite large percentages of fat, whereas fish such as cod, haddock, and whiting (lean fish) are almost free from fat (see p. 90).

We have already seen that fats, carbohydrates, and proteins supply us with the elements carbon, hydrogen, and oxygen, and proteins also with nitrogen. In addition, certain proteins and conjugated proteins yield a supply of sulphur and phosphorus, and other elements such as iron (in the pigment protein of blood), calcium (in the casein of milk), magnesium (in chlorophyll), &c. These inorganic elements may also be present in foodstuffs in the form of mineral salts.

The word salt is used in chemistry for substances formed by the interaction of certain definite proportions of acids and bases. In the case of mineral salts, the base is a metallic hydroxide, such as sodium hydroxide (caustic soda); and the first part of the chemical name of the salt is the name of the metal from which the hydroxide

is obtained. The second part of the name is derived from the acid. The mineral salt most familiar to us, to which we give simply the name of 'salt', is known to chemists as sodium chloride, because it is the result of the reaction between sodium hydroxide and hydrochloric acid.

We need mineral salts in our food for various reasons. About 5 per cent. of the weight of the body is made up of salts, the greater part being calcium phosphate, which is concerned in the formation of bones and teeth. Besides entering into the composition of body-tissues, salts are also necessary for the performance of various physiological processes, but they have no fuel value since they cannot be burnt in the body. When organic compounds are oxidized completely in the laboratory, any mineral matter remains in the form of ash. The percentage of ash in some common foodstuffs is given in the tables on pages 89-93.

All natural foodstuffs contain mineral salts, but they are not always present in the proportions required by man. For instance, milk is deficient in iron; it contains only 0.00024 per cent., whereas meat contains 0.0038 per cent. Since iron is one of the components of haemoglobin, the red colouring matter of blood, it is essential for the human body. There is a type of anaemia called 'green sickness', or chlorosis, that may possibly be caused by a deficiency of iron. But diets generally contain plenty of iron, and there is no doubt that most anaemias are caused by something other than lack of iron.

A deficiency of any of the essential mineral constituents has a bad effect on the system. Thus, bones and teeth will not develop properly if the diet lacks compounds containing calcium or phosphorus. Cereals are deficient in calcium, but calcium is present in milk, cheese, eggs, green vegetables, &c., and is not likely to be absent from an ordinary mixed diet. An element that is, however, often deficient in food is iodine. This is a serious matter, for lack of iodine is now considered to be the cause of most cases of the repulsive disease called exophthalmic goitre. We obtain our

iodine as iodides, chiefly from water and vegetables, and in districts where there is a deficiency of iodides in the water (and therefore of course in the local vegetables also), goitre is prevalent. One such district is the limestone region of Derbyshire, from which the disease has the name of 'Derbyshire neck'. Goitre is now treated by giving the patient iodides, but this should only be done under medical supervision as an excess may give rise to the pathological condition of hyperthyroidism, that is an excess of thyroid.

Vegetarians require more sodium chloride than those who take a mixed diet, not because their diet is deficient in salt, but because there is an excess of potassium salts in their food; this upsets the balance of sodium and potassium in the body, and actually leads to increased elimination of sodium salts. An extra allowance of salt is also necessary for people who perspire a great deal, because perspiration contains salts, especially sodium chloride. This is the physiological explanation of the fact that miners who work in hot pits salt their food excessively, and enjoy very salt bacon. Moreover, in some hot countries the natives consider salt a luxury, and their children will eat salt as English children eat sweets.

Green vegetables are an important source of mineral salts. During the process of cooking, however, the salts are to some extent transferred from the vegetables to the cooking water; this water should therefore be kept for soup-making.

Before leaving the chemistry of foodstuffs a word must be said about water. It forms over 60 per cent. of the weight of the human body, and is present in all the tissues. Water cannot be burnt in the body, and therefore has no fuel-value, but we need it for building up tissues, for carrying out chemical reactions, and for dissolving waste products. Needless to say, the body's supply of water can be obtained, not merely from water and other beverages, but also from solid foods, nearly all of which contain a considerable proportion of water.

Digestion

It's a very odd thing—
 As odd as can be—
 That whatever Miss T. eats
 Turns into Miss T. ;

says Walter de la Mare in 'Peacock Pie'; and to the physiologist as to the poet the process of digestion is one of the most remarkable of our bodily activities. It consists mainly in a simplification, both mechanical and chemical, of the various components of food, for generally speaking what we eat cannot be used in its original form either as a fuel or for tissue repairs.

The various stages of digestion take place in the alimentary canal, which is a tube about thirty feet long with some wider portions, such as the stomach, that can if necessary be isolated from the neighbouring sections. Here chemical reactions are brought about by curious substances called enzymes or ferments, which have special names referring generally to the particular compound that they are able to act upon. The first of these enzymes to be encountered by the food is present in the saliva of the mouth, and is capable of transforming starches, which are mostly insoluble, into simple soluble sugars. This transformation, however, does not actually take place until the food reaches the stomach. While the food is in the mouth it is mechanically disintegrated, and mixed with the saliva; little or no chemical change occurs here even when mastication is prolonged.

The importance of mastication was very much emphasized by an American called Horace Fletcher, whose system of 'Fletcherizing' consisted chiefly in chewing with intense thoroughness. He considered that food should be masticated until its original flavour had completely disappeared, and not swallowed until 'the true Swallowing Impulse' had been evoked. He claimed that this

method of eating gave a new appreciation of food and led to increased bodily vigour, besides having a beneficial effect on the process of digestion. Much less food was said to be necessary if 'Fletcherizing' was practised, and the choice of food tended to alter in the direction of a preference for carbohydrate foods. Extravagant claims were made for the new fad, and 'chewing clubs' were founded in London and New York. After a time, however, the enthusiasts abandoned their rather inartistic habit, and acquired sounder and less enthusiastic ideas of the value of mastication.

When the food leaves the mouth it passes into the stomach, where it meets the gastric juice. The enzyme of the saliva now sets to work, converting the starches into simple sugars. Since acids have the power of preventing this action, it is eventually stopped by the hydrochloric acid of the gastric juice. But it takes a certain amount of time for the food-mass to become thoroughly mixed with the acid, so that for about half an hour the digestion of starch proceeds unhindered. Any starch that escapes the action of the enzyme of the saliva is decomposed by a similar enzyme in the next section of the alimentary canal. Here also the complex sugars of the food, which have so far remained unchanged, are converted into simple sugars by suitable enzymes. These sugars, together with the simple sugars that have been formed by the decomposition of the starches, are finally absorbed by the cells which line the wall of this part of the canal, and thence pass into the bloodstream. Thus all the carbohydrates of the food are broken down into simple sugars before being utilized by the body. If more carbohydrate is eaten than is needed at the time, a certain amount of the surplus can be stored in the body in the form of glycogen (animal starch), which is changed back into a simple sugar when required for use as fuel. Any further excess of carbohydrate is converted into fat and stored in this form. Although the chief function of the carbohydrates in food is to supply the fuel necessary for muscular contraction and bodily heat, it is probable that they also assist indirectly in the formation of body-tissues.

The proteins, unlike the starches, are not attacked by the saliva, but undergo the first stage of their decomposition in the stomach by the action of the gastric juice. This stage is assisted by the acid reaction of the gastric juice, and results in the formation of simple proteins from the complex proteins of the food. After leaving the stomach, these simple proteins are nearly all converted by pancreatic enzymes into their component parts, the amino-acids. A third enzyme attacks the few remaining proteins in a similar manner, so that finally all the proteins are completely broken down into amino-acids. These finally pass into the blood-stream, and are used either for building up body proteins or indirectly as fuel.

When an amino-acid is to be burnt in the body, the nitrogenous portion, which cannot be used as fuel, is first split off. This portion undergoes chemical change, and is finally excreted as urea. The portion of the amino-acid that remains after the removal of the nitrogenous part can either be used as fuel or, if necessary, it can be converted into glycogen and stored in this form.

Like the proteins and the carbohydrates, the fats also undergo simplification in the process of digestion, but in this case the enzyme action takes place either mainly or entirely after the food has left the stomach. As might be expected, the fats are split up into their two component parts, fatty acids and glycerol. These substances are absorbed by certain body-cells and again resynthesized into fats, which can either be stored in this form or burnt as fuel. The burning (oxidation) of fats is a complicated process, and can only be carried to completion if carbohydrates are present. In the absence of carbohydrates 'acetone bodies' are produced which give rise to biliousness. In order to prevent this undesirable occurrence, it is necessary to balance the fat in the food with a suitable amount of carbohydrate.

This brief survey of the chemistry of digestion shows how the chief foodstuffs are broken down into simpler compounds before being used by the body. Water and salts are absorbed unchanged after the food has left the stomach. As regards digestibility, it

may be mentioned that carbohydrates are the most rapidly digested of foodstuffs, and proteins occupy an intermediate position. Fats are not only digested very slowly, but they also diminish the supply of the gastric juice and thus interfere with the digestion of any proteins which may be present.

To this prolonged period of digestion we owe the pleasant sensation of inward satisfaction that follows a meal containing fats, and is so noticeably absent from meals that consist largely of carbohydrates. Contrast, for example, the well-known empty feeling that develops an hour or two after a breakfast of porridge (chiefly carbohydrate), with the comfortable feeling of repletion that remains after a breakfast of bacon and eggs (fat and protein). It is, however, unwise to have a great deal of fat and protein in the same meal, because the fat causes the protein to remain so long in the alimentary canal that it is attacked by putrefactive bacteria, with the formation of harmful substances. This effect of fat on the digestion of proteins explains the 'indigestibility' of substances like fat pork.

If nursery rhymes are true,

Jack Sprat could eat no fat
His wife could eat no lean.

Such extreme dietetic peculiarities are not common, but there is no doubt that the amount of fat that can be digested varies very much with different people. For instance, Eskimos can cope with a much higher proportion of fat in their food than Europeans.

The food value of different fats varies to a very slight extent according to the chemical constitution (to neglect for the moment the subject of vitamin content), but not nearly as much as is the case with proteins, where the presence or absence of the essential amino-acids has a profound effect on food value. On the other hand, the final products of the digestion of carbohydrates are all so similar that (if our digestive system is working properly) it makes practically no difference what carbohydrates we eat, with the

exception of cellulose, which has no nutritive value since it cannot be digested.

The value of cellulose in a diet is that it serves as 'roughage', that is to say it stimulates the muscular movements of the alimentary canal. Two kinds of movement are essential for digestion. First of all, the food must be constantly churned up when it is in any particular compartment, so that the enzymes are able to reach the substances that they can attack. Secondly, the food-mass must be passed along from one section of the alimentary canal to another. Constipation is due to the partial failure of these movements, and can generally be prevented by eating a sufficiency of 'roughage'. Besides cellulose plant-fibres, there are other substances that act in the same way; for instance medicinal paraffin also passes through the body unchanged and is valuable for the treatment of constipation.

Now the muscular movements that are of such importance in digestion are partly under the control of the nervous system, and are therefore liable to be interfered with or stopped if the nervous system becomes deranged. This is the explanation of the familiar fact that continued worry and nervous strain cause serious digestive troubles. Similarly a sudden piece of bad news often leads to acute indigestion. To secure good digestion, meals should be eaten without undue excitement. The army tradition that religion, politics, and women must not be discussed in the officers' mess thus has a physiological as well as a social justification. Another nervous condition which paralyses the muscular movements of the alimentary canal is intense fatigue. If much food is taken immediately after very violent exercise, a certain degree of indigestion is to be expected. Thus schoolgirls are sometimes sick if they are made to eat a heavy meal immediately after playing in a hockey match.

The nervous system not only affects the muscular movements of the digestive tract, but it also has a considerable degree of control over the secretion of the digestive juices. For instance, saliva is secreted copiously if the sight, smell, and taste of food affect us

favourably, but not otherwise. The mere thought of attractive food makes the mouth water, or in other words causes a flow of saliva, before the food has been tasted or even seen. Similarly the gastric juice enters the stomach before the food is eaten, if pleasant sensations have been aroused, and the total amount of gastric juice secreted depends largely on this psychological factor. The greatest stimulant is of course appetite. If food is cooked or served in such a way that it takes away the appetite, the digestive juices will not be properly secreted, and indigestion will follow. The votaries of Bacchus are fond of saying that alcohol is good for the digestion, and they are right in so far as alcohol produces a happy feeling, and in this way encourages gastric secretion. But this effect is generally neutralized, because an excess of alcohol definitely delays the process of digestion. Also, alcohol has other very undesirable physiological effects, and cannot be recommended as an aid to digestion.

Besides the psychological factor in secretion, there is also a chemical factor, which is capable of acting even when the psychological factor fails. Certain chemical compounds when eaten cause a flow of gastric juice. The chief of these substances are the breakdown products of proteins (peptones, &c.) and substances called 'extractives' that are present in meat extracts. These extractives simply serve as chemical stimulants, and have practically no direct nutritive value. Soup nearly always contains extractives and is therefore an excellent course with which to start a meal, especially for people with weak digestions and feeble appetites.

Condiments (pepper, mustard, curry, &c.) also have the effect of stimulating gastric secretion, but they have the disadvantage that they tend to over-stimulate, especially if taken in excess. The danger is that the gastric juice loses its power of being secreted in the normal way when it is habitually stimulated by condiments.

Before we leave the subject of digestion, the fate of certain food-stuffs may be considered in more detail. First of all, let us take the substances which are absorbed by the body in their original state,

and undergo no process of digestion. Examples of this class are water, mineral salts, and a few carbon-containing compounds, for example alcohol and the simple sugars such as glucose. Organic compounds which are absorbed almost immediately have a special value as foodstuffs, though in the case of alcohol this value is lessened by its other well-known effects.

With the exception of the few substances that are absorbed unchanged, all foodstuffs are subjected to the process of digestion before being absorbed. Substances like cellulose that cannot be digested pass through the body unchanged. In ordinary conversation, when we say that a substance is 'indigestible' we do not mean that it cannot be digested, but merely that it will take a long time to be digested. Similarly when we say a food is highly digestible we mean that it is easily attacked by the necessary enzymes, and quickly transformed into substances that can be absorbed. The great disadvantage of 'indigestible' food is that it tends to remain so long in the alimentary canal that putrefactive bacteria begin to attack it.

We have already seen that the chemical nature of the foodstuff has a profound effect on its digestibility. Thus, fats are digested more slowly than other foods, and also delay the digestion of proteins. Hence fatty foods tend to be 'indigestible', especially if eaten with proteins. On the other hand, carbohydrates lessen the ill effects of fats by removing the injurious 'acetone bodies'. There is therefore good reason for eating potatoes or bread with fat meat.

Besides these chemical factors, the actual physical state of the food has a considerable influence on digestibility. Since fats, carbohydrates, and proteins are acted upon by different enzymes, the first task of the body is to separate out the constituents of the food eaten, in order to enable each enzyme to come into contact with the particular substance that it is able to attack. The consistency of some foods is such that this is a lengthy process, and in these cases digestion is correspondingly delayed. Thus the 'indigestibility' of very new bread is due to its dough-like consistency,

which makes the penetration of enzymes very slow. Similarly, hard-boiled eggs take a longer time to digest than those that are lightly boiled. Also, any food that is fried, or in other ways impregnated with fat, takes a long time to digest. Ordinary hard cheese is digested slowly owing to its firm consistency and its high fat content; but when cooked it takes much longer to digest, because the melted fat particles become very thoroughly mixed with the protein. Hence the well-known after-effects of toasted cheese for supper. The 'indigestibility' of rich pastry, plum puddings, &c., is chiefly due to the intimate way in which the fat is mixed with the other ingredients.

With reference to the question of acidity, it must be emphasized that the nutritive character of a food depends not on its original acid content, but on the acidic or basic nature of the substances formed as the result of digestion. Foods can thus be divided into acid-producers and base-producers; and the curious thing is that most foods which are acid in the original state actually yield a basic (alkaline) residue in the body. All fruits and vegetables come into this class. Even rhubarb, which is one of the most acid foods that we eat, yields a basic (alkaline) residue in the body. On the other hand lean meats, which are slightly alkaline in the natural state, leave an acid residue in the body. The more fat there is in meat, the less acidic will be the residue. Too much acid-forming food is harmful; it has to be neutralized and thus uses up the body's supply of bases, besides giving the kidneys extra work. Acid-producing foods should therefore be balanced as far as possible with base-producers.

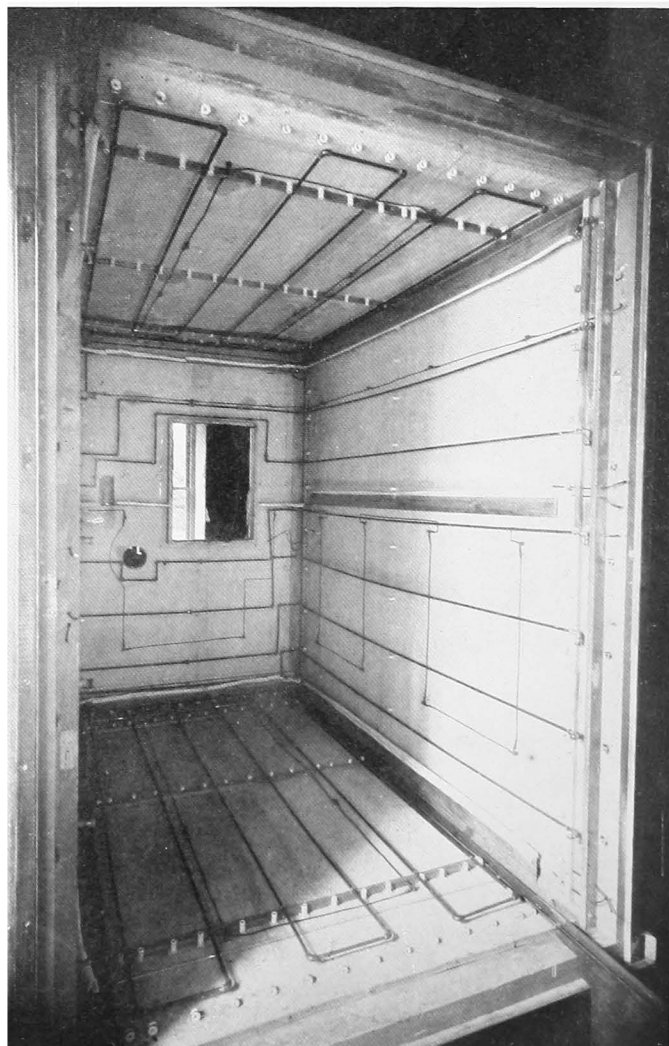


FIG. 1. Interior of large calorimeter

Food as Fuel

WE have seen that most of the food we eat is used as fuel to supply our bodies with energy and warmth. Even rapidly growing children need far more food for fuel than for growth. As might be expected, the more muscular work we do, the more fuel we require ; but our bodies when at rest still continue burning fuel in order to keep the body temperature at ' blood heat ', and to provide the energy for involuntary muscular movements, such as the beating of the heart. The amount of energy or heat thus expended when the body is at rest is remarkably constant for any one full-grown person. It can be measured in the following way. The subject is kept without food for some time, and then placed in a large calorimeter, which is a closed chamber with a special device for recording the amount of heat produced (see Fig. 1). It must be explained that, just as length is measured by inches, &c., and weight by ounces, &c., heat is measured by calories (from the Latin *calor* = ' heat '). One calorie (more correctly called a great calorie) is the amount of heat required to raise the temperature of a litre of water one degree centigrade.

Experiments carried out with the calorimeter have shown that a healthy young man when sleeping produces about 65 calories an hour, or, in other words, every hour that he sleeps his body burns an amount of fuel equivalent to 65 calories. If he remains at rest, but assumes a sitting position, he burns 100 calories an hour, that is 35 calories more than when lying down. This striking result explains why it is an advantage for patients in periods of great bodily weakness to lie down. There may be reasons against their doing so, for example if there is lung trouble, and there may be other advantages in lying down, for instance the even warmth provided by bedclothes. But the main fact is clear enough: to lie down is to save energy. As might be expected, the calorie output

of the sitting position is much less than that during exercise. Our healthy young man burns 170 calories an hour when doing light muscular exercise such as walking, and if his muscular work is considerably increased, he may burn anything up to about 600 calories an hour.

From these figures we can get a rough idea of how many calories an average man with a sedentary occupation requires a day. Let us suppose that he sleeps for 8 hours ($8 \times 65 = 520$ calories), sits at rest for 8 hours ($8 \times 100 = 800$ calories), indulges in light exercise such as standing or walking for $5\frac{1}{2}$ hours ($5.5 \times 170 = 935$ calories), and in somewhat heavier exercise for $2\frac{1}{2}$ hours ($2.5 \times 290 = 725$ calories), then his total requirement for the day is about 3,000 calories. This value is accepted by most physiologists as being the calorie requirement of a normal man of average weight (11 stone), with a sedentary occupation. In colder climates, of course, more calories are required, and as many as 7,000 are needed on Arctic expeditions. On the other hand, in hot countries a man requires only about 2,500 calories, and this figure is generally given for the people of the United States, probably because their climate is hot in summer, and in winter their houses are kept at a summer heat.

If we take 3,000 calories a day as the requirement for professional men, clerks, &c., we must take a higher value for men who lead more active lives. Curiously enough, women require less calories than men of the same weight who do the same amount of work. The value for women is obtained by multiplying by the factor 0.83. The requirement of children varies with age and sex. On the other hand, in old age the bodily activities diminish, and less calories are needed.

Since more calories are burnt during muscular exercise, it is clear that more food is required to serve as fuel. If we know the amount of work to be done, we can calculate the extra amount of energy that must be supplied as food. If no food is eaten, the body reserves of glycogen and fat are used as fuel. When these stores are

almost exhausted, if starvation is continued, the actual body-tissues are drawn upon to supply protein for fuel. Naturally this final stage has very serious effects on the body, and death soon follows. From this we see that fasting should not be kept up for long periods or health will be impaired. A moderate amount of fasting does little or no harm, and is definitely a good thing for the obese as it is a sound way of getting rid of surplus body fat.

Having determined the amount of energy that must be supplied as food in order to protect the body-tissues from the ravages of starvation and to compensate for the amount of muscular exercise taken, we must now obtain a measure of the energy value of the various foodstuffs. This can be done as follows. A man in a calorimeter eats a definite amount of a particular substance, and the additional amount of heat produced as the result of the food is measured. However, this is a laborious proceeding and fortunately the energy value of foods can also be ascertained in a much simpler way; for it has been found that when a fat or a carbohydrate is burnt in oxygen (that is, completely oxidized) in the laboratory, the same amount of heat is given off as when it is burnt in the human body. The apparatus used for this laboratory oxidation is a small calorimeter which is known as the bomb calorimeter, because the oxidation takes place inside a thick-walled vessel which in some ways resembles a bomb. In investigating proteins, the energy value obtained by the use of the bomb calorimeter is slightly greater than when the human calorimeter is used, because in the human body the oxidation of proteins is not carried quite to completion. Allowance has therefore to be made for this slight error.

The following energy values have been worked out by physiologists for the three chief types of food :

Protein . . .	1859·8 calories per lb. (4·1 cal. per gramme). ¹
Carbohydrate . . .	1859·8 calories per lb (4·1 cal. per gramme).
Fat . . .	4218·5 calories per lb. (9·3 cal. per gramme).

¹ 1 oz. = 28·36 grammes; 1 lb. = 453·6 grammes.

This means that every pound of carbohydrate or protein that is eaten yields an amount of energy equivalent to 1,860 calories. A similar weight of fat yields more than double this amount of energy, so that fat is the most efficient material for body fuel.

Hardly any of our foods consist entirely of either protein, carbohydrate, or fat, but we can easily work out the calorific value

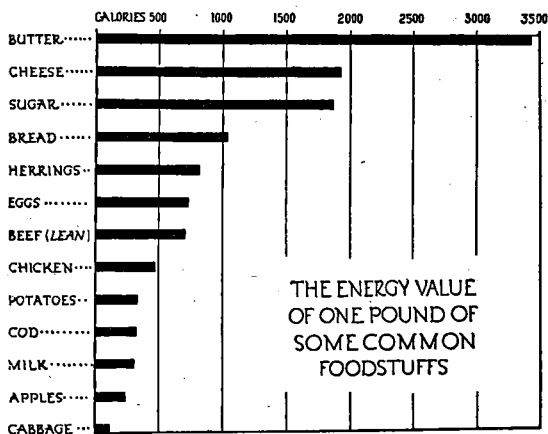


FIG. 2. Diagram illustrating the energy value of one pound of some common foods (edible portion only).

of a foodstuff if we know its chemical composition. For instance, let us calculate the fuel-value of a pound of salmon. The edible portion contains 18.6 per cent. of protein and 15.8 per cent. of fat; the ash and water can be neglected because they supply no energy. The calorific value of a pound of salmon (edible portion only) is

$$\left(\frac{18.6}{100} \times 1859.8\right) + \left(\frac{15.8}{100} \times 4218.5\right) \text{ calories,}$$

which works out at 1,012 calories. Even this simple calculation is unnecessary, because the calorific values per pound of a large

number of foodstuffs have already been worked out. The values given in this book have been taken from Professor Plimmer's analyses, because he worked with English foodstuffs. Tables of energy values of the edible portion of some common foodstuffs are given on pages 89-93. We have seen that fat yields more calories per pound than either protein or carbohydrate. For this reason the fat of meat yields more calories than the lean. Thus, bacon fat yields over 3,000 calories per pound, whereas the lean portion of bacon yields only about 650 calories per pound. Lard and dripping yield over 4,000 calories per pound. Most lean meat yields about 500 to 900 calories per pound. Lean fish gives only 300 to 400 calories, but fat fish gives more than double this amount. Cheese has a calorific value (per pound) of about 2,000, eggs 700, and milk 300 (N.B. there are about 8 eggs in a pound; a pound of milk is slightly more than three-quarters of a pint). The calorific value per pound of fresh fruit and vegetables is comparatively low (apples about 200, bananas 500, cabbages 100, potatoes 400), but dried fruits yield about 1,000 calories per pound, and dried peas and beans about 1,500. Cereals yield about 1,500 and sugar 1,800 calories per pound (see Fig. 2).

It is very interesting to compare the number of calories of different foodstuffs that can be obtained for one shilling. A number of these values are given in the following table. The prices (except for carrots and turnips) have been taken from the (June 1927) catalogue of a well-known London store. The cheapest quality of each commodity has nearly always been selected, because the relative cost of calories is only of vital importance to people who have not much money. A few more expensive foods have been added for comparison. For the calculations of the number of calories in one shilling's worth of various foods, the energy values given in the tables on pages 89-93 have not always been used because they are the results of analyses of the edible portion only. Where cost is concerned an allowance must be made for waste, as this is considerable in the case of meat, fish, fruit, vegetables, and nuts. In

the following table, the values in the last column refer (as far as possible) to a pound of the foodstuff as it is bought, including waste.

<i>Calories for 1s.</i>	<i>Foodstuff.</i>	<i>Price per lb., &c.</i>	<i>Calories per lb. of food as bought.</i>
9,057	Oatmeal	2½d. per lb.	1,886.1
8,278	Haricot beans	2½d. "	1,551.8
8,092	White flour	2½d. "	1,685.6
7,872	Rice	2½d. "	1,639.8
6,096	Margarine	7d. "	3,556.2
5,953	Sugar	3½d. "	1,859.8
5,310	Semolina	3½d. "	1,658.8
5,279	Beef suet	9d. "	3,958.1
5,061	Lard	10d. "	4,218.5
4,953	White bread	2½d. "	1,032.4
4,945	Cornflour	4d. "	1,648.4
4,780	Brown bread	2½d. "	995.6
4,632	Lentils	4d. "	1,544.0
4,620	Sago	4½d. "	1,635.7
4,366	Tapioca	4½d. "	1,637.5
3,963	Macaroni	5d. "	1,650.6
3,705	Dried peas	4½d. "	1,466.5
3,157	Old potatoes	1½d. "	394.6
3,017	Dates	4½d. "	1,131.3
2,682	Brazil nuts	8d. "	1,788.1
2,660	Dried figs	5d. "	1,109.0
2,235	Treacle	6d. "	1,117.7
2,065	Butter	1/8d. "	3,442.4
2,048	Marmalade	7½d. "	1,280.4
2,000	New potatoes	2½d. "	415.9
1,958	Plum jam	8d. "	1,305.5
1,941	Sirloin of beef	10d. "	1,618.4
1,788	Raisins	8d. "	1,191.6
1,652	Streaky bacon	1/6d. "	2,478.0
1,651	Currants	6d. "	825.6
1,562	Milk (1 lb. = 0.776 pint)	3d. per pint	303.0
1,454	Cheddar cheese	1/4d. per lb.	1,939.1
1,375	Onions (English)	2d. "	229.1
1,374	Fresh herring (Yearling)	6d. "	686.8
1,357	Carrots	1½d. "	169.6
1,286	Leg of Mutton	1/2d. "	1,501.0

Calories for 1s.	Foodstuff.	Price per lb., &c.	Calories per lb. of food as bought.
1,182	Loin of Mutton	2/2d. per lb.	2,562.4
1,147	Honey	1/1½d. "	1,290.0
1,108	Cocoa	2/- "	2,214.5
1,095	Kipper	8d. "	730.3
1,077	Loin of pork	1/6d. "	1,615.7
1,030	Mackerel	6d. "	514.8
952	Ham	2/- "	1904.7
910	Cabbage	1½d. "	113.8
896	Turnips	1½d. "	112.0
752	Rump-steak	2/8d. "	2,006.3
566	Rabbit (whole)	9d. "	424.6
565	Eggs (8 in a lb.)	1¾d. each	659.1
508	Cod (section)	7d. per lb.	296.2
392	Apples	6d. "	195.9
366	Plaice	1/- "	366.5
242	Salmon (section)	3/6d. "	847.3
207	Spinach	5d. "	86.2
174	Grapes	1/6d. "	260.8
172	Halibut	1/8d. "	286.7
166	Chicken (whole bird)	2/2d. "	359.7
151	Tomatoes	8d. "	100.7

From the point of view of calorific value, oatmeal, haricot beans, rice, and flour are the cheapest of the foodstuffs mentioned here (see Fig. 3). Other cheap sources of calories are sugar, cereals, bread, cheap fats, dried peas and lentils, and some dried fruits. Butter is moderately cheap, but milk and cheese are slightly dearer. Fresh fruit and vegetables, eggs, and most kinds of meat and fish are more expensive as regards the number of calories, but these foods are important for other purposes. Thus fish, meat, and eggs are valuable sources of animal protein, and fresh fruit and vegetables have a special value that is mentioned more fully in Chapters 4 and 5.

The next point to be settled is the proportion of fats, carbohydrates, and proteins that should be included in our diet. First of all let us fix the daily ration of proteins, because these substances

are necessary for growth and tissue repairs, and cannot be replaced by fat or carbohydrate. Since proteins are not particularly easy to digest, and are also the most expensive item in our food budget, it is important that we should not have them in great excess. The value usually adopted in this country is 100 grammes (just over

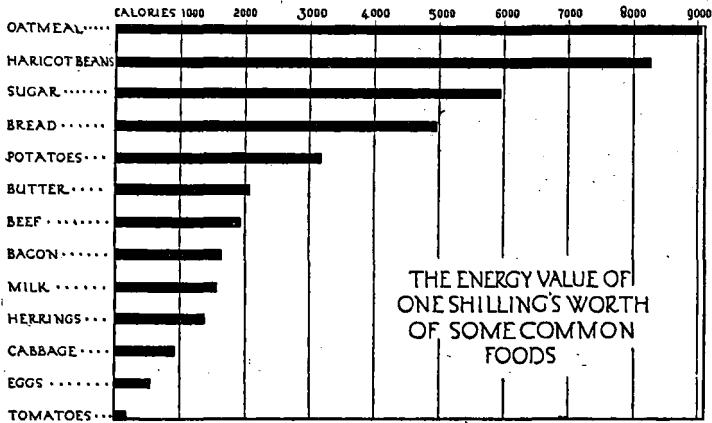


FIG. 3. Diagram illustrating the energy value of one shilling's worth of some common foods.

$3\frac{1}{2}$ oz.) for a 3,000 calorie diet. It may be mentioned that the question of minimum protein requirement was for many years a favourite battlefield for physiologists. Earlier workers advocated a daily ration of about 120 grammes. Then a number of investigators in America and Europe carried out experiments in which healthy adults appeared to flourish on diets containing only 40 grammes or even less. However, even if a low protein diet may seem to have no ill effects, it is certainly better to be on the safe side and fix the daily ration at 100 grammes (just over $3\frac{1}{2}$ oz.). According to Professor Mottram at least 30 per cent. of the protein ration should be of animal origin. Many physiologists consider that adults who require diets of lower calorific value should not

decrease the protein proportionately. Thus if a woman's diet yields 2,490 calories, she should probably have not 83 but about 95 grammes ($3\frac{1}{2}$ oz.) of protein. As might be expected, growing children require relatively more protein than adults.

Since every gramme of protein yields 4.1 calories, 100 grammes will yield 410 calories, and there remain 2,590 of our 3,000 calories to be supplied as carbohydrates and fats. Fats are physiologically the most efficient type of body fuel as they yield 9.3 calories per gramme; but they are difficult to digest and expensive, whereas carbohydrates are easy to digest and cheap. Both fats and carbohydrates are used mainly as fuel, and they are to some extent mutually replaceable. The exact proportion of one to the other is a matter for individuals to settle for themselves. People who have difficulty in digesting fat should of course avoid it, and eat carbohydrates instead. Many people find that the following way of proportioning the fat, carbohydrate, and protein is satisfactory:

Fat, 100 grammes (about $3\frac{1}{2}$ oz.)	930	calories
Carbohydrate, 400 grammes (about 14 oz.)	1,640	"
Protein, 100 grammes (about $3\frac{1}{2}$ oz.)	410	"
Total	2,980	"

At first sight these suggested rations appear to be ridiculously small. Are we really to be allowed only $3\frac{1}{2}$ oz. of fat and protein and 14 oz. of carbohydrate? It sounds almost as if we shall have to cut out all our meals except breakfast. But we shall be reassured when we realize that $3\frac{1}{2}$ oz. of protein means much more than $3\frac{1}{2}$ oz. of a protein-containing foodstuff, because of the high water content of most foods. Take for instance rump-steak. The edible portion contains 69.2 per cent. of water, and only 21.9 per cent. of protein, so that in order to obtain our $3\frac{1}{2}$ oz. of protein we should have to eat a pound of rump-steak.

In the same way the weight of food necessary to supply our daily ration of animal protein (30 grammes, or slightly over 1 oz.) varies according to the foodstuff chosen. For instance, there is

30 grammes of animal protein in 4 oz. of Cheddar cheese, in 7 oz. of cod (section), and in 10 oz. of ham. The approximate cost of the daily ration of animal protein is shown in the following table:

<i>Approximate cost of daily ration (30 gr.) of animal protein.</i>	<i>Foodstuff.</i>	<i>Approximate weight (to nearest half ounce) which gives 30 gr. of animal protein.</i>	<i>Percentage of protein.</i>	<i>Price per lb., &c.</i>
3 <i>d.</i>	Cod (section) . . .	7 oz.	15·7	7 <i>d.</i> per lb.
3½ <i>d.</i>	Herring (Yearling)	9 oz.	12·1	6 <i>d.</i> "
3¾ <i>d.</i>	Mackerel . . .	9 oz.	11·8	6 <i>d.</i> "
4 <i>d.</i>	Sirloin of beef . . .	6½ oz.	16·57	10 <i>d.</i> "
4¾ <i>d.</i>	Cheddar cheese . . .	4 oz.	25·2	1/4 <i>d.</i> "
4¾ <i>d.</i>	Milk	2 lb. (slightly over 1½ pints)	3·3	3 <i>d.</i> per pint.
4¾ <i>d.</i>	Rabbit	8½ oz.	12·53	9 <i>d.</i> per lb.
5¾ <i>d.</i>	Leg of mutton . . .	6½ oz.	16·07	1/2 <i>d.</i> "
6¾ <i>d.</i>	Plaice	8 oz.	12·9	1/- "
8¾ <i>d.</i>	Eggs	9½ oz. (about 5 eggs)	11·1	1½ <i>d.</i> each
9¾ <i>d.</i>	Loin of pork . . .	8 oz.	12·94	1/6 <i>d.</i> per lb.
11¾ <i>d.</i>	Streaky bacon . . .	10 oz.	10·3	1/6 <i>d.</i> "
1/1¾ <i>d.</i>	Chicken	8½ oz.	12·49	2/2 <i>d.</i> "
1/3 <i>d.</i>	Ham	10 oz.	10·65	2/- "
1/5 <i>d.</i>	Salmon	6½ oz.	16·3	3/6 <i>d.</i> "

In this table, like that on pages 32 and 33, waste has been allowed for, and the results refer to foodstuffs as bought. The protein percentages were taken from Professor Plimmer's book. The general conclusion as regards cost of animal protein is that cod, herring, and mackerel are especially cheap. Cheese, even at 1*s.* 4*d.* a lb., is also very cheap, and imported cheese at 11*d.* a lb. would probably work out as being much cheaper. Milk and most kinds of meat and fish are rather more expensive sources of animal protein, and eggs, pork, chicken, and ham are dearer still. Salmon at 3*s.* 6*d.* a lb. has been given for purposes of comparison.

The Discovery of Vitamins

IF the general principle of the conservation of energy applies to the special case of the human body, then the number of calories taken into the body as food, minus the number of calories excreted as waste material, should equal the amount of heat (or energy) produced by the body. By means of ingenious laboratory experiments, physiologists have succeeded in proving that this is actually the case. Balance-sheets of the energy exchange of man have been worked out, and an immense amount of research has been done on the calorific value of foods, and the calorie requirement of man. Great emphasis has accordingly been laid on the energy value of foodstuffs, and at one time it seemed as though the whole problem of nutrition resolved itself into a decision as to the necessary number of calories and the proper balance of fat, carbohydrate, and protein.

It was left for Sir Frederick Gowland Hopkins (then Dr. Gowland Hopkins) to show that man cannot live by calories alone. The discovery which he made, the discovery of vitamins, marked an epoch in the history of the science of diet. He fed a series of rats on a diet of chemically pure fat, carbohydrate, and protein, and found that they soon ceased to grow, and even began to lose weight. Great care had been taken to ensure that the diet had the correct number of calories, a suitable proportion of fat, carbohydrate, and protein, and the necessary ration of water and mineral salts; and yet the rats rapidly declined. What was lacking? Hopkins had an inspiration. It occurred to him that natural foodstuffs might contain substances necessary for growth, but not present in the highly purified food given to the rats. He tested this possibility by feeding a second series of rats on an exactly similar purified diet, to which he added a trace of fresh

milk. The amount of milk was not enough to have any appreciable effect on the calorific value of the diet, but it had a very striking effect on growth, for this series of rats gained in weight

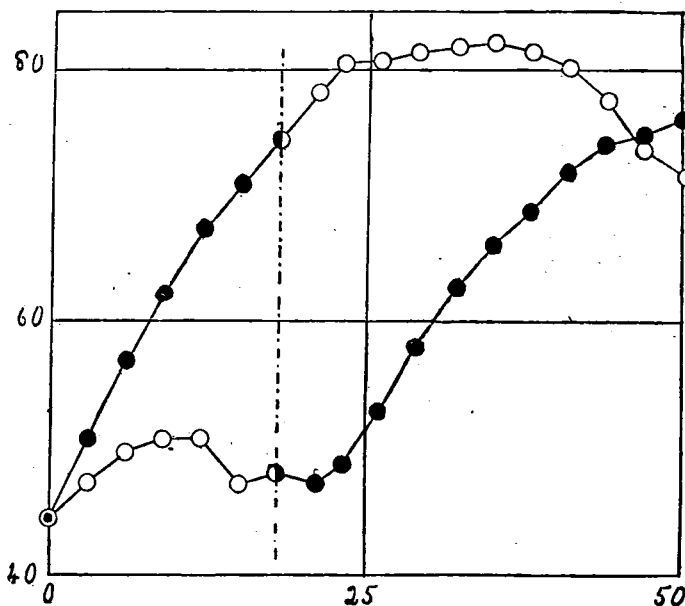


FIG. 4. Lower curve (up to 18th day), 8 male rats on pure dietary; upper curve, 8 similar rats on the same diet with added milk. On the 18th day (marked by vertical dotted line), the diets were reversed. Abscissae, time in days; ordinates, average weight in grammes.

steadily. In order to complete the proof of the value of the added milk, the diets were then reversed. The rats which had previously been losing weight on the purified diet were now given a trace of milk in addition to their former ration, and they at once began to gain in weight. The second series of rats, which originally had the added milk, were now given only the purified diet, with the result that they gradually lost weight. The results of this classical experi-

ment are given in Figure 4. The growth-promoting substances of milk must have been present in remarkably small amount, for the milk was still effective after the proteins and salts had been removed. The accessory factors were not obtained in a chemically pure state, but an active fraction associated with the milk fat was prepared. For some time it was thought that this factor was the only accessory substance necessary to supplement diets of purified fat, carbohydrate, and protein. American investigators then discovered that yeast contained an accessory factor which was not the same as that associated with the fat of milk. They suggested the name 'fat-soluble A' for the milk-fat factor, and 'water-soluble B' for the yeast factor. Water-soluble B was found also in milk, but not in such abundance as in yeast. Fat-soluble A proved to be present in butter, egg-yolk, cod-liver oil, and various other animal fats. Other accessory food factors, or vitamins as they are now called, have since been discovered in natural foodstuffs, and will be referred to later.

The most striking feature of the vitamins as a class is that, compared with the total daily ration of food, the amount of vitamin that we need is almost negligible; yet this small trace makes all the difference to our health. Sir Frederick Gowland Hopkins was the first to point out clearly that deficiencies in the supply of accessory food factors lead to actual disease. This conception is now so familiar that it is difficult to realize that, as recently as the period just before the War, it was a revolutionary doctrine. Disease had been so constantly associated with positive agents, such as bacteria, toxins, &c., that it was hard to convince people that the mere lack of something could lead to a definitely pathological condition.

For some time before Sir Frederick Gowland Hopkins published his critical experiments (1906 and 1912), it had been known that certain diseases were in some way connected with diet, but the exact nature of the connexion was not clear. The disease called beri-beri illustrates this point. Beri-beri is a serious disorder of

the nervous system which has, in the past, been prevalent among the rice-eating populations of Japan, the Malay Peninsula, the Dutch East Indies, &c. Dr. Eijkman, the medical officer of the prison at Java, had a number of cases of beri-beri under his care, and he noticed that the poultry of the establishment constantly developed nervous symptoms strangely reminiscent of those of his patients. The fact that the fowls, like the patients, were fed on polished rice suggested that the diet was responsible. Dr. Eijkman and other investigators found that beri-beri occurred if the diet consisted of polished rice, but not if the rice was in the crude unpolished state. During the process of milling rice the outer layers, 'rice-polishings', were removed; if these 'polishings' were added to the diet of polished rice, beri-beri was prevented. Similarly, beri-beri could be cured by feeding patients or fowls with the previously discarded 'polishings'. This admirable piece of research was not at first correctly interpreted. Dr. Eijkman thought that the rôle of the 'polishings' was probably to neutralize the deleterious effect of a diet too rich in starch, but more recent work has shown that the anti-beri-beri nature of the 'polishings' is in reality due to their vitamin content.

The anti-beri-beri, or anti-neuritic vitamin, was for some time considered to be identical with the growth-promoting water-soluble B of yeast, and both factors were included in the term vitamin B. More recent evidence, however, shows that these factors are not identical. The present suggestion is that the term vitamin B should be reserved for the growth-promoting factor, and that the other factor should be called the anti-neuritic vitamin. The distribution of vitamin B was worked out when the two factors were considered to be identical. At that time the chief sources of vitamin B were found to be unpolished rice and most other plant seeds such as wheat, peas, beans, &c., also birds' eggs, yeast, and many other natural foodstuffs. The actual distribution of the anti-neuritic factor in cereals is important. The largest amount is present in the germ (embryo); there is a certain amount in the

bran, which consists of the outer envelope (pericarp), together with the outer layer (aleurone cells) of the endosperm ; but the rest of

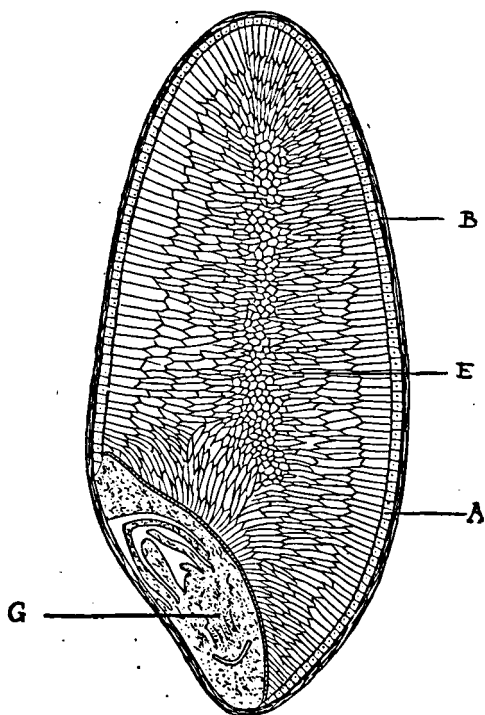


FIG. 5. Diagram of longitudinal section of grain of wheat, showing B the pericarp, A the aleurone layer, E the endosperm, and G the embryo.

the endosperm, which occupies a large portion of the grain, is deficient in the anti-neuritic factor (see Fig. 5).

People living on the usual European mixed diet are not likely to suffer from a deficiency of the anti-neuritic vitamin, but there have

been many cases of deficiency, and consequent outbreaks of beri-beri, when for some reason the diet has been restricted. An instance is afforded by the case of the Norwegian mercantile marine. Before 1894 beri-beri was very rare in Norwegian ships, for the food consisted chiefly of biscuit made from rye flour, in the milling of which there is no separation of the germ, so that the anti-neuritic vitamin remains in the flour. In 1894 there was a popular agitation in favour of lessening the hardships of a sailor's life, in response to which the rye biscuit was replaced by bread made from white wheaten flour, or from a mixture of white flour and rye flour. White wheaten flour, like polished rice, gives no protection against beri-beri, because wheat, like rice, loses its supply of the anti-neuritic vitamin during milling. Since none of the other foods contained a sufficiency of this vitamin, this alteration of diet led to frequent cases of beri-beri.

Scurvy is another disease which, like beri-beri, has long been attributed to a faulty diet. Seafaring folk have known for centuries that scurvy developed if fresh fruits and vegetables were absent from the diet for a long time, and until fairly recent times scurvy was the common dread of all sailors. Fresh fruit and vegetables were recommended as a cure. Bachstrom, who wrote in 1734 (as translated by Lind in his book called *A Treatise on the Scurvy*, published in 1753), says that 'recent vegetables are found alone effectual to preserve the body from this malady'. Lind also gives the following account of the conclusions of Kramer, chief surgeon with the Austrian Army in Hungary in 1720 :

'The scurvy is the most loathsome disease in nature ; for which no cure is to be found in your medicine-chest, no not in the best-furnished apothecary's shop. Pharmacy gives no relief, surgery as little. Beware of bleeding ; shun mercury as a poison : you may rub your gums, you may grease the rigid tendons in the ham, to little purpose. But if you can get green vegetables ; if you can prepare a sufficient quantity of the fresh noble antiscorbutic juices ; if you have oranges, lemons, or citrons ;

or their pulp and juice preserved with sugar in casks, so that you can make a lemonade, or rather give to the quantity of three or four ounces of their juice in whey, you will, without other assistance, cure this dreadful evil.'

Navigators constantly noted the special curative effect of oranges and lemons, and in 1804 a regular issue of lemon juice was made compulsory in the British Navy, after which scurvy became very rare, although previously thousands of cases had been reported annually.

Careful experiments, carried out at the Lister Institute and elsewhere, have established the fact that scurvy, like beri-beri, is a deficiency disease caused by the lack of an accessory food factor. Vitamin C, as the anti-scorbutic is called, is present in raw (but not usually in dried) fruit and vegetables, and to a much less extent in milk and meat. Tinned meat, however, offers no protection from scurvy. Oranges and lemons are especially rich in vitamin C, as are also tomatoes, and green leaves such as lettuce and cabbage. Unfortunately vitamin C is destroyed when heated in air (the destruction is due to oxidation), so that fruit and vegetables are not as effective when cooked as when raw. However, if the cooking process is short (20-30 minutes), some of the vitamin will escape unharmed; but if vegetables are allowed to simmer for two or three hours, the anti-scorbutic power is completely lost. Since the presence of alkali greatly increases this destructive action of heat, sodium carbonate should not be added when green vegetables are cooked. The loss of vitamin C in cooking was responsible for 82 cases of scurvy in a Scottish camp in the spring of 1917. Ample rations of swedes had been provided as an anti-scorbutic, but they had been cooked for 5 hours in a stew, and had thus lost the power of protecting against scurvy. The potato is not a rich source of vitamin C, but it is an important one in communities where it forms the staple foodstuff. Thus outbreaks of scurvy have been recorded after the failure of the potato crop, for example in Ireland in 1847, and in Norway in 1914. The onion is fairly rich in

vitamin C, and as it is cheap and easy to transport it is a useful anti-scorbutic.

The accessory factor originally called fat-soluble A has now been found to contain two separate components, which are known as vitamin A and vitamin D. Cod-liver oil is a very rich source of these vitamins, and they are also present in most animal fats, but absent from vegetable fats. Both A and D are necessary for growth, especially during the early years. Diets deficient in vitamin D give rise to the disease of rickets (see Chapter 5); if vitamin A is lacking growth ceases, and sometimes in the case of children an eye disease called xerophthalmia (keratomalacia) develops. Xerophthalmia is especially apt to occur in breast-fed infants whose mothers are not supplied with an adequate amount of vitamin A. For instance, in Denmark xerophthalmia increased greatly during the early part of the War, because the nursing mothers ate vegetable margarine instead of butter. During 1918 and 1919, however, butter was rationed in Denmark and was eaten by every one, with the result that fewer cases of xerophthalmia occurred (13 cases in 1918 and 1919 compared with 149 cases in 1916 and 1917).

Lack of vitamin A does not generally lead to any definite symptoms in adults, except that they appear to become more susceptible to bacterial infection. But there is a certain type of 'night-blindness' of adults which is probably caused by a deficiency of vitamin A. This 'night-blindness' was frequently found among Russian peasants before the War, especially in the period of religious fasting before Easter, when all animal foods were forbidden, including fish, eggs, butter, and milk. The fact that this disease, like the xerophthalmia of children, is rapidly cured by cod-liver oil, supports the belief that it is caused by lack of vitamin A.

In addition to A and D, another 'fat-soluble' vitamin has recently been described under the name of vitamin E. It is found in the embryo (germ) of many cereals such as wheat, and in the green leaves of plants, for example lettuce, and in lower concentrations in some vegetable oils. There is also a small amount in

animal tissues, milk-fat, and cod-liver oil. Without this vitamin, growth is apparently normal, but sterility ensues.

Recent work has thus led to the conclusion that there are at least six different vitamins, and it is highly probable that others will gradually be added to the list, either by the discovery of new factors, or by the separation of some of the present factors into two or more components. There is already a suggestion that vitamin E really contains two factors; one factor prevents sterility, and the other, which has been provisionally named vitamin F, has the property of promoting lactation. Some of the important points about vitamins are summarized in the following table:

<i>Name of vitamin.</i>	<i>Result of deficiency.</i>	<i>Principal sources.</i>
A.	Growth ceases. Children may develop xerophthalmia and adults 'night-blindness'.	Cod-liver oil, butter, egg-yolk, and most other animal fats.
B. Anti-neuritic (formerly included in the term vitamin B).	Growth ceases. Adults lose weight. Beri-beri.	} Yeast, plant seeds (especially the germ and the husk), birds' eggs.
C.	Scurvy.	
D. (irradiated ergosterol).	Rickets.	More or less the same as A. (See Chapter 5).
E.	Sterility.	The germ of cereals, and green leaves of plants.

A list of foodstuffs rich in vitamins is given on page 87.

It must be emphasized that, although vitamin deficiency must be fairly complete before such an acute condition as for example scurvy develops, there is no doubt that partial deficiencies are

responsible for ill-health of a vague but serious nature. We must therefore make sure that our diet is not deficient in any of these factors. Adults who live on a good mixed diet (including fresh fruit and vegetables) probably have an adequate supply of vitamins; but children may easily suffer from a deficiency, as more vitamins are necessary during the growth period. Lack of vitamins in early life is a serious matter; it has deleterious effects on the health that cannot be remedied even by eating ample supplies of vitamins in later years. The adults who are most in danger of suffering from vitamin deficiency are those whose diets are in some way restricted, as is often the case with soldiers, sailors, explorers, &c. Since lack of vitamins leads to illness and disease, it might be imagined that a superabundant supply would produce a race of supermen. Unfortunately, however, even the magical vitamins cannot accomplish so great a task; experiments have shown that there is no benefit gained by eating them in more than the necessary quantities.

Sir Frederick Gowland Hopkins's classical experiment showed that, in certain circumstances, the addition of milk to a purified diet could supply all the accessory factors necessary to maintain health. But it has since been found that there is great variation in the vitamin content of milk. For instance, in England summer milk contains more vitamins than winter milk. This observation led to an investigation of the origin of the vitamins in milk. Are they built up by the cow from simpler substances, or is the cow, like man, incapable of synthesizing vitamins, and dependent on a supply of vitamins in food? It was found that the vitamin A content of cow's milk depends on the food of the cow, being at a maximum when the cow is fed on fresh green food, and at a minimum when the cow has a winter feed of cereals and roots. The effect of sunlight is discussed in the next chapter.

There is good evidence that the ultimate source of vitamin A is to be found in the plant kingdom rather than in the animal kingdom. Thus, the origin of the vitamin A of cod-liver oil has

been traced back through a series of fishes, &c., to minute plant structures that live in the sea. The cod feeds on small fish and other marine animals. These eat copepods, amphipods, larval decapods, &c., which in their turn live on marine Algae such as diatoms. The concentration of vitamin A in the latter is very great, and it is highly probable that they synthesize vitamin A and thus originate the supply. Laboratory experiments have shown that one of these marine diatoms (*Nitzschia closterium*, see Fig. 6) can synthesize vitamin A when grown in sterilized sea-water.



FIG. 6. *Nitzschia closterium*, a marine diatom which is capable of synthesizing vitamin A when grown in sterilized sea-water. $\times 525$.

A great many attempts have been made to obtain vitamins in a chemically pure state, and to identify their chemical constitution. They are present in such relatively minute amounts in foodstuffs that the process of isolation is extremely tedious. In spite of this, great advances have been made, and probably in the near future the chemical structure of several vitamins will be known. Already the chemistry of the precursor of vitamin D has been worked out. The vitamins probably belong to several different classes of chemical compounds, but it is convenient to class them together on account of their physiological action. From the dietetic standpoint, since vitamins represent an almost negligible proportion of the total daily food ration, they must be considered as belonging to a category very different from that including fats, carbohydrates, and proteins.

The word 'vitamine' was first used by Dr. Funk for the anti-beri-beri factor, and was later extended to include the other accessory food factors, and the spelling was then altered from

'vitamine' to 'vitamin'. Although this name is not altogether satisfactory from the chemical point of view, it would be difficult to alter it now because it has become a household word.

5

Rickets

FEW people know how widely the disease called rickets prevails and how much havoc it causes. It is not merely a human disease : dogs and some other animals also suffer from it. It is not merely a modern disease : a distinguished pathologist remarked that his enjoyment of Italian art was completely spoilt because he so often recognized the symptoms of rickets in the babies painted by the great Florentine masters. But in modern times it is still widespread. Among the children of industrial towns it is appallingly prevalent, and causes greater damage than is generally known. Not only does it result in defective bone formation, which is responsible for the well-known symptoms of bent legs, &c., but also it leaves its mark on the teeth, which remain imperfect for life. An even more serious result is that it leads to a decreased power of resisting other diseases.

From time to time a great many different views have been held concerning the cause of rickets. In this country the views most commonly held were first that it was due to a faulty diet, and secondly that unhygienic conditions were responsible. The latter view gained considerable support from the results of an investigation carried out in Glasgow. The children who developed rickets lived in crowded, unwholesome surroundings, whereas the disease was not found where housing conditions were better.

Those who considered that rickets was due to a dietetic factor were not unanimous as to what particular substance in the diet

was concerned. Since calcium phosphate is a most important constituent of bone, the defective bone formation of rickets has frequently been attributed to lack of calcium in the food. But we now know that, although, of course, calcium is essential for proper bone formation, the lack of it does not produce the symptoms characteristic of rickets, nor does the addition of calcium (for example, as lime water) to the diet effect a cure. Other investigators thought that rickets was due to an excess of carbohydrate (cereals) in the diet, a view that is of special interest in connexion with recent results. Another suggestion, based chiefly on work with lion cubs carried out at the Zoo, was that rickets was due to a deficiency of fat.

As early as 1906 Sir Frederick Gowland Hopkins expressed the view that rickets, like scurvy, was due to a deficiency of what we now call a vitamin. This was confirmed by researches on rickets in puppies. Cod-liver oil or butter protected puppies from rickets and cured the disease if given in time. At first it was thought that the accessory food factor concerned with the prevention and cure of rickets was the same as the growth-promoting factor, fat-soluble A, but later work led to the conclusion that, although both factors frequently occur together in butter, cod-liver oil, &c., they are not identical. They are now differentiated as vitamin A (growth-promoting) and vitamin D (anti-rachitic). If plenty of food containing vitamin D was given to children, they did not develop rickets, and, in the case of children who had already become rickety, cod-liver oil (a rich source of vitamin D) proved to be an excellent cure.

For a time it seemed as though this was the whole explanation. But evidence was gradually accumulating that sunlight also played a part. It had been known for a considerable period that in England most cases of rickets developed in winter rather than in summer, and that rickets was unknown in the tropics. In 1919 it was found that rickety children could be cured by exposure to ultra-violet rays, produced by a special apparatus (a quartz mercury vapour

lamp). Shortly afterwards similar results were obtained with sunlight, which owes this action to its ultra-violet rays. This led to the extraordinary conclusion that the effect of ultra-violet light was more or less the same as the addition of vitamin D to the diet. Apparently rickets could either be cured by sunshine or by cod-liver oil. The inter-relation between these two factors was to some extent worked out. Less cod-liver oil was needed if sunlight was also available, but sunlight could not effect a complete cure in serious cases unless the diet contained a certain amount of vitamin D; on the other hand, vitamin D could prevent or cure rickets even in the absence of sunlight. The effect of sunlight was found to be of importance in connexion with the anti-rachitic power of cow's milk. Cows kept in open pasture supplied milk containing vitamin D, but this factor was absent from the milk of cows kept all day in stalls. Alteration of the diet of the cow made very little difference. It is therefore advisable that if possible children should be given milk from pasture-fed cows, so that they can obtain a plentiful supply of the vitamin which protects them from rickets. Sunlight loses its ultra-violet rays when it passes through ordinary glass, but special glass can be obtained through which the curative rays can pass. Windows made of this special glass are valuable for sick-rooms, hospitals, &c., but are not necessary for ordinary purposes. It is better for people who can do so to go out of doors to obtain their ultra-violet light, because in this way they have the added benefit of the fresh air. In warm weather infants should have their legs freely exposed to sunlight, but their eyes should be carefully protected.

It was difficult to explain the rôle of sunlight in rickets until it was discovered that certain foodstuffs, that did not originally contain the anti-rachitic factor, developed it after exposure to ultra-violet light. For instance, the anti-rachitic power of milk can be greatly increased by treatment with ultra-violet rays. Irradiated milk has actually been used as a cure for rickety children, but this is not a satisfactory proceeding, because irradiation makes milk

unpalatable and causes certain other undesirable chemical changes, such as the destruction of vitamin A. Thus, if irradiated milk forms the chief part of the diet, although the children will be protected from rickets they will suffer from the effects of lack of vitamin A. Vegetable oils are more suitable for irradiation than milk, for they are not made unpalatable by the ultra-violet light treatment.

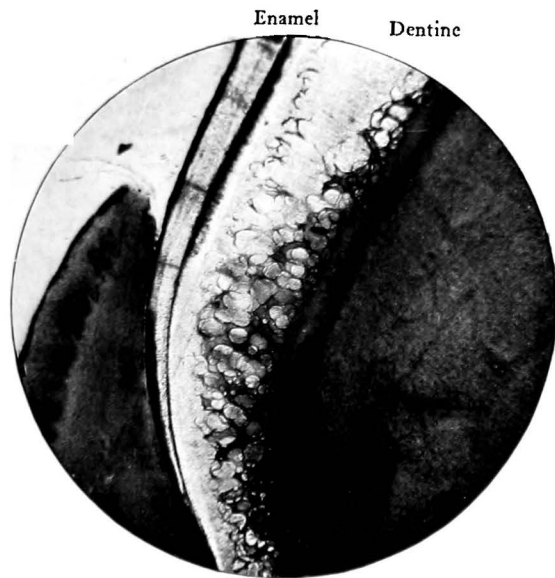
At one time it was thought that air itself developed anti-rachitic properties when it was irradiated. It appeared that rats could grow in perfect darkness if the air of the room had been previously exposed to sunlight, but not otherwise. Sometimes, however, the rats failed to grow even in the 'tonic air', and it was found that they only grew if the irradiated cages contained sawdust. It was the sawdust and not the air that acquired the curative properties. Experiments were then set up to find whether sawdust gave out some emanation that was responsible for the wonderful effect on growth, but, as scientists say, negative results were obtained. It was finally discovered that the rats were only benefited by the irradiated sawdust when they ate it!

The next problem was to find out what particular constituent of the sawdust, milk, &c., was changed by irradiation. It was found that the capacity for this remarkable change was constantly associated with the presence of a wax-like substance called cholesterol. It seemed as if vitamin D was simply irradiated cholesterol. Further research, however, showed that it was not cholesterol itself that became activated, but another substance, ergosterol, which was present in minute quantities in what was formerly thought to be pure cholesterol. The reason why this impurity had escaped the attention of chemists for so long is that it is only present to the extent of one part in two thousand. When ergosterol is irradiated it acquires the property of preventing or curing rickets, that is to say, it becomes vitamin D. It is highly probable that this new source of vitamin D will be used extensively because ergosterol can be prepared fairly cheaply from vegetable fats and yeast, and the

irradiated substance is free from the objectionable flavour of cod-liver oil. Irradiated ergosterol is amazingly active as an anti-rachitic ; less than half an ounce of the pure substance is enough to supply the daily ration of vitamin D for an average lifetime ; it is 1,000 times more active in curing rickets than any preparation that has been obtained before.

One of the many interesting points arising from this recent work on rickets is that it links up several previously conflicting views. The fact that housing conditions appeared to affect the incidence of rickets is now explained by the lack of sunshine in slum dwellings, especially tenement houses. The view that rickets was due to lack of fat can readily be understood, because a diet deficient in fat would almost certainly lack the anti-rachitic factor. The suggestion that excess of carbohydrates (cereals) was responsible for rickets has also been brought into line with recent theories, for it has been found that some cereals, notably oatmeal, contain an anti-vitamin which modifies the effect of vitamin D. Thus, if oatmeal is eaten, more vitamin D is needed to prevent rickets than if the oatmeal is replaced by wheat-flour or rice. Scotsmen will be relieved to hear that they need not banish porridge from the breakfast table, so long as they eat food containing vitamin D to counter-balance the anti-vitamin of oatmeal.

The work on puppies showed that lack of vitamin D invariably resulted in defective tooth formation (see Fig. 7). As it seemed probable that badly formed teeth would decay more readily than perfect ones, it was suggested that the diseased condition of many children's teeth might be due to imperfect tooth formation as a result of malnutrition. This suggestion was severely criticized by dentists who said that it was impossible, because only 3 per cent. of the deciduous teeth of children are badly formed, whereas 90 per cent. ultimately decay. Microscopic examination, however, showed that not 3 per cent. but 80 per cent. were badly formed. This result supports the view that teeth of normal structure are more resistant to disease than badly formed teeth.



(a) Section of tooth from puppy fed on diet deficient in Vitamin D

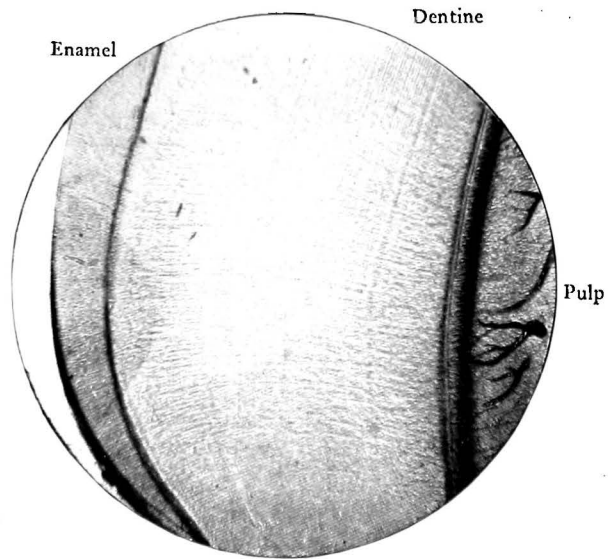


FIG. 7

(b) Section of normal tooth

Since it is highly probable that lack of vitamin D is the chief agent responsible for the malformation of teeth, the presence of an adequate supply of this vitamin becomes more important than ever. Children are most likely to lack this factor at the transition period between a complete milk diet and the ordinary mixed diet, and it has been found that the permanent teeth formed at this period are those that are most often badly formed. Even in adults a proper daily ration of vitamin D can improve defective teeth by making them more resistant to disease.

6

The Choice of Food

AFTER our survey of the principles of diet in general, we are now in a position to deal directly with a subject about which a good deal has already been said incidentally, or by way of illustration. We can consider the good and bad points of some ordinary food-stuffs and beverages.

Meat is a valuable source of animal protein, but is undoubtedly expensive. This difficulty can be overcome to some extent by choosing the cheaper cuts, which are just as nutritious as the more expensive. Another way of economizing is to buy frozen or chilled meat, the flavour of which is sometimes almost as good as that of fresh meat. As for digestibility, the white meats, especially the breast of chicken and game, are the most digestible of all meats, and pork the least so. The relative ease with which mutton and beef are digested appears to depend to some extent on individual idiosyncrasy.

All kinds of fish, like meat, supply animal protein, but here the cost per calorie varies with the fat content. Lean fish (e.g. cod, whiting, &c.) are expensive from the point of view of calorie value, but are highly digestible. Fat fish (e.g. herring, mackerel,

salmon, &c.) are slightly more difficult to digest, but in most cases cheaper; cod, herrings, and mackerel are about the cheapest possible source of animal protein.

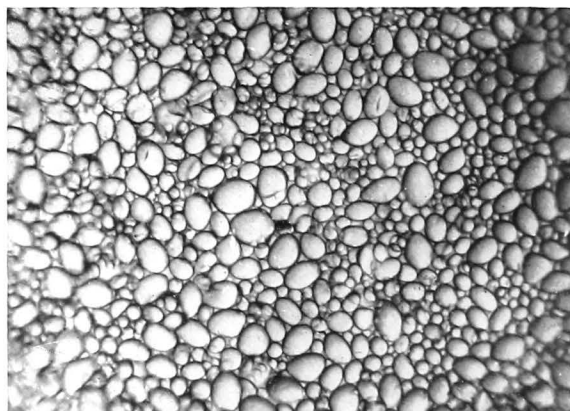
Eggs are an expensive source of animal protein, but they are an excellent source of vitamins A and B. Moreover, although the cost is high compared with the number of calories yielded, this is to some extent neutralized by the ease and cheapness of cooking.

Milk is a splendid food and deserves to be used much more freely. It is a fairly cheap source of animal protein, and also contains fat, carbohydrate, and salts. Summer milk is an admirable source of vitamins A, B, C, and D, but winter milk may be deficient in A and D.

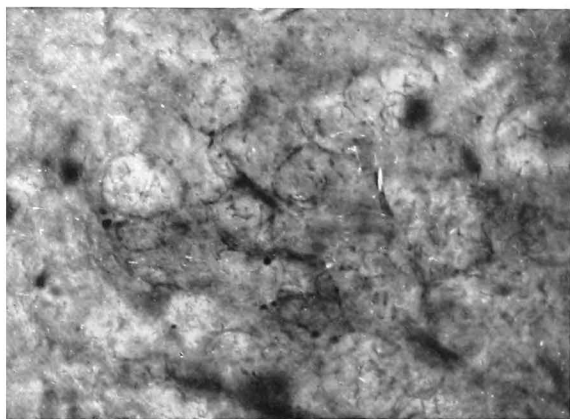
As might be expected, butter and cheese contain vitamins A and D only if they are made from milk that has these factors. Butter is moderately cheap as regards fuel value, and is generally considered to be the most easily digested of fats. Neither margarine nor lard forms an adequate substitute for butter in vitamin content, though margarines made from animal fats contain a certain amount of vitamin A. Cheese is a cheap source of animal protein, and also has a high fat content.

Fresh fruits and vegetables are very valuable foodstuffs because of their comparatively high vitamin content. They are also important as 'roughage', but their calorific value is very low, except for bananas, potatoes, peas, beans, &c. Dates, currants, and raisins, and dried peas and beans are a cheap source of calories, but their proteins are inferior to those of animal foods. All dried fruits and vegetables contain a good deal of 'roughage', but their vitamin content is not nearly as high as that of fresh fruits and vegetables. One of the great disadvantages of a vegetarian diet is that, in order to obtain enough calories, a huge bulk of food has to be eaten, and this causes a strain on the digestive system. Nuts have a high content of vitamin B, and their price is usually reasonable from the point of view of the number of calories yielded.

Sugar is cheap as regards calories, but contains no vitamins.



(a) Section of raw potato



(b) Section of cooked potato

FIG. 8

Honey is more expensive but has the advantage of containing vitamin B.

Cereals are a very cheap source of calories, and are rich in vitamin B when the husk and embryo have not been removed by milling. From the point of view of calorific value, all kinds of bread are a cheap food. The exact nutritive value of course depends on the type of flour used. White bread lacks vitamin B. It also contains less 'roughage' than brown bread, and is for this reason of special value to people who suffer from certain types of diarrhoea. On the other hand, brown bread is rich in 'roughage' and useful for the prevention of constipation. As a matter of fact 'brown bread' is a vague term that includes bread made from a good many different grades of flour. Thus brown bread may mean wholemeal bread, or it may simply mean that certain proportions of bran or germ have been added to the flour. Old-fashioned 'household' bread is made from so-called 'standard' flour, and is not brown but a slightly darker colour than white bread. It contains both the germ and the semolina, and is highly nutritious. Both standard flour and brown flour contain vitamin B.

Cooking is a branch of dietetics that should not be neglected. It usually increases the flavour of food and improves the keeping qualities by partial sterilization. With most animal foods it improves the appearance, but tends to lessen the digestibility because the proteins are coagulated by heat. This effect is less apparent with vegetables because they contain less protein. Generally speaking, vegetables are made more digestible by cooking, for the cellulose cell-walls are thus broken down. Moreover, all starch-containing foods are more digestible when cooked. Boiling ruptures the envelope of the minute starch grain, and causes the starch to form a jelly, and this jelly gradually expands and finally breaks the cell walls (see Fig. 8). Dry heat converts starch into somewhat simpler carbohydrates called dextrins. This change takes place to some extent in the making of toast. The special flavour of the crust of bread is also due to the presence of dextrins. When sugar

is heated it tends to be converted into caramel, and by this means the flavour is improved. In jam-making cane sugar is more or less converted into invert sugar (a mixture of glucose and fructose) which is highly digestible since it can be absorbed without change. The superiority of home-made jam is partly due to the fact that it is boiled for a longer time than bought jam, and thus contains more invert sugar and less cane sugar. One of the disadvantages of cooking natural foodstuffs is that it tends to destroy the vitamins. In green vegetables this effect is more serious when washing soda is added. The best way of preserving the vitamins from destruction is to boil the vegetables briskly for a short time without any washing soda.

Research work on vitamins has emphasized the importance of eating fresh foods, and undoubtedly we should find the choice of a diet a simpler and pleasanter task if we could dispense altogether with foods that have been preserved. But since this is difficult or impossible for the majority of people who live in industrial communities, it is important to appraise the various ways of preserving food.

The method that is least open to objection is cold storage. The great advantage of this process is that the food remains almost in its original state. No foreign matter is added, and such chemical changes as do take place are mainly the normal changes (e.g. ripening of fruit), the difference being that in the cold store they occur at a much slower rate. In some cases foodstuffs which have been in cold storage lose part of their flavour, but in other cases the stored food is almost indistinguishable from the fresh product. The calorific value is unchanged, and as far as is known at present cold storage under suitable conditions makes no appreciable difference to the vitamin content. It may be mentioned that cold stores are kept at various temperatures, according to the type of food stored. Fruits and vegetables are usually kept at temperatures above the freezing point of water, whereas meat and fish are sometimes frozen solid, the temperature used for storage being about 14° F. It is popularly supposed that 'chilled' beef has not been frozen,

but as a matter of fact it is kept at 29°-30° F., at which temperature it is slightly frozen, that is to say, a few ice crystals are present in the tissues.

Preservation by drying tends to destroy those vitamins which are readily oxidized, but otherwise it is satisfactory. Dried fruits and vegetables, chiefly pulse, are useful in a mixed diet for they are cheap and easy to cook. Dried meats and fish, which are often salted, smoked, &c., as well, are also convenient for many purposes because of their greatly reduced bulk.

The addition of preservatives to food cannot be recommended. The preservative itself is often a substance that is either undesirable or actually dangerous to health. Even if the preservative is quite harmless, it is better not to use it, because it will probably mask the effects of decomposition in the food without preventing them. In this way bad foods can be made to appear fit to eat. Food that is prepared in a clean and proper way needs no preservative.

In recent years more and more foods have been preserved by canning and bottling, and although in the past this process often led to the destruction of vitamins, it is probable that in the future manufacturers will be able to prevent this. Canned and bottled foods are generally very expensive, but a more serious disadvantage is that they are liable to cause outbreaks of food poisoning. Products that show any signs of deterioration should never be eaten. Unfortunately, however, the food may be seriously contaminated and yet look normal. This is sometimes the case with foods that contain preformed toxins, such as the toxin of botulism, or the toxins made by the *Salmonella* group of bacteria. In America outbreaks of botulism have been fairly common, but in this country there has only been one undoubted outbreak. It took place at Loch Maree in 1922; eight people (six guests from the hotel and two gillies) had sandwiches made from the contents of a glass jar of preserved 'wild-duck' paste; only eight people ate the paste, and they all died of botulism within a week. The majority of cases of food poisoning in Great Britain are caused by the *Salmonella* group

of bacilli. The foods that are most likely to become infected are those that are handled a good deal, as for example 'made-up' foods, sausages, &c. Canned and bottled foods are responsible for a large proportion of the total number of cases of food poisoning. It is possible to subject the bottles and cans to such a temperature that all the bacteria and spores are killed, but this process would greatly increase the expense, and would in some cases damage the foodstuff. Manufacturers will probably soon devise methods of procedure which will practically eliminate the danger of food poisoning. Home-canned and bottled foods are of course much more likely to be poisonous because of the difficulty of obtaining suitable conditions in an ordinary kitchen. On the other hand, home-made jam and marmalade are safe (except from mould growth which can easily be removed), because of the high sugar content and prolonged boiling.

The great popularity of tinned and bottled foods appears to be due to the fact that they require little or no preparation in the home. It is certainly quicker and simpler to open a tin of tongue than to buy a fresh tongue and cook it; and it is less trouble to pour mayonnaise sauce out of a bottle than to prepare it from the ingredients. At the same time foods that are properly prepared in the home taste much more delicious than those bought ready cooked. It is unfortunate that, owing to the difficulty of obtaining satisfactory domestic help, far less cooking is now done at home than was formerly the case. In the Midlands and the southern parts of England home-made cakes are becoming comparatively rare, and home-made bread is almost unknown. Jam, marmalade, mince-meat, &c., are frequently bought, although the home-made article is nearly always far superior. Jellies, custards, and even soups are constantly made from packet preparations. All this would not be so lamentable if we had some guarantee that the best ingredients were used for the foods that we buy more or less ready made, but at present we have nothing of the kind. In fact we suspect that custard powders contain no eggs, and that the contents of soup and

jelly packets bear little or no relation to the flavour mentioned on the label. Similarly the names given to potted foods do not appear to be intended to indicate the nature of the meat, fish, &c., used in the preparations. Housewives who wish to provide nutritious meals will do well to avoid all ready-cooked and packet foods of unknown constitution; instead of these they should buy plenty of fresh milk, cheese, butter, eggs, meat, fish, fruit, and vegetables.

The subject of beverages is best approached by a study of water, which is, after air, the cheapest and yet the most essential of foods. Without oxygen man cannot live for more than a few moments; if air is supplied, but both food and water are withheld, life cannot be prolonged for more than about 8 or 10 days. But with no food other than air and water human life can be maintained for a considerable time. There are apparently well authenticated records of people who have survived under these conditions for over 6 weeks. Professional fasters always drink water when fasting, and the famous Succi also took laudanum in considerable quantity to alleviate the pain in his stomach. He fasted several times for 30 days, during which time he was capable of considerable exertion, such as walking and riding, without ill effects. Dr. James, an American physician, once fasted for 40 days, and Merlotti in Paris for 50 days.

Water is essential for all forms of life. It is necessary in the human body for building up tissues, and for carrying out chemical and physiological processes. We obtain a good deal of water indirectly because most foodstuffs contain a high proportion of water, and beverages are often composed almost entirely of water. Milk contains 88 per cent. of water, fermented beverages contain 85-95 per cent., and even distilled alcoholic drinks are usually more than half water.

Drinks like home-made lemonade which are made from the juices of fresh fruits are excellent, because they are very refreshing and often serve as a source of vitamin C. Alcoholic drinks cannot be recommended without considerable reservation, because alcohol is a poison as well as a food, and, though there is some con-

troversy among scientists as to the limits of its harmlessness, it is not seriously denied that it very frequently has ill effects.

Another rather undesirable and very popular beverage is tea. Both tea and coffee owe their action as stimulants to the fact that they contain an alkaloid called caffeine, excess of which leads indirectly to disturbances of digestion. Tea has the additional disadvantage that if it has been left to 'draw' for more than a few minutes it contains an injurious amount of tannin. It was found with a certain sample of tea that the tannin increased as follows :

	<i>After 5 mins.</i>	<i>10 mins.</i>	<i>20 mins.</i>	<i>40 mins.</i>
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Tannin . . .	6.85	8.52	11.73	16.32

Practically all the caffeine and oil are extracted in five minutes, so that the proper way to make tea is to pour it off the leaves after five minutes. It should then be put in another warmed teapot, which should be covered with a tea-cosy. The amount of tea and coffee that can be drunk without injury to health is very much an individual matter, but there is no doubt that nervous people and dyspeptics should take these beverages sparingly.

The best of all beverages is undoubtedly milk, but unfortunately many people have a prejudice against it. It is said that the chemist van Helmont called it brute's food, and suggested as a substitute bread boiled in beer and honey.

7

Patent Foods

PATENT foods are often convenient to use in cases of illness, but they are never absolutely necessary, either in sickness or in health. There is always an ordinary foodstuff or home-made dish that will do just as well. The chief objection to patent foods is their high cost ; but there is another which is also serious, namely that there are a number of patent foods which are far from being what they

pretend to be. The extravagant claims made in the advertisements ought by themselves to be enough to make people suspicious. But the simple faith of the general public is astonishing. Many people attribute marvellous properties to certain patent foods, which are really quite ordinary foodstuffs, disguised by attractive trade names.

Amongst the most useful of the patent foods are the meat extracts. They are rather tiresome to prepare at home, and there are several good brands on the market. Sometimes the advertisements are decidedly misleading. For instance, it is occasionally stated that one pound of an extract contains the nutritive properties of many pounds of meat. This is quite untrue for, as we have already seen, meat extracts have practically no nutritive value at all. Their importance lies in the fact that they promote the flow of gastric juice, and thus facilitate digestion. Meat extracts are useful for dyspeptics and invalids who have no appetite.

Peptonized foods are also of value in the treatment of certain diseases, but they should not be taken by people who are capable of digesting the proteins of ordinary foodstuffs. In peptonized foods the complex proteins of milk, meat, eggs, wheat, &c., have been broken down, either partially or completely, into simpler proteins such as peptones and albumoses. Since this process is normally carried out in the body the continued use of peptonized foods probably tends to impair the digestive system of healthy people. When these foods are required they can be prepared at home with the aid of pancreatic extracts or peptonizing powders.

The malted foods are another class of patent foods that are to some extent predigested. Malt is rich in an enzyme called diastase, that is capable of converting starch into dextrins and maltose. Extracts of malt are prepared by concentrating infusions of malted barley, and they contain a considerable amount of diastase. Fresh infusions of malt have valuable anti-scorbutic properties, but extracts made for commercial purposes are generally deficient in vitamins (except of course when cod-liver oil is added). Malt

extracts are recommended as foods to assist in the digestion of starch by means of the diastase, and to serve as a source of easily digested carbohydrate. As regards the first point, it may be stated that, except for infants, the number of people who cannot digest starch is extremely small, and is limited to certain dyspeptics. As a source of carbohydrate, malt extracts and malted cereals can be recommended for people who have weak digestive powers. In malted foods the carbohydrate is in the form of dextrins and maltose, both of which are readily digested. There is some evidence that cane sugar, in fairly large quantities, acts as an irritant to the stomach, but maltose is free from this objection. It may, however, be pointed out in this connexion that malt extracts are in no way superior to honey, which contains about 70 per cent. of the highly digestible invert sugar (a mixture of glucose and fructose). The food value of some of the malted foods is increased by the addition of dried milk. For example, a well-known brand of malted milk contains 50 per cent. of desiccated milk, 26 per cent. of wheat-flour, and 23 per cent. of malt. Other nutritious malted foods contain eggs, marrow fat, &c.

Malt extracts, meat extracts, peptones, &c., are sometimes added to port or sherry for the preparation of so-called medicated wines. In other cases these foods contain drugs, such as cocaine. There is no special value in these preparations. If malt or meat extracts, &c., are required, it is cheaper to buy them separately.

Milk forms the basis of a great many patent foods. First there are the condensed milks, which are convenient substitutes when good fresh milk is not available. These and other foods that are used for infants are discussed in more detail in a later chapter. Some of the so-called 'tonic foods', 'nerve-foods', &c., are composed chiefly of casein, one of the proteins of milk. Now casein is a useful foodstuff, but it is unlikely that these dried preparations of casein are any better than fresh milk. Moreover, milk is cheaper, and contains several valuable constituents that are not present in the dried foods.

There are a number of patent foods that are advertised as special vitamin foods. There is absolutely no need to take vitamins in this form, so long as a variety of fresh natural foods can be obtained. If not, or if vitamins are required in a more concentrated state, A and D can be obtained by taking cod-liver oil. Children who dislike the flavour of the oil alone can generally be persuaded to take a mixture of malt extract and cod-liver oil. There is also on the market a substitute, which tastes rather like toffee, and contains A and D. Vitamin B can be obtained in a concentrated form in Marmite, a preparation of yeast which is free from the rather unpleasant fermentative properties of the patent foods that contain yeast in the living state. Vitamin C, the anti-scorbutic factor, is destroyed by oxidation, and is therefore more difficult to obtain in a concentrated form. The study of vitamin E is at present in a relatively less advanced position.

Patent breakfast foods are both palatable and easy to digest, but the unaltered cereal is always much cheaper, and has just as high a food value.

8

How to Arrange a Diet

IN arranging diets, the first thing to bear in mind is individual taste. For this reason those who are responsible for ordering meals for large numbers of people should see that there is plenty of variety, and that alternative dishes are served. There is no need to prove by scientific reasoning that it is foolish for people to eat food that disagrees with them. It is necessary to learn from experience what one can eat and what one cannot eat. There are rare cases of people who have curious idiosyncrasies with regard to certain special foodstuffs. For instance, there are people who suffer from serious digestive troubles and skin eruptions if they eat shellfish, In a similar way some people are susceptible to white of egg, others to milk and so on. These remarkable effects are possibly

due to a type of protein poisoning. If this is the case, the particular protein concerned appears to escape the usual process of digestion, and in some way gain access to the blood-stream. It is well known that foreign proteins can act as poisons when they are injected into the blood, and this is considered by some investigators to be the explanation of some of these rare idiosyncrasies of diet.

Not only is it unwise to eat food that you cannot digest, but it is also physiologically unsound to eat food that you dislike very much, because the proper secretion of the saliva and the gastric juice is to some extent dependent on pleasurable sensations. The Victorian idea that it was a virtue in children to eat food they did not like, and an offence against discipline to pull faces over it, was based on a false view of diet. At the same time appetite is not always a safe guide. The best way to plan a diet is to write out a list of meals that are agreeable, and then, if necessary, alter them until they conform to the physiological standard. If strict economy has to be practised, foods should be chosen which give a large number of calories for the money, and the animal protein ration should be supplied by means of herrings, cheese, &c. (see p. 36).

The most important physiological requirements are three in number. First, there must be an adequate supply of vitamins; secondly, the calorific value must be suitable; and thirdly, there must be enough protein, of which at least 30 per cent. should be animal protein. The proportion of fat and carbohydrate can usually be left to individual taste and capacity, but it must be remembered that fats are not easy to digest, and moreover they cannot be properly digested unless carbohydrates are also present.

Since the vitamins are all found in natural foodstuffs, the more fresh food we eat the more vitamins we are likely to obtain. It is fairly safe to say that a diet including fresh fruit, vegetables, butter, eggs, and meat will not be deficient in vitamins. Vitamins A, B, and C are all present in (summer) milk, tomatoes, oranges, spinach, lettuce, carrots, cabbages, &c. Foods especially rich in vitamin B are egg-yolk, germ of wheat flour, walnuts, celery, lettuce, tomatoes,

yeast, &c. Vitamin C is found in comparatively large amounts in fresh oranges, lemons, tomatoes (also tinned tomatoes), swedes, cabbages, &c., and vitamin A is abundant in cod-liver oil, (summer) butter, and egg-yolk (see p. 87). Vitamin D has more or less the same distribution as A, but its place can be taken to some extent by sunlight. We obtain vitamin E from milk, cod-liver oil, meat, green leaves such as lettuce, and foods that contain the germ of wheat and certain other cereals.

We now come to the question of calorie requirement. Healthy young men of 11 stone, who take a certain amount of exercise, need a diet that yields about 3,000 calories if their occupation is sedentary. If they are engaged in manual labour they should have food of higher calorific value. Thus University boat crews in training require 4,000 calories. Workmen such as painters and joiners, who do light manual work indoors, require 3,600 calories; furniture removers, gardeners, &c., require 4,500 calories; and miners, sawyers, &c., require about 5,000 calories. The calorific value of a woman's diet should be 83 per cent. of the corresponding values for men's diets. Thus a young woman of sedentary occupation requires 2,490 instead of 3,000 calories. As men and women grow older they require less calories than they did in early adult life.

The protein requirement for a 3,000 calorie diet is about 100 grammes (just over $3\frac{1}{2}$ oz.), but adults who have diets that yield less than 3,000 calories are not advised to decrease the protein quite in proportion. This applies especially to women. If a woman has a 2,500 calorie diet, she should probably have about 95 grammes ($3\frac{1}{2}$ oz.) of protein. The requirements of children are dealt with in the next chapter.

Having decided upon our calorie requirement and protein requirement, we can proceed to examine our proposed diet in order to see whether we are obtaining enough protein and the right number of calories. Let us take the case of a lady of sedentary occupation. We will suppose that her meals for one day are as follows :

Breakfast. Half a grape fruit ; poached egg on toast ; coffee with milk and sugar ; toast, butter, and marmalade.

Lunch. Cold ham and a roll, with salad (lettuce, tomato, and mayonnaise) ; banana.

Tea. Cucumber sandwiches ; chocolate cake ; tea with milk.

Dinner. Celery soup with brown bread ; roast lamb, peas and new potatoes ; strawberries with sugar and cream ; coffee with sugar.

The calorific value and the amount of protein are shown in the following table :

		<i>Weight of edible portion in ounces.</i>	<i>Calorific value.</i>	<i>Weight of protein in ounces.</i>
BREAKFAST	Grape fruit	3	23	0·018
	Egg	2	92	0·246
	Bread	2	129	0·132
	Butter	1	215	—
	Milk	8	152	0·264
	Sugar	0·25	29	—
	Marmalade	0·5	40	0·001
LUNCH	Lean ham	2	112	0·406
	Tomato	2	13	0·014
	Lettuce	1	4	0·011
	Mayonnaise	2	182	0·550
	Roll	2	129	0·132
	Banana	4	126	0·064
	TEA	Bread	1	65
Butter		0·5	108	—
Cucumber		0·5	2	0·003
Milk		2	38	0·066
Chocolate cake		2	206	0·124
DINNER	Celery soup	8	125	0·168
	Brown bread	1	62	0·075
	Leg of lamb (lean)	3	118	0·615
	Peas	4	90	0·204
	New potatoes	8	196	0·112
	Strawberries	4	52	0·028
	Sugar	1	116	—
	Cream	1	57	0·025
TOTAL			2,481	3·324 (94 grammes)

The calorific value (2,481) is highly suitable, and there is about the right amount of protein present (94 grammes). Since considerably more than 30 per cent. of the protein is from animal sources, there is no danger of a deficiency of any of the essential amino-acids. Also plenty of vitamin-containing foodstuffs are included. This diet may therefore be considered satisfactory from the physiological point of view, but the cost is unnecessarily great, and an equally satisfactory and much cheaper menu could easily be worked out. It must be emphasized that this diet is not intended to be a model one, but is given merely to show the way in which diets should be tested.

Two other points deserve consideration. One is the amount of water (including the water in tea, coffee, &c.) that should be drunk. In temperate regions the daily ration for an adult should probably be at least 3 or 4 pints, which is more than most people are in the habit of drinking. In tropical climates more water must be taken to compensate for that lost in perspiration. The question as to whether we should drink with meals or between meals can be answered best by saying that it is a fairly safe rule for healthy people to drink when they are thirsty. There is no reason why moderate amounts of liquid should not be taken with meals. Very large amounts of fluid might possibly tend to dilute the gastric juice too much, and thus delay digestion. On the other hand, if meals are too dry it may be difficult for the digestive enzymes to penetrate the food-mass.

The other point that should be mentioned is the acid- or base-forming nature of the food. We have seen that it is not advisable to eat a large excess of acid-forming foods. If possible acid-forming foods should be eaten together with base-formers. As a matter of fact, this is usually done in practice. We generally eat vegetables (base-formers) with meat (acid-former), milk (base-former) with cereals (acid-formers), and so on. All animal foods except milk are acid-formers, especially oysters and certain fish, for example cod; next in acid-producing power come fowls, eggs, and lean beef, while

lamb, mutton, and goose are examples of less acid-forming meat foods. Cereals are also acid-formers, but not of the same order as meats. Rice is somewhat less acid-forming than wheat. All fruits and vegetables are base-formers, spinach being the most effective. Other vegetables and fruits of high base-forming value are beet-roots, cabbages, carrots, cucumbers, dried figs, lettuces, onions, parsnips, pineapples, rhubarb, and tomatoes. Milk has a base-forming value slightly less than the acid-forming value of cereals. Nuts are almost neutral in their final reaction.

It must be admitted that many young people can cope with a diet which does not by any means conform to the physiological standard. But even if there are no apparent ill effects, there may be a subtle undermining of the health. It is well known that diseases caused by errors of diet are difficult to detect in the early stages. With advancing age people become more liable to suffer from the effects of faulty diets. For instance, young people can deal with an excess of food more successfully than old people. There are, it is true, some old people who have remarkable powers of digestion. They can eat all kinds of unsuitable food and yet remain in good health. But these are exceptional cases. Generally speaking, the powers of digestion diminish with increasing age.

There is not much scientific work that helps us to decide how many meals to have in the day. The usual practice of having three or four meals seems to be free from objection, but it is probably not generally advisable to have more than four meals a day. There is no doubt that it is better to take nourishment at certain definite mealtimes rather than to keep taking snacks at irregular intervals. Eating between meals is certainly a very bad habit. On the other hand there is no harm in drinking water between meals.

The question arises as to what we mean by a meal. During the hearing of a recent lawsuit it was stated that the plaintiff had refused food, but had drunk a cup of tea. 'May not a reasonable man think that a cup of tea is not food?' asked the judge. 'Not

a medical man, my lord,' said the witness. 'I said a reasonable man,' the judge replied (see *The Times*, Law Reports, 1 April 1927 : *De Freville v. Dill*). Probably the witness was right in considering the cup of tea as food, not because there is any appreciable nutritive value in tea itself, but because most people add milk and sugar to tea, and both milk and sugar are highly nourishing foods. A cup of tea that contains neither milk nor sugar can hardly be regarded as a meal, even by the unreasonable.

The times of meals must to a large extent depend on individual occupations, but in any case there are one or two practices that should on the whole be avoided. For instance, it is unwise to do much muscular work in the morning before taking food. A light meal, such as a glass of milk and a piece of bread and butter, should if possible be taken before early morning walks, &c. People who are not strong should not attempt to work or take exercise before breakfast. Another bad habit is to have a very late evening meal. The wisest plan is to have the last meal at least two hours before going to bed.

9

Diets for Mothers and Children

ALL authorities agree that the diet of an expectant mother has a profound influence on the development of the child. It is therefore necessary to decide what constitutes the proper diet for such a case. Physiologists generally recommend that more protein should be taken, but that the calorific value of the diet should not be greatly increased. An extra supply of vitamins should certainly be eaten, as they are of such special importance for growth purposes during the early years of life. An expectant mother who is accustomed to good, simple food that fulfils the physiological requirements (see Chapter 8) will not need to make much alteration in her diet ; but those who are in the habit of eating 'indigestible'

foods, such as fried foods, rich pastry, and puddings and cakes, &c., should try to get used to plainer food. With a little ingenuity, simple food can be made extremely agreeable to the taste. It is most important that an expectant mother should keep her digestive system in good working order. Constipation should be dealt with at once by taking more foods that contain roughage. Before the birth of the child the calorific value of the mother's diet should be worked out for subsequent use.

According to Professor Mottram, the 'morning sickness' that so often makes its appearance at this time can be cured by eating less fat and more carbohydrate. He explains the sickness as follows. During pregnancy sugar is used for special purposes, thus less sugar is available for assisting in the oxidation of fats. As we have already seen, the incomplete oxidation of fats leads to biliousness. This can be prevented by eating more carbohydrates. Professor Mottram states that, if his method were adopted, 75 per cent. of the cases of 'morning sickness' would be eliminated and the remaining 25 per cent. would be greatly benefited. It is rather difficult to plan a diet that is poor in fat. Those who wish to try Professor Mottram's method may find the following suggestions helpful :

Early morning cup of tea with skimmed milk, and sugar if desired.

Breakfast. Cereal with banana, plenty of sugar, and a little skimmed milk.

Toast, lean fish, and marmalade or honey. Tea with lemon and sugar.

Lunch. Lean meat with vegetables. Fresh or stewed fruit with sugar.

Tea. Bread with a trace of butter and plenty of jam. Malt extract with cod-liver oil (for vitamin). Tea with lemon and sugar.

Dinner. Clear soup with bread. Chicken (or rabbit, hare, veal, or lean meat) and several vegetables. Jelly. Fruit.

When sickness threatens, a diet such as this may be adopted for a short time, the normal diet being substituted as soon as possible.

After the birth of the child, the mother's diet should continue to be simple and wholesome. More food must be eaten to allow for the formation of mother's milk. In order to fix the extra ration, it is useful to have a rough idea of the calorific value of a day's

supply of mother's milk. This value of course varies with the age of the child. As the nursing period progresses the infant requires more food. Roughly speaking, an infant under the age of six months requires about 50 calories per pound of body-weight. According to Dr. Pritchard, the quantities of breast milk required by the average infant are approximately as follows :

	oz.
1st week	0·5-9
2nd „	9-14
3rd „	14-18
4th „	18-22
2nd month	22-5
3rd „	25-8
4th „	28-30
5th „	30-2
6th „	32-4
7th „	34-5
8th „	35-7
	(or 34-5 plus a supplementary ration)
9th „	37-9
	(or 35-6 plus a supplementary ration).

The calorific value of milk is about 20 calories an ounce. Thus, an infant of two months should have an amount of milk (25 oz.) that yields about 500 calories a day. The mother's ration should be increased by considerably more than this amount, in order to allow for the work done in producing the milk. At present we have no data that helps us to fix this extra allowance; let us suppose that the effort of producing the milk costs the mother 250 calories. When her baby is two months old the nursing mother should then have a total extra ration of 750 calories. This represents quite a substantial amount of food. It means a daily addition of food that has the calorific value of a pound of lean beef or eight eggs. A good proportion of this extra food should be protein, because the act of nursing undoubtedly increases the wear and tear of tissues. The extra food should be taken in a digestible and

appetizing form, and the daily ration of water or other beverages should be increased.

At present we know very little about the effect that any particular substance in the mother's food has on her milk. It is quite certain, however, that if the mother has a very poor diet, her milk will not be nutritious, and her own health will be impaired. Moreover, if a mother does not obtain a good supply of vitamins her milk will be deficient in these factors, and the baby will suffer. An adequate supply of fat, carbohydrate, and protein, including animal protein, water, salts, and vitamins, is necessary for the health of both mother and child. There is a possibility that proteins stimulate milk production, but beyond this we have practically no evidence that any particular foodstuff has any special value for this purpose. There appears to be no scientific basis for the popular notion that if the mother eats fruit, especially oranges and lemons, her milk will give the baby indigestion.

If at any time the mother's milk begins to fail, she should make a great effort to increase the supply. More plain food should be eaten. Another excellent plan is based on physiological principles. The process of sucking acts as a stimulus to milk production. If the baby is allowed to have both breasts at each meal, instead of only one, the extra stimulation soon leads to an increase in the amount of milk secreted. This is a very simple and effective way of maintaining the supply. There is no doubt that nowadays more mothers are unable to feed their babies than was the case about thirty years ago, although the modern mother is certainly not less physically fit than the mother of that time. What is the cause of this unhappy state of affairs? Many authorities connect it with the rise of modern civilization. Dr. Ralph Vincent wrote: 'The increasing inability of women to nurse their infants, due undoubtedly to the effect of high civilization, is widespread and calls for adequate recognition.'

The suggestion here put forward is that two factors are to some extent responsible for the decrease in the number of mothers who

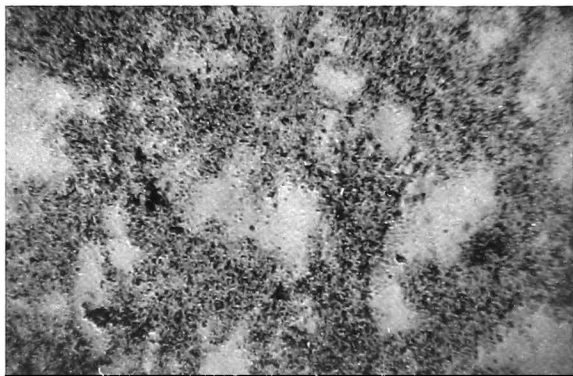
are able to feed their babies. The first factor concerns the diet of the mother, and the second factor concerns the length of interval between the baby's meals. Thirty years ago nursing mothers generally ate large quantities of extra food. Nowadays most educated middle-class women tend, on all occasions, to under-eat rather than to over-eat; and when they have babies they do not sufficiently increase their already too scanty ration. With regard to the intervals between the baby's meals, customs have also changed considerably. Thirty years ago babies were usually fed every 2 hours during the daytime, and once or twice at night. In 24 hours they had about ten meals. Now, most well-cared-for babies are fed at 3- or 4-hourly intervals during the day, and not at all at night. They have not more than five or six meals in 24 hours. This reform has undoubtedly had an excellent effect on the digestion and general health of the baby, but it is probably one of the factors responsible for the all too frequent failure of the supply of mother's milk. We should certainly be ill-advised to go back to the old-fashioned practice of giving babies large numbers of meals every day. What we want to do is not to increase the number of the baby's meals, but to increase the amount of stimulation of the mother's breasts, because stimulation is necessary for milk production. Mothers are generally advised nowadays, as formerly, to use the breasts alternately, giving the baby only one breast at each meal, except at the 10 p.m. meal when both breasts are given. Thirty years ago, when babies were fed every 2 hours, each breast was stimulated every 4 hours. Now that the intervals between the baby's meals have been increased to 3 or 4 hours, each breast is only stimulated every 6 or 8 hours. It is not surprising that this should sometimes result in a falling-off of the flow of milk. If this tendency shows itself, it can fortunately in many cases be checked by the simple method of giving the baby both breasts at each meal. Experience shows that this may quickly produce a much more abundant supply of milk. The amount of milk that the baby obtains should be carefully regulated to prevent

overfeeding. From time to time the fully dressed baby should be weighed immediately before and after a meal, in order to find out how much milk has been taken. An excellent plan is to do this for each meal in the 24 hours regularly one day each week. In this way under- or over-feeding can be detected at once. The amount of milk that the baby takes when in good health should always be ascertained, as this information is often required when difficulties arise.

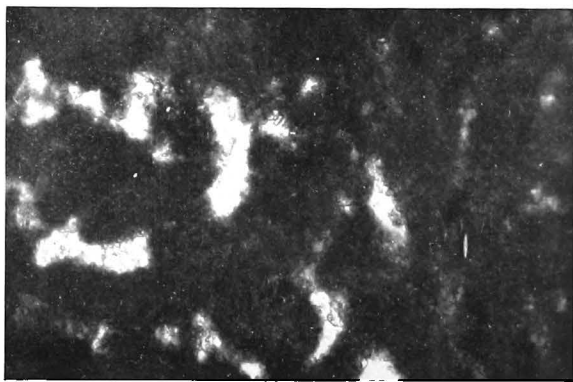
It cannot be too strongly emphasized that the best food for a baby is the milk of a healthy mother. Substitutes should be used only if this is not available, or for supplementary meals. In the few cases where the mother's milk does not agree with the child, substitutes must be used at first, but an effort should be made to alter the mother's milk by suitable dieting.

Our ideas about foster-mothers have altered very much in recent years. In olden times the employment of a foster-mother was often the only way of saving a baby's life. Now that the principles of baby feeding are more or less understood, foster-mothers are neither necessary nor desirable. The great disadvantage of resorting to them is that, even if they appear to be quite healthy, they may communicate some disease to the infant. Also, if the mother's own milk does not suit her baby, the milk of another mother will not necessarily be any better.

At the present time the best substitute for mother's milk is probably certified cow's milk that has been properly modified. Some children thrive on unaltered cow's milk, but this is by no means always the case. The advantage of modified milk is that the composition can be adjusted to the needs of each particular case. The disadvantage is that the preparation is laborious. In some parts of the country dairies supply ready-modified milk. Unaltered cow's milk is not an ideal food for infants because it is difficult to digest and its composition is not the same as that of human milk. Cow's milk has less carbohydrate and more protein. Moreover, the proportion between the two types of protein (casein and



(a) Curds from human milk



(b) Curds from cow's milk

FIG. 9

lactalbumin) is different. The following table brings out these points :

	Human milk.	Cow's milk.
	Per cent.	Per cent.
Fat	4	4
Lactose	7	4.5
Protein { Lactalbumin	1	1
{ Casein	0.5	2.75
Mineral salts	0.25	0.75
Water	87.25	87

The fat content is about 4 per cent. in both cases, but cow's milk is somewhat deficient in lactose. As regards proteins the concentration of lactalbumin is the same in both cases, but there is more than five times as much casein in cow's milk as there is in human milk. The 'indigestibility' of cow's milk is due to the fact that this mass of casein forms, in the infant's stomach, a tough curd that cannot easily be attacked by the digestive enzymes (see Fig. 9). This difficulty is to some extent overcome when cow's milk is diluted with water, but this results in a milk of less nutritive value, owing to the lowering of the concentration of the lactose, fat, and lactalbumin. Lactose can easily be added to these diluted milks, and the fat content can be increased by the addition of cream, but the concentration of lactalbumin cannot readily be adjusted. A more satisfactory method of modifying milk is to add whey, which consists chiefly of lactose, lactalbumin, and water. The concentration of carbohydrate and fat can be adjusted by the addition of lactose and cream. By the careful manipulation of fat-free milk, cream, lactose, and whey, a milk can be prepared that has more or less the composition of mother's milk. A little lime water is generally added as cow's milk tends to be slightly acid.

It is of the greatest importance that all cow's milk that is given to babies should be 'certified', that is, obtained from cows which are free from tuberculosis. Milk for babies is often pasteurized, in order to ensure some degree of sterilization. As a matter of fact,

by no means all the disease germs are killed by this process. It is safer to use good, clean, fresh milk than bad milk that has been pasteurized or boiled. One of the disadvantages of heating milk is that it tends to destroy the vitamins. If it is not possible to obtain a supply of good certified milk, it is advisable either to heat the milk or (in hot weather when bacteria multiply very rapidly) to use a dried preparation.

Two points have to be borne in mind when choosing a patent baby food. First of all it must fulfil the physiological requirements, and secondly it must suit the baby. There are a number of physiologically inadequate baby foods that may appear to suit babies quite well. The reason for this is that they contain so little real food that it is easily digested. The baby is free from digestive troubles, but is being slowly starved. The choice of an artificial food cannot be satisfactorily made unless the composition is known. The standard by which it should be judged is mother's milk. Not only should the concentration of fat, carbohydrate, and protein be the same as in mother's milk, but also the type of each constituent should be as similar as possible. The protein should be of animal and not vegetable origin, and should consist of casein and lactalbumin, preferably in the proportions present in human milk. The fat should be milk-fat, and the sugar should be milk-sugar (lactose). Cane sugar is probably not a good substitute as it is said to irritate the stomach. Maltose (malt-sugar), however, is free from this objection and appears to be digested with ease by infants. Starch is never present in mother's milk and should not be given to infants before they are six months old.

At the present time the artificial food that most nearly comes up to the standard is dried cow's milk that has been properly modified before drying. On the addition of water, the composition closely resembles that of mother's milk. Several such preparations are available. Some approximate more nearly than others to the standard, and some contain a certain amount of added vegetable protein. It is best in this place not to mention such proprietary

articles by name ; but information about their make-up can sometimes be obtained from the manufacturer or from a doctor or nurse. Analyses and notes on the composition of most of the well-known baby foods are given in Dr. Robert Hutchison's *Food and the Principles of Dietetics*. In actual practice dried milk does not seem to need modification as much as fresh milk for, during desiccation, the casein undergoes some change that apparently makes it more digestible. A number of patent baby foods contain dried milk together with cane sugar or maltose. These often suit individual cases, but on the whole lactose is probably preferable.

The only kind of condensed milk that should ever be used as a baby food is unsweetened, full cream. When properly diluted this is often found to be more digestible than fresh cow's milk, but it is not so convenient as dried milk as it soon goes bad after the tin has been opened.

There are a number of farinaceous foods that are not intended to be complete baby foods, but that require the addition of fresh cow's milk. Often the fresh cow's milk would be better for infants without the addition of the patent food. This is particularly the case with those that consist chiefly of starch (although these foods may be quite suitable for older children). Malt is present in some cereal preparations, and when the food is prepared in the home the malt-diastase converts the starch of the cereal more or less completely into dextrins and maltose. Other products are completely malted before desiccation. The extra nutriment furnished by these foods consists chiefly of carbohydrate (about 80 per cent.), with about 10 per cent. of vegetable protein, and a minute amount of fat (sometimes less than 1 per cent.). The only advantage to be gained by the addition of these foods to milk is that it tends to make the casein of cow's milk more digestible.

All infants that are fed on patent foods should have a daily ration of vitamins, whether the food is supposed to contain these factors or not. About half a teaspoonful of cod-liver oil mixed with one or two teaspoonfuls of orange juice should be given every day.

Even breast-fed infants and those reared on fresh cow's milk should have this extra supply of vitamins, at any rate after the age of 2 or 3 months. One reason for this is that it enables the child to become accustomed to the vitamin ration before weaning. Another and more important reason is that both cow's milk and mother's milk are sometimes deficient in vitamins, and the results of vitamin deficiency are especially serious in the first 6 months of life. There have been a few isolated cases of nursing mothers whose milk offered no protection from rickets although their diets contained the necessary vitamin. The reason for this was presumably that these mothers had previously been suffering from serious vitamin deficiency. There is no doubt that it is advisable to be on the safe side and give all infants a daily ration of vitamins. Regular supplies of cod-liver oil protect children absolutely from rickets, and orange juice is an effective anti-scorbutic. Moreover, children that have a proper ration of vitamins are free from the many minor disorders caused by partial deficiencies of these factors. Without vitamin D (which is present in cod-liver oil) neither bones nor teeth develop properly, and slight deficiencies of this factor are probably responsible for the bad condition of teeth that is so common a feature of modern civilization.

The vitamin ration is especially important during the period when the food of an infant is changed from an all-milk diet to a mixed diet. If babies have to be weaned before they are 8 months old they should be given modified cow's milk, or one of the artificial foods which resemble mother's milk. This should also be the procedure for infants that are weaned at a later date if they are at all delicate. Even in the case of healthy babies of 9 months old it is probably safer to give modified milk instead of whole cow's milk. (Some authorities now recommend that children should not have unaltered cow's milk before they are 16 or 17 months old.) In any case weaning should be a very gradual process. The new food should be given first for one meal each day, and after a few days for two meals, and so on until it forms the whole diet (except

for the cod-liver oil and orange juice). The next stage is the addition of cereals. A suitable preparation of oatmeal or other cereal should be given once a day, at first in small quantities, and then twice a day. The child can also be gradually introduced to lightly boiled eggs, bread and milk, milk puddings, mashed vegetables with red gravy, and so on. Stale bread or rusks should be given to encourage mastication. From the age of one onwards, children should have three good meals a day, and a light supper. For breakfast children of one may have porridge with milk and sugar, bread or rusk and butter with honey or home-made jam, and a drink of milk. A lightly boiled egg or tender piece of meat (such as stewed mutton) or boiled fish, with mashed potatoes and spinach or other soft vegetable can be given for dinner, followed by milk pudding or baked custard and fresh or stewed fruit, with water to drink. For tea there should be bread or rusk and butter with fresh fruit, honey, treacle, or home-made jam, and a drink of milk. When the child grows older, an egg can be given for breakfast. Various kinds of meat or fish and vegetables can gradually be included in the midday meal, and light suet puddings with treacle or jam. For tea there can be home-made cakes such as sponge cake.

We can work out the amount of food necessary for children of various ages if we know the approximate calorie requirements. Dr. Emmett Holt recommends the following values for the average daily calorie requirements of boys and girls :

<i>Age.</i>	<i>Boys.</i>	<i>Girls.</i>	<i>Age.</i>	<i>Boys.</i>	<i>Girls.</i>
1 . .	950	940	10 . .	2,330	2,195
2 . .	1,135	1,110	11 . .	2,510	2,520
3 . .	1,275	1,230	12 . .	2,735	2,865
4 . .	1,380	1,300	13 . .	3,040	3,210
5 . .	1,490	1,410	14 . .	3,400	3,330
6 . .	1,600	1,520	15 . .	3,855	3,235
7 . .	1,745	1,660	16 . .	4,090	3,160
8 . .	1,920	1,815	17 . .	3,945	3,060
9 . .	2,110	1,990	18 . .	3,730	2,950

These figures show that children require more calories every year from infancy until the age of 14 to 16; after the age of 12 both boys and girls actually need more food than adults. This can easily be understood when we remember that they are using food for growth as well as for fuel. If the father has a sedentary occupation, a daughter of 13 ought to eat more than he does, and a son of 16 should (and generally does) have a diet with a calorific value about 36 per cent. higher than that of his father.

In arranging diets for children it must be remembered that they require relatively more protein than adults. At the age of one they should have, every day, about 25 grammes (nearly an ounce) per stone of body-weight. This should be gradually diminished so that it is 15 grammes (just over half an ounce) per stone of body-weight from the age of 6 until the end of the growth period. The proper balance between fat and carbohydrate is to some extent an individual matter. Some children suffer from digestive troubles because they have too much fat and not enough carbohydrate. They cannot digest all the fat completely (see p. 21) and begin to lose weight. Their parents often make the mistake of giving them more fat, when as a matter of fact they require less fat and more carbohydrate. On the other hand, it is a mistake to give children a large excess of carbohydrate. This tends to make the child very fat, but a fat child is not necessarily a healthy child.

All through the years of childhood, vitamin-containing foods must be included in the diet. For this reason margarine should not be given if there is any chance of procuring butter. Milk should be the only drink, except for water and such beverages as can be made at home with fresh fruit juices. Alcohol should never be given to children. Surprising as it may appear, it is also an utter mistake to give them tea or coffee. Cocoa is not as bad as tea or coffee, but it is far better for children to have milk without any of these additions. The milk should of course be clean and pure, and obtained from cows that are free from tuberculosis. If children get very hungry between meals they should have fresh fruit or a glass

of milk. The habit of sucking sweets or chocolates is very bad for the teeth, and also makes children lose their appetites and not take their meals properly. Fresh foods should be given rather than preserved, and the whole diet should consist of simple foods.

Many people when they look back on their childhood have very unhappy memories of being compelled to eat food they disliked. We are all anxious to save our own children from this experience if it can possibly be done, and the more we know about their real needs, the more alternatives we can discover to take the place of forcing particular dishes on them. At the same time it must be remembered that when a child makes difficulties over meals, the trouble may not lie in the food at all. The diet may be perfectly suitable for the child, and yet there may be difficulties in getting the child to take it. Nervousness in children often manifests itself in this way, and the wise nurse or parent must bring to these difficulties not only a knowledge of diet, but also, what is always necessary, a real sympathy and understanding for the individual child.

IO

Food as a Cure for Disease

' SOLON was wont to say that " eating was, as all other drugges are, a medecine against the disease of hunger "' (see Florio's translation of Montaigne's *Essays*). Recent work has shown that food can also be used as a cure for other diseases. Rickets, beri-beri, scurvy, xerophthalmia, and ' night-blindness ' are all diseases that can be prevented or cured by a proper supply of vitamin-containing foods. Besides these, there are a number of other pathological conditions that can be alleviated or cured by means of suitable dieting.

Constipation is an example of such a condition. It should always be treated by regulation of the diet, rather than by patent cures. Constipation can nearly always be cured by eating plenty of oatmeal, brown bread, fruit, vegetables, and other foods that contain ' roughage '. On the other hand, some cases of diarrhoea can be cured by

eating white rather than brown bread, and by avoiding too much 'roughage'. Some people who tend to suffer from diarrhoea find that plain chocolate, milk, cheese, and hard-boiled eggs have a beneficial effect, and that the reverse is true of coffee. It is impossible to lay down general rules because in this respect people vary considerably. But it is quite simple for individuals to find out the effect of different foods and regulate their own meals accordingly.

Gout, and those types of arthritis which are caused by deposits of uric acid, can generally be treated more effectively by a change of diet than by drugs or patent medicines. The diet in cases of gout should be a spare one, composed of simple foodstuffs and plenty of water. Foods containing purine derivatives should be avoided as much as possible. The chief foods that are free from purine derivatives are milk, cheese, eggs, bread, fat, sugar, and nuts. Cabbage, cauliflower, and lettuce are also purine-free, and potatoes and onions only contain slight traces of purine derivatives. The following results (taken from *The Purine Bodies of Foodstuffs* by I. Walker Hall) show the amount of purine derivatives present in some foodstuffs :

		<i>Grains per lb.</i>
<i>Fish.</i>	Cod	4·074
	Plaice	5·565
	Halibut	7·140
	Salmon	8·155
<i>Meats.</i>	Pork, neck	3·969
	Rabbit	6·314
	Mutton	6·755
	Beef, ribs	7·959
	Ham	8·085
	Veal, loin	8·137
	Pork, loin	8·487
	Turkey	8·820
	Chicken	9·065
	Beef, sirloin	9·135
	Beefsteak	14·455
	Liver	19·264
	Sweetbread	70·431

		<i>Grains per lb.</i>
<i>Cereals.</i>	Oatmeal	3·456
<i>Vegetables.</i>	Onions	0·063
	Potatoes	0·140
	Asparagus	1·505
	Beans (haricot)	4·166
	Lentils	4·166
		<i>Grains per pint.</i>
<i>Beers.</i>	Lager beer	1·095
	Pale ale	1·271
	Porter	1·358
		<i>Grains per tea-cup.</i>
<i>Tea and Coffee.</i>	China tea	0·750
	Indian tea	1·050
	Ceylon tea	1·210
	Coffee	1·700

Alkaline mineral waters are to be recommended for gouty people. It is also advisable that they should avoid a great excess of acid-forming foodstuffs (see pp. 67-8).

The treatment of obesity is another case in which dietetic measures should be adopted. The causes of obesity are various, and somewhat obscure. Some people soon get fat on a limited diet, whereas others who eat more food remain thin. However, obesity is generally due to overeating, combined with lack of exercise. The patent medicines advertised as cures for obesity should always be avoided. There is no drug that reduces the body-weight without in some way damaging the general health. Many of the quack remedies are useless and harmless, but some of them are effective because they ruin the digestion. The use of thyroid extract is extremely dangerous. The ingredients commonly found in so-called cures for obesity are citric acid (the chief constituent of some of them), sulphur, potassium iodide. The price of these remedies bears little or no relation to the cost of the materials used. The proper treatment for obesity is based on physiological principles. We have seen that fat is deposited when excessive amounts of

carbohydrate or fat are eaten. The way to prevent further deposits of body fat is therefore to cut down the daily ration of carbohydrate and fat. In some cases it is advisable to reduce the number of calories to about half the normal physiological requirement, but the protein ration should not be altered. Fat already deposited can be removed by taking exercise. Foods for the obese should be somewhat restricted because variety encourages appetite; spices and condiments should be taken sparingly or not at all.

One of the features of several methods of treating obesity is the restriction of the total amount of fluid that is drunk. This leads to an almost immediate loss of weight, owing to the decrease in the amount of water in the body fluids. Another effect is that less food can be eaten dry than when water is drunk with meals, and this may lead to a further decrease in weight. These, however, are indirect results and the amount of fluid drunk appears to have no direct effect on the production or loss of body fat.

The so-called Banting system is one of the most interesting of the numerous methods of treatment for obesity. It consists in reducing the fats and carbohydrates and increasing the proteins, the calorific value of the diet being about 1,100 calories. Banting himself was at one time so fat that he had to go downstairs backwards. He consulted various physicians without success, and was finally cured by Dr. Harvey of Soho Square. Banting then popularized the treatment that had cured him, and it now bears his name. In 1863 he wrote a *Letter on Corpulence, addressed to the Public*, in which he stated that milk, sugar, beer, and butter 'are the most insidious enemies man, with a tendency to corpulence in advanced life, can possess, though eminently friendly to youth'. He found sugar the most fattening of all foods. He described his diet as follows:

For breakfast, I take four or five ounces of beef, mutton, kidneys, broiled fish, bacon, or cold meat of any kind except pork; a large cup of tea (without milk or sugar), a little biscuit, or one ounce of dry toast.

For dinner, Five or six ounces of any fish except salmon, any meat except

pork, any vegetable except potato, one ounce of dry toast, fruit out of a pudding, any kind of poultry or game, and two or three glasses of good claret, sherry, or Madeira—Champagne, Port and Beer forbidden.

For tea, Two or three ounces of fruit, a rusk or two, and a cup of tea without milk or sugar.

For supper, Three or four ounces of meat or fish, similar to dinner, with a glass or two of claret.

For nightcap, if required, A tumbler of grog—(gin, whisky, or brandy, without sugar)—or a glass or two of claret or sherry.

On this diet Banting lost 35 lb. in 38 weeks, and said that he felt better than he had done for twenty years. It must however be pointed out that, although Banting's system is undoubtedly a successful method of treatment for obesity, it causes a severe strain on the kidneys owing to the excessive quantity of protein in the diet. If the system is adopted plenty of water should be drunk in order to assist in the elimination of waste products.

Conclusion

THE results of recent scientific research have taken us a long way from the conclusions reached by the earlier investigators. Nearly four centuries ago the alchemist Paracelsus taught that there is in each one of us a good spirit, an archæus, who uses the good qualities of our food for our nourishment and expels those things that would harm us. The modern view of digestion is less picturesque and less simple. The archæus of Paracelsus has given place to a complicated series of digestive enzymes.

Our ideas about food have also altered almost out of recognition. There have been great advances in our knowledge even during the last twenty years. Before that time it was generally considered that a properly balanced diet of protein, carbohydrate, fat, water, and salts contained all that we needed. Now we realize that health cannot be maintained unless our food also contains vitamins.

In spite of these recent advances our knowledge of the constitu-

tion of natural foodstuffs is still far from complete. Our knowledge of the composition of 'manufactured' foods is even more scanty; often the manufacturers themselves have no idea what effect their methods of procedure will have on the nutritive value of the food. There are numbers of cases in which the use of a new method of food preparation has led to unexpected and disastrous results. The introduction of milling machinery into the East is a case in point. Rice has for centuries been the staple food of the poorer classes in Japan, the Malay States, &c. In the past, when domestic or native mills were used, the resulting rice had anti-neuritic properties that protected rice-eating peoples from the ravages of beri-beri. When western methods of milling and refining were adopted beri-beri became increasingly frequent, because the highly refined 'polished' rice was deficient in the anti-neuritic vitamin.

Every year foods of all kinds are becoming more and more sophisticated, and it is increasingly difficult to find out how and where any particular foodstuff has been prepared. The housewife should make every effort to avoid all made-up foods of unknown origin. She should buy fresh natural foods whenever possible. This is not only the safest, but also the happiest plan. Sentiment and science are for once in agreement.

*Table showing some Common Foodstuffs that are Rich in
Vitamins A, B, and C*

<i>Vitamin A.</i>		<i>Vitamin B.</i>		<i>Vitamin C.</i>	
*Butter	+++	Celery	+++	Cabbage (raw)	+++
Cod-liver oil	+++	Egg-yolk	+++	Grape-fruit	+++
Egg-yolk	+++	Lettuce	+++	Lemon	+++
Beans (runner)	++	Liver (ox)	+++	Orange	+++
Cabbage	++	Tomato (raw)	+++	Swede	+++
Carrots (young)	++	Tomato (tinned)	+++	Tomato (raw)	+++
*Cheese	++	Beans (kidney)	++	Tomato (tinned)	+++
*Cream	++	Cabbage	++	Beans (runner)	++
' Fat ' fish	++	Carrots (young)	++	Beans (sprouted)	++
Lettuce	++	Lentils	++	Lettuce	++
*Milk	++	Nuts	++	Lime-juice (fresh)	++
Peas (green)	++	Onions	++	Marrow	++
Spinach	++	Peas (green)	++	Peach	++
Tomato (raw)	++	Spinach	++	Pineapple	++
Tomato (tinned)	++	Turnips	++	Potatoes	++

N.B.—These results have been selected from the Medical Research Council Special Report No. 38, second edition. This was published in 1924. At that time, the anti-neuritic vitamin was included in the term vitamin B.

* See p. 54.

Notes on the Tables of Analyses and Energy Values of Foodstuffs

The chemical composition of foodstuffs is by no means constant. Fish varies according to the time of the year. Milk varies tremendously. Margarine varies according to the type of fat used; the cheaper margarines are generally made from vegetable fats, and the more expensive ones from animal fats. Vegetables vary according to the conditions in which they are grown; their water content is considerably higher in wet weather than in periods of drought. Fruit varies according to the state of ripeness, and so on.

Another difficulty about the analysis of foods is that there is often a portion that is not accounted for by the usual methods of analysis. This 'undetermined matter' may be as much as 7 per cent. in fresh fruits and 30 per cent. in dried fruits. Some of this 'undetermined matter' of fruits is probably water, the rest pectins, organic acids, &c.; in the banana it is said to be chiefly starch.

The values given in this book are taken from Professor R. H. A. Plimmer's *Analyses and Energy Values of Foods*. The analyses were nearly all carried out on uncooked foods. The loss on cooking is almost negligible with meat, but is slightly greater with vegetables. The values for cooked and uncooked peas (see p. 92) illustrate this point. In all cases the analysis of the edible portion only has been given.

Analyses and Energy Values of Foods (edible portion only)

Meat, Poultry, &c.

	Water. %	Ash. %	Protein. %	Carbo- hydrate. %	Fat. %	Calories. Per lb.
Bacon, streaky (fat)	14.3	4.4	3.5	—	77.2	3,321.7
" " (lean portion)	56.3	15.1	21.5	—	5.9	648.7
Beef, rump-steak (lean portion)	69.2	1.2	21.9	—	7.3	715.3
" sirloin (lean portion)	69.1	0.9	21.2	—	9.0	773.8
" tongue (centre)	64.8	0.9	15.6	—	19.2	1,100.0
" kidney	76.3	1.3	18.1	—	2.6	446.3
" liver	70.8	1.6	19.9	4.4	3.2	587.0
" suet	5.9	0.2	1.2	—	93.3	3,958.1
Chicken, breast	74.0	1.2	24.6	—	0.2	465.8
" leg	72.2	1.2	22.9	—	2.5	531.2
Duck, leg	67.1	1.1	20.1	—	11.4	854.6
Goose, leg	66.3	1.0	20.9	—	10.3	823.3
Grouse, leg	69.9	1.5	24.4	—	3.0	580.1
Ham (lean portion)	61.5	8.8	20.3	—	12.3	896.3
Hare, foreleg	72.4	1.1	23.4	—	2.4	536.6
Lamb, leg (lean portion)	71.7	1.2	20.5	—	5.9	630.0
Mutton, leg (lean portion)	70.8	1.1	21.1	—	7.0	687.7
" loin (lean portion)	65.8	1.0	21.6	—	11.8	899.5
Partridge, leg	69.3	1.4	24.4	—	5.3	677.2
Pheasant, leg	66.3	1.4	20.8	—	10.6	834.2
Pigeon, leg	69.2	1.3	22.1	—	6.6	689.5
Pork, loin (lean portion)	66.0	1.1	21.4	—	11.1	866.4
Rabbit, foreleg and shoulder	73.2	1.1	21.7	—	3.8	563.8
Turkey, leg	71.3	1.0	22.4	—	7.0	711.7
Veal, forequarter (meat)	74.4	1.2	19.6	—	4.1	537.5
Venison, rib (fat)	5.2	0.2	5.4	—	89.4	3,871.9
" " (lean portion)	68.7	1.1	23.6	—	6.1	696.3

Analyses and Energy Values of Foods (edible portion only)—contd.

Fish and Shellfish

	Water. %	Asb. %	Pro- tein. %	Carbo- hydrate. %	Fat. %	Calories. Per lb.
Cod	80.6	1.2	17.5	—	0.1	329.8
Crab (flesh)	73.6	2.7	22.4	1.1	0.2	445.4
Haddock, smoked	75.3	4.5	19.6	—	0.3	377.4
Halibut	79.0	1.4	18.8	—	0.5	370.6
Herring, fresh (male)	67.5	2.6	18.6	—	10.9	805.6
Kipper	62.5	4.5	18.8	—	14.9	978.4
Lobster (flesh)	75.0	3.1	19.7	1.9	0.3	414.6
Mackerel	69.3	1.2	19.1	—	10.7	806.5
Oyster (flesh)	77.3	4.1	8.9	8.7	1.0	369.7
Plaice	80.8	1.0	15.7	—	2.0	376.5
Salmon	64.4	1.3	18.6	—	15.8	1,012.4
Shrimp	67.6	6.9	23.2	1.4	0.9	495.3
Sole	77.9	1.1	18.8	—	1.8	425.5
Whiting	80.4	1.1	17.7	—	0.2	337.5

Eggs, Milk, Butter, &c.

Butter, Cornish	13.8	2.3	—	—	81.6	3,442.4
Cheese, Caerphilly	43.0	5.2	27.2	—	13.4	1,279.6
" Cheddar	33.7	4.4	25.2	—	33.4	1,939.1
" Stilton	24.6	3.8	26.3	—	42.8	2,341.0
" Wensleydale	26.3	6.2	29.2	—	35.1	2,083.4
" Little Wilts.	40.4	3.4	22.0	—	32.3	1,807.1
Dripping	—	—	—	—	100	4,218.5
Eggs (without shell)	73.7	1.1	12.3	—	11.26	734.4
Lard	—	—	—	—	100	4,218.5
Margarine (one sample)	13.6	1.7	—	—	84.3	3,556.2
Milk (1 lb. = 0.776 pint)	87.6	0.7	3.3	4.8	3.6	303.0

*Analyses and Energy Values of Foods (edible portion only)—contd.**Fresh Fruit*

	<i>Water.</i> %	<i>Ash.</i> %	<i>Fibre.</i> %	<i>Pro- tein.</i> %	<i>Carbo- hydrate.</i> %	<i>Fat.</i> %	<i>Calories.</i> Per lb.
Apples, Cox's orange							
pippin	83·6	0·4	0·7	0·3	12·5	0·2	246·3
" cooking	85·6	0·3	0·7	0·4	8·1	0·2	166·5
Bananas, Canary	68·5	0·9	1·5	1·6	8·0	0·1	543·4
" Jamaica	73·1	0·8	2·9	0·7	17·7	0·1	433·6
Blackberries, wild	82·3	0·8	4·8	1·4	6·3	0·2	151·5
Cherries, black	81·3	0·5	0·8	1·0	16·7	0·1	333·4
Currants, black	80·8	0·9	2·4	1·3	8·0	0·2	181·4
" red	85·7	0·6	4·0	1·3	6·3	0·1	145·6
Gooseberries, cooking	89·7	0·4	1·9	0·7	5·1	0·1	112·0
Grapes, average	84·7	0·5	0·6	0·6	13·9	0·1	274·0
Lemons	91·1	0·3	0·4	0·5	3·1	0·5	88·0
Oranges, Californian	86·0	0·5	0·4	0·9	9·5	0·1	197·8
Pears, William	87·6	0·3	1·4	0·3	8·1	0·1	160·6
Plums, Victoria	85·7	0·4	0·8	0·4	10·3	0·3	211·8
Raspberries	86·8	0·6	3·1	1·2	6·6	0·1	149·2
Strawberries, selected	88·6	0·5	0·9	0·7	10·2	0·1	206·8

Dried Fruit

Apricots	27·9	3·3	2·6	5·5	49·6	0·3	1,037·4
Currants	20·5	2·6	2·3	1·7	42·0	0·3	825·6
Dates (without stone)	21·8	2·0	2·3	1·6	69·7	0·1	1,330·4
Figs	20·8	2·3	4·2	2·0	56·5	0·5	1,109·0
Prunes (without stone)	28·1	1·9	1·8	3·0	40·4	0·3	819·6
Raisins	19·3	2·5	4·1	2·2	61·2	0·3	1,191·6
Sultanas	18·5	2·3	1·1	1·7	64·9	0·3	1,251·5

Analyses and Energy Values of Foods (edible portion only)—*contd.*

Fresh Vegetables

	Water. %	Ash. %	Fibre. %	Pro- tein. %	Carbo- hydrate. %	Fat. %	Calories. Per lb.
Artichokes, Jerusalem	79.7	1.3	0.7	1.9	17.4	0.03	360.2
Asparagus	90.8	0.9	0.9	3.1	4.25	0.05	138.8
Beans, broad	65.5	1.4	0.5	9.4	22.8	0.4	615.5
" French	91.5	0.7	1.0	1.9	4.8	0.1	128.8
Beetroot	90.2	1.3	1.0	1.2	6.2	0.1	142.0
Brussels sprouts	88.3	1.1	1.1	3.6	5.7	0.2	181.4
Cabbage	92.6	0.6	0.8	1.4	4.5	0.1	113.8
Carrots	89.4	0.7	0.9	0.9	8.0	0.1	169.6
Cauliflower	90.2	0.9	0.9	1.9	5.9	0.2	153.3
Celery	93.7	1.0	0.8	0.6	3.8	0.1	86.2
Cucumber	96.7	0.4	0.2	0.6	2.0	0.07	51.3
Leeks	85.3	1.1	1.7	2.5	9.3	0.1	224.5
Lettuce	95.4	0.8	0.6	1.1	1.9	0.2	64.4
Mushrooms	91.3	1.1	0.9	4.5	2.0	0.2	129.3
Onions, English	86.7	0.5	0.6	1.3	10.8	0.1	229.1
Parsnips	72.6	1.1	3.0	1.7	21.1	0.5	445.0
Peas (raw)	75.0	0.9	0.2	6.5	16.8	0.6	458.6
" (boiled)	78.5	0.9	0.5	5.1	14.3	0.7	360.2
Potatoes, new (boiled), tuber	77.7	0.8	0.4	1.4	19.7	0.01	392.8
Potatoes, new (boiled), skin	66.6	2.3	3.6	3.7	23.5	0.3	518.5
Potatoes, old (boiled), tuber	80.5	1.0	0.6	1.9	16.0	0.02	333.9
Potatoes, old (boiled), skin	76.4	2.1	2.7	2.7	15.9	0.2	354.3
Radishes	93.6	0.8	1.1	1.0	3.4	0.1	86.2
Rhubarb	94.4	0.7	0.6	0.6	3.63	0.07	81.6
Spinach	92.8	1.8	0.5	1.8	2.9	0.2	95.7
Tomatoes	93.5	0.5	0.7	0.7	4.5	0.1	100.7
Turnips	93.0	0.7	0.6	1.2	4.4	0.1	108.4
<i>Dried Pulse</i>							
Beans, butter	11.2	4.0	3.3	18.6	62.2	0.7	1,532.3
" haricot (small)	11.1	3.5	2.6	17.8	64.5	0.5	1,551.8
Lentils, whole, brown	12.2	2.3	3.1	22.2	59.7	0.5	1,544.0
Peas, whole, green	13.8	2.7	5.4	20.4	57.1	0.6	1,466.5

Analyses and Energy Values

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Analyses and Energy Values of Foods (edible portion only)—contd.

Nuts

	Water. %	Asb. %	Fibre. %	Pro- tein. %	Carbo- hydrate. %	Fat. %	Calories. Per lb.
Almonds, Valencia	3·6	3·1	3·1	18·6	15·2	56·4	3,007·8
Brazil nuts	2·9	3·3	2·1	13·2	8·1	70·4	3,366·2
Chestnuts	44·3	0·9	1·7	3·0	48·2	1·9	1,032·4
Walnuts, dried	2·2	2·0	1·8	13·6	14·0	66·4	3,314·5

Bread, Cereals, &c.

Arrowroot	13·2	0·1	0·03	0·2	86·44	0·03	1,612·6
Bread, brown (one sample)	44·0	1·8	0·8	7·5	45·8	0·1	995·6
„ white (one sample)	42·8	1·8	—	6·6	48·7	0·1	1,032·4
Cornflour	11·4	0·1	—	0·8	87·6	0·1	1,648·4
Flour, white (one sample)	10·8	0·5	0·2	11·1	76·1	1·3	1,685·6
Macaroni, stick	10·9	0·5	0·1	12·8	75·5	0·2	1,650·6
Oatmeal, medium	6·9	1·8	0·8	11·9	70·0	8·6	1,886·1
Oats, rolled (one sample)	9·2	1·8	0·8	12·9	69·0	6·3	1,789·0
Rice, unpolished	11·8	0·6	0·2	6·8	80·0	0·6	1,639·8
„ ground	11·1	0·4	0·2	6·4	81·6	0·3	1,649·3
Sago	11·9	0·1	0·07	0·2	87·71	0·02	1,635·7
Semolina	11·4	0·5	0·3	11·4	75·3	1·1	1,658·8
Tapioca	11·9	0·1	0·01	0·2	87·74	0·05	1,637·5

Sugar, Jams, &c.

Chocolate (average)	1·0	1·4	1·8	4·8	59·9	31·1	2,514·8
Cocoa (average)	4·9	6·3	3·7	18·1	40·3	26·8	2,214·5
Golden syrup	15·1	0·90	—	0·3	76·4	—	1,426·6
Honey	18·3	0·30	0·10	0·4	71·4	—	1,290·0
Jam, plum	24·0	0·85	0·63	0·2	70·0	—	1,305·5
„ strawberry	29·3	0·28	1·37	0·3	66·4	—	1,240·6
Marmalade	27·9	0·17	0·68	0·2	68·6	—	1,280·4
Sugar, Demerara	0·7	0·1	—	—	98·0	—	1,822·6
„ lump, castor, &c.	—	—	—	—	100	—	1,859·8
Treacle	23·4	4·20	—	0·2	59·9	—	1,117·7

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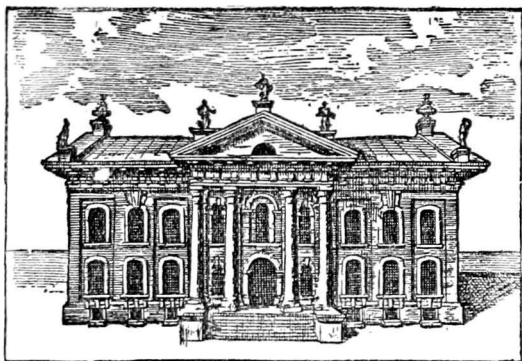
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