

MINISTRY OF FOOD
SCIENTIFIC ADVISER'S DIVISION

MANUAL OF
NUTRITION
1947

LONDON
HIS MAJESTY'S STATIONERY OFFICE
1947
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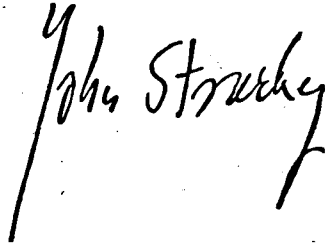
Foreword

This Manual of Nutrition has been reprinted four times and now the time has arrived for a new edition to be prepared. The fact that this has become necessary within two years of its original publication shows that its author, Dr. Magnus Pyke, now principal Scientific Officer (Nutrition) of the Scientific Adviser's Division of the Ministry of Food, has supplied a need.

The Manual is designed chiefly for teachers, students, people who run canteens for adults or school children, and for all people concerned in any way in catering or public health. But it has also been bought by many citizens who realise that an understanding of the scientific basis of good diet ought to be part of the everyday knowledge of an educated person.

That is very encouraging. I should like to see more and more people interested in seeing that the right foods prepared in the right way reach our tables in attractive form.

It is for that reason especially that I am glad to write the foreword to the second edition of the Manual of Nutrition and to wish it well.

A handwritten signature in cursive script, reading "John Strachey". The signature is written in dark ink and is positioned to the right of the typed text.

Ministry of Food,
February, 1947.

MINISTRY OF FOOD

MANUAL
OF
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Preface

THERE is no short cut to the knowledge of nutrition. It cannot be picked up effortlessly from coloured posters or popular lectures or wireless broadcasts or films. In order to understand the principles of nutrition, which apply equally to all kinds of feeding in any country, it is necessary to devote some length of time to serious and conscientious study.

An understanding of the principles of any process is essential for practical people who intend intelligently to apply that process. An efficient motor mechanic must know something of the principles of the internal combustion engine. A competent aircraft pilot must understand the principles of flight. It is equally necessary for a caterer, the supervisor of an institution, or a cook whether responsible for a single family, a hospital kitchen, or five thousand coalminers in a canteen, to understand the principles of nutrition upon which proper health must be based.

Without a grounding in nutrition, it is impossible for anyone to know whether diets are satisfactory or not, whether an unfamiliar recipe is nutritious or not, whether advice in an advertisement or an article in a newspaper is good advice. There are many habits and prejudices which affect what people eat. Some are good habits with good reasons behind them. Much of British cooking and British food could not be bettered, some of it could, as also could some of the foreign habits which are accepted, perhaps without question. It is only by the possession of a proper knowledge of nutritional principles that we shall achieve a steady and progressive advance, rather than a vacillating progress susceptible to any passing craze or disingenuous advice.

SYLLABUS OF INSTRUCTION

This Manual of Nutrition is designed to give a grounding in the principles of nutrition to people who may already possess a practical knowledge of catering. It is important to remember, however, that no attempt is made here to teach chemistry, general physiology or any other of the basic subjects upon which itself the subject of nutrition depends. It follows, therefore, that even when people have gained a mastery of the material set out in this book they cannot claim to be qualified dietitians. It is hoped, however, that they will at least be able to grasp the underlying principles of nutrition and that they will be able to see something of the reasons which must carry weight with a good caterer.

The Manual is divided into four parts. It will probably be found most convenient for the instructor to devote three lessons to each of the four parts. Each of these twelve lessons can usefully be made up partly of theoretical instruction and partly of practical work. In order that sound knowledge may be acquired, it is important for the instructor to be a qualified dietitian or someone of equal attainment. Although there may be a certain usefulness in teaching the subject to a standard level of proficiency, each instructor may choose to vary in some degree from the sequence of detail set out here. In particular, it has in practice been found of value to use some of the questions during the course of a class and others for home work.

PART I

Lesson 1

- General introduction to nutrition.** p. 1
- Carbohydrates.** p. 3
- Practical.** Examine and taste glucose, lactose, maltose and sucrose. Examine under the microscope, if the students have had previous experience with this instrument, starch from potato, flour, cornflour, rice, etc. cooked and raw. Demonstrate grams and ounces and calculate weights in grams and ounces.

Lesson 2

- Fats.** p. 5
- Proteins.** p. 7
- Practical.** Demonstrate by dissection the amount of fat in two pieces of meat. Demonstrate saponification of animal fat and resistance to saponification of mineral wax. Compare egg albumin, gelatin, gluten, casein and dried meat. Compare dried milk and flour, etc.

Lesson 3

- Food consumption and physical work.** p. 10
- Practical.** Answer the questions given at the end of Part I.

PART II

Lesson 4

- Inorganic elements.** p. 18
- Calcium and phosphorus.** p. 20
- Iron.** p. 23
- Practical.** Weigh out amounts of cheese, milk, watercress, cabbage, potato and flour each containing 100 mg. of calcium. Weigh out 250 mg. of chalk which also contains 100 mg. of calcium. Compare the weights of foods providing 100 mg. of calcium with amounts containing 200 mg. of phosphorus. Weigh out amounts of meat, bread and potato each containing 1 mg. of iron.

Lesson 5

- Vitamin A.** p. 25
- The vitamin B group of nutrients.** p. 27
- Practical.** Compare the amounts of vitamin A, vitamin B₁, riboflavin and nicotinic acid by weighing the ingredients of the two meals provided.
- (a) Meat, potato, cabbage, bread, black coffee.
- (b) Bread, butter, cheese, milk, onion.

Lesson 6

- Vitamin C.** p. 30
- Vitamin D.** p. 32
- Practical.** Weigh out sufficient potato, cabbage, lettuce, orange and apple to provide 50 mg. of vitamin C. Examine for comparison 50 mg. of ascorbic acid.

Answer the questions given at the end of Part II.

PART III

Lesson 7

The digestion of foods, the absorption of nutrients and their fate in the body. p. 34

Practical. Examine the dissected digestive tract of a pig. Compare the result of a piece of meat shaken up in pepsin solution, bread shaken up in saliva and fat shaken up with bile salts with corresponding treatment with water alone.

Lesson 8

Nutritional requirements. p. 40

Practical. Calculate the complete nutritional value of two diets provided, by weighing their ingredients and make suggestions for improving them :

- (1) for a coalminer.
- (2) for a child of 10 years old.

Lesson 9

The composition of food. p. 45

Practical. Answer the questions given at the end of Part III.

PART IV

Lesson 10

Cooking. p. 50

Practical. Calculate complete nutritional value of a cake by weighing the ingredients provided. Weigh out amounts of (1) the baked cake and bread, (2) boiled potatoes and chips to provide 300 calories. Weigh amounts of boiled cabbage and salad both containing 30 mg. of vitamin C.

Lesson 11

Meals. p. 54

Practical. With the ingredients provided, put together a meal containing 1,000 calories, 25 g. or more of protein, 300 mg. or more of calcium, 2000 i.u. of vitamin A and at least 30 mg. of vitamin C. Calculate how much food would be needed to supply 500 such meals.

Lesson 12

Diets. p. 58

Practical. Answer the questions at the end of Part IV.

MANUAL OF NUTRITION

PART I

CHAPTER I

GENERAL INTRODUCTION TO NUTRITION

THE kinds of food which people eat in different countries of the world often differ widely. Even between different districts of a single country there may be marked variations in dietary habits. Nevertheless, whatever kind of diet a person may eat, it must contain sufficient of the appropriate foods to fill his nutritional needs if the health of that individual is not to suffer. The principles by which the sufficiency or otherwise of any diet can be measured are comprised within the science of nutrition. Anyone, therefore, whose business it is to provide meals ought to possess a knowledge at least of the fundamentals of nutrition, so that he will be in a position to know the true value of the food he is providing.

Before starting to discuss nutrition in any detail it is necessary to make three definitions:

1. The science of *nutrition* is the study of all the processes concerned in the growth, maintenance and repair of the living body which are connected in a fairly direct way with the nutrients supplied by food.

2. *Life*, by which living things are distinguished from those which are inanimate or non-living, is a chemical process in which an organism obtains from food the energy for its activity and the material for its growth, maintenance and reproduction.

3. *Food* is anything, either solid or liquid, which when it is swallowed can do one or more of three things:

- (a) furnish the body with material from which it can produce heat, work, or other forms of energy;
- (b) provide material to enable growth, repair or reproduction to proceed;
- (c) supply substances which normally regulate the production of energy or the process of growth, repair or reproduction.

Although there is a very large number of foodstuffs from which a diet can be chosen, all of them, in the last analysis, qualify to rank as foods, according to the definition given above, because they contain one or more of the groups of materials listed below: these components which give a material its right to be called a food are known as *nutrients*.

THE NUTRIENTS OF WHICH FOODS ARE COMPOSED

1. **Carbohydrates** provide the body with energy and may also produce fat.
2. **Fats** provide energy and may produce body fat.
3. **Proteins** provide energy and material for growth and repair and sometimes the formation of fat.
4. **Mineral substances** provide material for growth and repair and for the regulation of body processes.

5. Vitamins and other accessory substances regulate the body processes.

Water, and the oxygen provided by air, are necessary for animal life, but, although an argument could be made for including them in the list given above, it is not proposed to classify them as nutrients.

Although there are a few foods which contain only one nutrient, *most foods are mixtures and contain several nutrients.*

MALNUTRITION AND UNDER-NUTRITION

Appropriate amounts of all the nutrients must be provided in a diet if the nutrition of an individual is to be properly maintained. If there is a wrong proportion of one or other nutrient, a condition of *malnutrition* will occur. If the total amounts of nutrients provided by a diet are insufficient, the condition of an individual eating it may be described as *under-nutrition*. The most extreme degree of under-nutrition due to lack of sufficient nutrients is, of course, *starvation*.

Stunting in the growth of children due to lack of protein, or cracking and ulceration of the lips of adults due to a shortage of vitamins may just as truly be described as due to malnutrition as can excessive fatness due to the consumption of *too much* food.

LIFE AS A CHEMICAL PROCESS

When it was said that the life of an individual was a *chemical process* and that the body derived its energy and the material for its growth and maintenance from food, this was literally true. In the laboratory, wheat can be treated so that it will combine with oxygen from the air and produce a measurable amount of heat or energy. In times of glut, this knowledge has been used when wheat has been employed as fuel for railway engines. When wheat is eaten, an almost identical amount of heat or energy is produced and the same chemical products are finally formed as was the case in the laboratory or in the boiler of an engine. The chemical pathway by which this is achieved is different in the body from that followed in the engine, but the result is the same. Similarly, just as the process by which fuel is used to move the wheels of a motor car is a chemical one, so is the process by which food causes a muscle to contract to move a limb.

THE MULTIPLE FUNCTION OF FOOD

It has been stated in the definition of food that it may do other than provide energy for the body, it may also supply material for growth or for the regulation of the body's activities. Thus iron, even in the form of rust from cooking pots, is a food since it may serve to repair worn-out elements in the blood. Small amounts of iodine rank as food since iodine normally regulates a function of the body. Alcohol is also a food because it can provide energy. Nevertheless, the given definition of food is not perfect and must be used with discretion. For example, alcohol, besides possessing properties rightly attributable to foods, is also a narcotic drug, and iodine in quite small excess is a poison. Although substances which can regulate bodily function but which are, purely and simply drugs, are excluded by the definition from being classed as foods, the two examples, and there are many more, show how difficult it may be to decide whether anything is a food or not. Salt, which enters into the repair and regulation of the body, is a food; pepper is not. Tea might be said to regulate the body's processes, but the drug which gives tea its qualities is not a substance which *normally* acts as a regulator. Since tea provides no energy and no materials for growth or repair it is, therefore, not a food. The milk and sugar drunk with tea are, of course, foods.

CHAPTER II

CARBOHYDRATES

1. A carbohydrate is a nutrient which provides the body with heat or other forms of energy. Under some circumstances carbohydrates may be converted into fat and stored in the body.

2. There are three kinds of carbohydrates :

- (a) sugars ;
- (b) starches ;
- (c) cellulose and related materials.

3. Sugars. (i) *Glucose*. This is the simplest of the sugars. It can be made from starch or by splitting of more complex sugars such as cane sugar. It occurs naturally in the blood of animals while they are alive and in fruit and plant juices. It is specially abundant in onions, unripe potatoes and sweet corn.

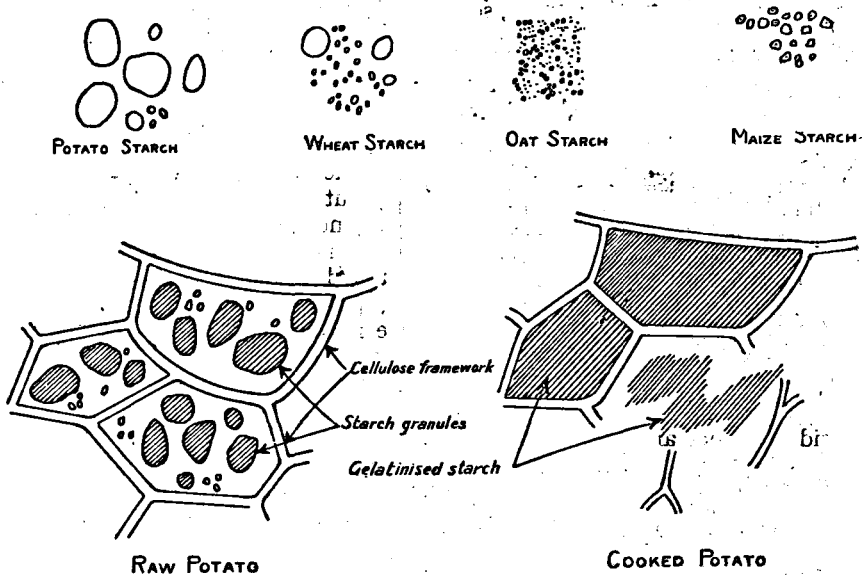
(ii) *Fructose* is another simple sugar. It can, under some circumstances, be changed into glucose. Fructose can be derived from cane sugar, of which it forms a part. It occurs naturally in plant juices and in fruit and, especially, in honey.

(iii) *Sucrose* is the scientific name for cane or beet sugar (which are identical). It is composed of the chemical combination of glucose and fructose. Sucrose occurs naturally in beet and sugar-cane, in sweet fruits and in roots such as carrots.

(iv) *Lactose* bears many similarities to sucrose. It also is a combination of two sugars, of which glucose is one ; the second is *galactose*. Lactose is less sweet than sucrose. It occurs in all types of milk, including human milk.

(v) *Maltose* is formed naturally from starch during the germination of grain. Chemically, maltose is composed of two glucose sugars combined.

4. Starch. By far the largest proportion of carbohydrate in human food occurs as starch. Starch is the form in which plants store the major part of their food reserves. More than half the solid material in cereal grains and



in potatoes is consequently made up of starch. Unripe apples and bananas also contain starch which changes into sugar as the fruit ripen.

Starch is composed of a large number of glucose units chemically combined. In the form in which it occurs in, say, potatoes or flour, the actual starch is enclosed within granules. These granules can easily be seen with a microscope and differ in appearance depending on the source from which they are derived. Starch granules cannot easily be digested, consequently flour, potatoes and other materials containing starch cannot be used as food raw. When, however, they are heated in water, the granules swell until they burst and the starch is released.

5. Cellulose and related material. Much of the stiffer structure of vegetables and of cereal foods is composed of cellulose and related substances. In the diagram on page 3 of the effect of cooking on potato starch, the starch granules are shown within a framework of cellulose. Although cellulose is chemically composed of a combination of sugar molecules, it is only digested to a very small degree by human beings and therefore makes an insignificant contribution to the day's food. Cellulose is, however, of some value for giving bulk to the diet.

FOODS WHICH CONTRIBUTE CARBOHYDRATES TO THE DIET

All carbohydrates which are absorbed by the body serve the same purpose: they contribute warmth or energy or they may be converted into fat. In comparing foods with regard to the proportions of carbohydrates in them, it is logical to consider *the total carbohydrate available to the body* rather than the different amounts of sugars, starches and indigestible cellulose. The list below compares foods from the point of view of total available carbohydrate.

Except in the case of a few foods, of which sugar from the grocer which is 100 per cent. carbohydrate is one, *all foods contain more than a single nutrient.* Consequently, although, say, wheatmeal bread is a high-ranking source of carbohydrate, it also contains substantial amounts of protein and other nutrients.

Grams and Ounces. The list below gives figures in *grams per ounce* (g. per oz.). A gram is a unit of weight: 28 g. are about 1 oz. (the exact figure is 28.36 g. = 1 oz.). Consequently, jam, for example, which is shown to contain 17.6 g. of carbohydrate per oz., could equally well be said to contain 17.6 g. per 28 g., that is 63 g. per 100 g., that is 63 per cent. carbohydrate.

	Available Carbohydrate G. per oz.		Available Carbohydrate G. per oz.
Sugar	27.0	Potatoes	4.6
Syrup	20.2	Beans (baked)	4.5
Jam	17.6	Parsnips	2.9
		Peas (green)	2.7
		Beetroot	2.3
White flour	21.2		
National flour (85 per cent. extraction)	20.0	Bananas (peeled)	4.9
Oatmeal	18.6	Grapes	4.1
White bread	15.6	Apples	3.0
		Cherries	3.0
Raisins	16.5	Pineapple	3.0
Dates	16.3	Pears	2.7
Currants	16.0	Oranges	2.2

The Properties of Sugars. Sugars, which are the simplest members of the carbohydrate group, are all *soluble in water* and are all capable of forming *crystals* when the water in which they are dissolved becomes saturated with them.

Nutrition and Sweetness. Fructose is the *sweetest* of all the sugars. Although sweetness is pleasant to the taste, there is no nutritional virtue in it. *Saccharin*, which is also sweet, bears no chemical or nutritional relationship to sugar. It is not of any value to the body and does not, therefore, rank as a food.

The Properties of Starch. Although plants form sugar by the action of the sun on their green leaves, they store the sugar in their stems, roots or seeds as *starch*. In the granules in which starch is stored it is entirely *insoluble in water*. When, however, starch granules are broken, a *starch paste* is formed. Starch does not form crystals.

When starch is heated it can be changed into *dextrin*. Dextrin is more soluble than starch although less so than sugar. It can, for example, be used as the gum on postage stamps. Dextrin is formed in making toast.

Glycogen. Glycogen is similar in composition to starch. It is formed from glucose in the liver and muscles of living animals and is the way in which the body's carbohydrate fuel is stored for use. After a big meal of carbohydrate the stores of glycogen in the body increase. On the other hand, after a very hard spell of muscular effort, the stored supplies of glycogen may become almost exhausted. The amount of glycogen in most meat is very small since it becomes broken down into glucose after the death of the animal. An exception is horseflesh which contains sufficient glycogen to give it a sweet taste if it is well chewed. Oysters and mussels also contain glycogen.

Cellulose. Cellulose is one of the substances of which the plant framework is composed. It is even less soluble than starch and is consequently almost completely unavailable to the body as food. Manufacturing processes have been devised for breaking down cellulose in sawdust and other materials into the glucose of which it is composed. Although human beings cannot make direct use of cellulose as food, ruminating cattle can do so and certain insects, notably the death-watch beetle and the worms which get into old furniture, can obtain energy from it.

Hemi-cellulose. If the cellulose in straw is subjected to mild chemical treatment it becomes converted into hemi-cellulose which is partially available as food to cattle, whose digestive machinery is specially devised to deal with material of this nature. *Beans* contain quite large amounts of hemi-cellulose.

Pectin is a complex carbohydrate present in apples and other fruit and in such roots as turnips. It has the property of forming stiff jellies which causes jam, for example, to set. Pectin itself, like hemi-cellulose, is of no direct nutritive value as food for man.

CHAPTER III

FATS

The substances which are defined under the classification of fats include all fatty materials, including the fat from meat, butter fat, and all the oils derived either from animal or vegetable sources.

1. Fuel for energy can be stored in plants as starch. It can, however, also be stored, and stored in its most compact form as far as living things are concerned, in the form of *fat*. Fat is, therefore, *the most concentrated of all energy foods*.

2. Fats are not soluble in water. The property by which they are most readily distinguished from other components of food is that they will dissolve in such liquids as petrol, chloroform or ether. These liquids, in fact, are often called *fat-solvents*. Fat-solvents, like fats themselves, usually will not mix with water.

3. *All common fats possess almost the same value as food.* Some natural fats contain other nutrients mixed with them but, so far as the fats themselves are concerned, their values may be taken to be equal.

4. The physical qualities of different fats differ principally because *certain of them become liquid at a lower temperature than others.* Oils are merely fats which remain liquid at ordinary atmospheric temperatures. If oils are cooled they become solid.

5. *In plants,* fats are formed from carbohydrate. When seeds, such as cotton-seed or linseed, ripen, the amount of starch in them falls as the fat increases. *Oil seeds* such as these are among the most important sources of fat for the manufacture of margarine or other purposes.

6. *In animals,* like plants, fat may also be formed from carbohydrate. If an individual eats more starchy food than is needed for the physical work to be done, fat will be laid down in the body. Similarly, pigs can be fattened on food largely composed of carbohydrate. Besides being capable of forming fat from carbohydrate, however, animals can deposit in their bodies some of the fat from their food. If a pig is given large amounts of cod-liver oil, its own body-fat will soon taste of cod-liver oil.

7. When fats are treated with alkali, for example, soda, they become split into *glycerol* and *soap*. Since both of these are soluble in water, fat can by this treatment be made to dissolve in water. The process of splitting fats into glycerol and soaps is called *saponification*.

All fats and oils which are useful to the body as food can be saponified. Mineral oils, such as liquid paraffin, or greases, such as vaseline, cannot be saponified. They are, therefore, unavailable to the body for the production of energy and do not qualify to be classified as food.

Foods providing Fat in the Diet

	Fat G. per oz.	Per cent.
Frying oil (olive oil, cottonseed oil, etc.)	28.4	100
Lard, dripping	28.1	99
Margarine	24.2	89
Butter	23.4	84
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Brazil nuts	17.5	63
Almonds	15.2	54
Peanuts	13.9	50
Coconuts	10.2	36
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Bacon	12.8	46
Cheese	9.8	35
Mutton	8.8	31
Beef	8.0	29
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Herring	3.3	12
Egg	3.3	12
Salmon (canned)	2.8	10
Milk	1.0	4

(i) Oils and fats like cooking oil and dripping are almost 100 per cent. fat. Butter is a mixture of *butter-fat* from milk, and water. It also contains a proportion of salt and certain other nutrients.

(ii) The figures for the amount of fat in beef and mutton given above are averages. It is a commonplace that meat may vary very widely in fatness depending on the way the animal it came from was fed.

(iii) Fish, such as herrings, mackerel, salmon, sardines, pilchards and eel, are sometimes called *fat fish*. The amount of fat in them, however, depends on the sexual development of the fish and is greater at one period of the year than another. *White fish*, which include cod, whiting, haddock and sole, contain very little fat.

(iv) Most of the common vegetables and fruits contain almost no fat at all. The amount in flour and other cereal products is small, except in the case of *oatmeal* which contains 2.5 g. of fat per oz.

THE CHEMICAL NATURE OF FATS

Chemically, fats are made up of three *fatty acid* units combined with a single unit of *glycerol*. In the process of saponification, which has already been described, these fatty acids become combined with the alkali to form *soaps* and the glycerol remains free.

A large number of fatty acids are known to exist. These differ from one another. The differences between one fat and another are due to the different fatty acids in each. For example :

- (1) The distinctive flavour of *butter* is principally due to the presence of *butyric acid* in its composition. Butyric acid has a strong and unpleasant smell. When butter becomes *rancid* some of the butyric acid which is volatile breaks off from the butter-fat to which it was attached and thus gives rise to the smell of rancidity.
- (2) *Caprylic acid* is one of the fatty acids in coconut oil, in *butter* made from cow's milk or goat's milk, and in *human fat*. Caprylic acid is one of the substances which give goats their characteristic smell. (Caprylic=caper=goat. Latin),
- (3) *Palmitic* and *stearic* acids are present in almost all fats. They are the most frequently found in *solid fats*.
- (4) *Oleic acid* is also very widespread. This fatty acid is present in largest amounts in *liquid oils*.

The unbroken fat, in which the fatty acids are chemically combined with glycerol, is not soluble in water but is soluble in *fat solvents* such as ether. When the fat is split up by saponification, the bulk of it in the form of free glycerol and free fatty acids, or soaps or fatty acids, becomes water-soluble. In all natural fats, however, a small residue remains unsaponified. This *unsaponifiable residue* contains a mixture of substances some of which may be of nutritional importance. If a fat contains vitamins, they will remain in the unsaponifiable residue.

CHAPTER IV

PROTEINS

Proteins are substances which are essential constituents of plant and animal cells. There is no known life without them. In animals the muscular tissue of the body is composed of protein. It consequently follows that protein is needed in nutrition for the growth and repair of the human body. The muscular tissue of the body of animals, that is to say, lean meat, is also composed of protein and serves, therefore, to provide one source of protein as a nutrient in the human diet.

Just as plants can build up carbohydrate, and hence derive energy, from substances present in the soil and the air, so can they also form their own protein from inorganic materials. Animals cannot do this. They can, however, use for food, for the construction of their own bodies, the protein from plants.

There are, therefore, two sources of protein for nutrition :

1. **Animal protein.** Animal protein forms a constituent of :

- (1) Meat of all kinds.
- (2) Game, poultry, etc.
- (3) Fish of all kinds, including shellfish.
- (4) Milk, dried milk, condensed milk, etc.
- (5) Cheese.
- (6) Eggs.

2. **Vegetable Protein.**—Protein forms part of all living plant cells. There is, therefore, a proportion of protein in *green vegetables* although the amount is small. Since *root vegetables* contain a high proportion of water, their protein content is also low. Potatoes, however, contain more protein than turnips or carrots. Among seeds, the proportion of protein is highest in *peas* and *beans*. The figure for *dried* peas and beans is highest of all but this value may be misleading when human nutrition is in question because it becomes several times lower when the peas are soaked. *Nuts* may perhaps be grouped with other seeds. They contain amounts of protein similar to those present in peas and beans. As nuts are, however, eaten dry they may be considered to rank higher.

The most important class of seeds used for food are cereals. In a grain of cereal, such as wheat, the most active living cells are in the embryo from which the new plant will in due course develop. The largest proportion of the actual grain is, however, the stored starch upon which the plant itself depends until it has grown leaves, and which makes it attractive to man as a source of human food. This part of the grain contains less protein than the parts associated with the embryo. It consequently follows that while the whole grain contains useful amounts of protein, the more completely the parts associated with the embryo are removed in the process of milling flour, the lower will the proportion of protein become. Thus brown flour contains less protein than the wheat from which it is made, and white flour contains less protein than brown flour.

The Uses of Protein in the Body. Protein from the diet is used for two main purposes :

- (1) For the growth and repair of the body.
- (2) For the production of heat or other forms of energy.

1. *The Use of Protein for Growth and Repair.* The protein structure of which the human body is made is not the same as that found in plants. Although it is similar to that found in animals it is not identical with that either.

If the protein in the diet is derived from *vegetable sources* a variety of foods must be eaten and quite large amounts taken so that the body may have the opportunity of taking to pieces the various vegetable proteins to find sufficient ingredients to put some parts of them together again as human muscle.

If the protein in the food is derived from *animal sources*, less will be needed since the degree of difference between animal protein and human protein is less than that between vegetable protein and human protein.

If protein is derived from a *mixture* of animal and vegetable sources, the amount required may be as little as if it all came from animal foods, since the variety of protein available to the body may enable it to put together human protein economically.

Children who are growing and women who are pregnant or nursing obviously need proportionally more protein in their food, since the protein is needed for growth, than normal adults who need it for repair and maintenance only. *A certain amount of protein is, however, essential for everybody.*

2. *The Use of Protein as a Source of Energy.* Since under normal circumstances the amount and kinds of protein present in the food will not exactly fit together to provide what is needed for growth and repair only, there will usually be a proportion of spare protein material. This is used for the production of energy or heat. Indeed, *protein is equally useful for providing energy for the body as carbohydrate.*

Note.—Although protein serves to provide the body with energy, its fundamental importance in the diet and the function for which no other nutrient can act as a substitute, is for growth and repair.

Foods Providing Protein in the Diet

	Protein G. per oz.	Per cent.
Animal Protein		
Cheese	7.2	26
Corned beef	7.0	25
Beef	4.0-5.2	14-19
Mutton	3.8	14
Egg	3.6	13
Milk	0.9	3
Vegetable Protein		
Soya flour, low fat	14.0	49
Peanuts	7.1	26
Wholemeal flour	3.9	14
White flour	3.1	11
Beans (baked)	1.7	6
Peas (green)	1.6	6
Spinach	0.8	3
Potato	0.6	2
Cabbage	0.4	1
Carrot, turnip	0.2	1

THE COMPOSITION OF PROTEIN

Just as starch is composed of a number of glucose units linked together, so also are proteins made up of a number of *amino acid* units. In the case of starch, however, all the glucose units are the same, whereas there may be *more than twenty different kinds* of amino acids in a single protein.

Proteins differ from one another because of the different kind and different arrangement of amino acids in them. Thus it comes about that whereas purified rice starch, potato starch and corn starch are all very similar, since they are all composed of glucose units, beef protein, bean protein and cheese protein are by no means similar since the arrangements and kinds of amino acids in them are different.

The human body can convert many of the amino acids it does not need for its own structure into others that it does. There are, however, *ten amino acids* which the body cannot make and which must, therefore, be supplied in the diet. These ten are called *essential amino acids*.

Proteins from different foods can be graded depending on whether or not they contain all ten of the essential amino acids *in sufficient quantity* to satisfy the needs of the body.

In general, it can be said that *animal proteins* usually contain the essential amino acids in proportions reasonably appropriate for human needs, while *vegetable proteins* may be lacking in one or other of them. For this reason animal

proteins are often called *first class protein* and vegetable proteins *second class protein*. There are, however exceptions, to the superiority of animal over vegetable protein, and to the "completeness" or "incompleteness" of either.

Gelatin, which is an animal protein derived from meat and is the principal ingredient in gristle, hoofs, horn, etc., is completely deficient in at least one essential amino acid, *tryptophane*. Gelatin has, therefore, little value as food unless supplemented by other proteins.

On the other hand, certain of the proteins in cereal grains, soya beans and Brazil nuts contain all ten essential amino acids.

PROPERTIES OF PROTEINS

1. *Some proteins will dissolve in water.* An example is *egg albumen* (the white of egg). This protein coagulates on heating.
2. *Most proteins do not dissolve in water.* Many common food proteins are, however, soluble in *salt and water mixtures* of various strengths.
3. When proteins are heated strongly, or treated drastically in other ways, they become *denatured*. This is usually accompanied by hardening to varying degrees.

CHAPTER V

FOOD CONSUMPTION AND PHYSICAL WORK

One of the principal uses of food is to supply energy to the living body. It has already been explained that each of the three nutrients, carbohydrates, fats and proteins, of which the diet is composed can provide energy. Most foods contain a mixture of these three nutrients so that it follows that the total energy value of any particular food is made up from the sum of the energy derived from carbohydrate, fat and protein.

The energy value of food is measured in terms of heat units called *calories*.

A calorie used in nutrition studies is really what is known as a "large calorie" and is the amount of heat needed to raise the temperature of 1000 grams of water 1 degree Centigrade.

(Strictly speaking, the Calories used in nutrition should be written with a capital C to distinguish them from calories used in the science of physics. These calories are the amount of heat needed to raise the temperature of 1 gram of water 1° C.)

Although the energy value of food is expressed in heat units, the body is not a heat engine like, for example, a steam engine. Indeed, heat produced in excess of that needed to maintain the normal temperature is energy lost so far as the body is concerned.

To the engineer, units of heat and of energy are interchangeable, that is why, for convenience, calories are used in nutrition although, to the body, heat is not the same as energy.

THE ENERGY VALUE OF NUTRIENTS

1 gram of <i>carbohydrate</i> absorbed by and oxidised in the body produces	4	calories
1 gram of <i>fat</i>	9	calories
1 gram of <i>protein</i>	4	calories

By using the values shown above, the energy value of any particular food can be calculated from the proportions of nutrients in it. For example, wheatmeal bread contains 11.2 g. of carbohydrate, 0.6 g. of fat and 3.1 g. of

protein per oz. The energy value of 1 oz. of wholemeal bread can hence be calculated as follows :

$$\begin{aligned} 11.2 \times 4 &= 44.8 \text{ calories from carbohydrate} \\ 0.6 \times 9 &= 5.4 \text{ calories from fat} \\ 3.1 \times 4 &= 12.4 \text{ calories from protein} \\ \hline \text{Total} &= 62.6 \text{ calories} \end{aligned}$$

THE ENERGY VALUE OF FOODS

Since the calorie value of foods is derived from the amount of nutrients in them, it follows that *very watery foods* such as turnips or lettuce or, for that matter, soup, possess little value for the production of energy. On the other hand, *foods rich in fat* have the highest calorie values.

	Calories per oz.		Calories per oz.
Cooking fat	253	Potato	21
Butter	211	Banana	21
Bacon	128	Milk	17.5
Cheese	117	Apples	12
Sugar	108	Beer	10
Beef	89	Orange	10
White bread	73	Cabbage	7
Dates	68	Turnip	5

The energy value of meat depends to a great degree on the amount of fat in it. Meat is mostly composed of the two nutrients, protein and fat, and water. An increase in the proportion of fat in meat is associated with a decrease in the proportion of water and not of the protein, so that the extra fat represents a clear gain to the diet. The amounts of fat in two pieces of beef for example may vary widely and will consequently affect the calorific value. Similarly the composition of other foods may fluctuate. The figures given above must, therefore, be used with judgment and taken as averages.

The figures for milk and beer in the list above are given, as for other foods, in calories per oz. *There are 20 ozs. in a pint.* Hence a pint of milk provides 340 calories and a pint of mild beer 200 calories.

THE USE OF ENERGY BY THE BODY

The energy from food is used by the body for three purposes :

- (1) *To maintain the processes of living such as the beating of the heart and the circulation of the blood ; breathing ; and to maintain the normal body temperature, etc.*
- (2) *For the everyday activity of daily life : standing ; eating ; moving about dressing, etc.*
- (3) *For the performance of muscular work. (No calorific energy from food is required for mental work.)*

The amount of energy used by different individuals for each of the three purposes set out above depends on the total amount of living tissues *and is found to be proportional to the surface area of their bodies.* Since, in general, men are bigger than women, *the total number of calories needed by men is greater than the number needed by women.*

1. **Energy needed to maintain the Processes of Living.**—The amount of energy used up by people of the average size found in Great Britain, if they lie still and warm in bed, that is to say, if they restrict their needs for energy merely to the processes of keeping alive, is about 70 calories per hour for men and 60 calories for women. Thus, per day, the average needs are :

Men	1,700 calories per day
Women	1,450 calories per day

2. **Energy needed for the Everyday Activity of Life.**—In addition to the expenditure of 70 calories per hour which a man must make merely to keep alive, he uses up extra energy every time he moves. The amounts of energy needed for different kinds of activity are, as follows :

	Calories per Hour		Calories per Hour
Sitting	15	Walking moderately fast	215
Standing	20	Walking downstairs	290
Dressing or undressing	33	Walking upstairs	1,000
Walking slowly	115		

An average figure for the energy expended during the 8 hours which are filled each day with miscellaneous domestic activities is given below :

Men	360 calories
Women	215 calories

These figures may not be appropriate for individual cases, where, for example, there are numerous stairs to be climbed or much walking to be done.

3. **Energy needed for doing Work.** Everybody, regardless of his occupation, needs food to maintain the processes of living, and also for the everyday activity of life. The important factor, however, which decides the amount of food an individual needs is the muscular activity of his work. The approximate average values of calories used up in the performance of a number of occupations are shown in the list below.

(1) <i>Sedentary occupations</i>	Calories per hour
Writing	20
Typing	30
Tailoring	45
(2) <i>Moderately active occupations</i>	
Shoemaking	90
Carpentering	140
Light engineering	140
(3) <i>Active occupations</i>	
Heavy carpentering	180
Light blacksmithing	275
Stone mason's work	300
(4) <i>Very active occupations</i>	
Coal-mining	320
Heavy blacksmithing	350
Wood cutting	380

NOTE.—It is important to remember that all these figures are averages. Two important factors which may influence them are (a) trained people can do work with less expenditure of energy than untrained people; (b) work of nominally the same character may differ widely under different circumstances.

THE DAY'S NEED FOR ENERGY

The total daily calorie needs of men doing work of varying degrees of activity can be calculated as follows:

	Calories
(a) <i>A clerk</i> : sedentary occupation	
24 hours of the processes of living	1,700
8 hours of everyday activity	360
8 hours writing: 8×20	160
Total day's calorie need	2,220
(b) <i>A carpenter</i> : moderately active occupation	
24 hours of the processes of living	1,700
8 hours of everyday activity	360
8 hours of carpentering: 8×140	1,120
Total day's calorie need	3,180
(c) <i>A blacksmith</i> : active occupation	
24 hours of the processes of living	1,700
8 hours of everyday activity	360
8 hours of blacksmithing: 8×275	2,200
Total day's calorie need	4,260
(d) <i>A woodcutter</i> : very active occupation	
24 hours of the processes of living	1,700
8 hours of everyday activity	360
8 hours of woodcutting: 8×380	3,040
Total day's calorie need	5,100

THE CALORIE NEEDS OF CHILDREN

The two factors which most powerfully affect the energy requirement of all individuals have already been mentioned, they are:

- (1) *The size of the body surface.*
- (2) *The degree of physical activity of the daily life.*

Children have a smaller body surface than adults. Their need for calories in food is, therefore, less. On the other hand children are more active than adults so that although their total needs still remain smaller, their needs in proportion to their size are greater than those of adults.

FOOD CALORIES AND FATNESS

If more food is eaten than is needed for an individual's daily activity some of it will be converted in the body into fat. Just as calories are supplied either by carbohydrate, fat or protein in the diet, so can any of these three nutrients be converted into fat in the body if they are eaten in excess of the calorie output of work. Thus, foods which are the most "fattening" are those which contain the most calories. These are fats, such as butter, or dishes including much fat, such as pastry or suet pudding; sugar; or commodities made with flour, particularly if these also include fat and sugar.

Individuals vary in their propensity to get fat, usually because they vary in the activity of their daily life, but in general if people wish to become thinner they can do so by two methods :

- (a) *Decrease their calorie intake from food without decreasing their bodily activity.*
- (b) *Increase their bodily activity without increasing their calorie consumption from food.*

These two principles, reversed, apply equally to people who want to get fatter. In considering this matter it is important to remember the figures which have been given in the course of this chapter. For example, if a man who is trying to reduce his weight goes for an hour's brisk walk, he expends about 200 calories. At the end of his walk he is thirsty and he drinks a pint of beer. This puts back the 200 calories he has used up. He cannot, therefore, be surprised if his weight does not change.

HOT FOODS AND THE CALORIFIC SIGNIFICANCE OF THEIR TEMPERATURE

The body temperature is maintained by a part of the calorific value of the food that is eaten. The calories provided by food are not, however, necessarily used to produce heat. Other forms of energy are needed by the body.

The heat of hot food provides only a trifling addition to the day's calories. This can be seen in the following example.

An average soup provides 10 calories per oz.

A half-pint serving (10 oz.) therefore contributes 100 calories.

The heat provided by the hotness of the soup, with a temperature of, say, 60°C., to the body, the temperature of which is 37°C., can be calculated as follows :

(1) 10 oz. = 280 g.

(2) 1 calorie = by definition the heat needed to raise 1,000 g. of water 1°C.

(3) Hence, the heat needed to raise 280 g. of soup from 37° to 60°C., i.e.

$$23^{\circ} \text{ amounts to } \frac{23 \times 280}{1,000} = 6 \text{ calories}$$

It can be seen that the heat of the soup, 6 calories, is a trifling contribution compared with 100 calories in the fuel value of the soup, or compared with 3,000 calories needed during the day by a moderately active man.

On the other hand, however, some of the calories in hot soup are already in the form of heat and warm the body of a cold exhausted individual in just the same way as would an equal amount of hot water in a hot-water bottle.

SPECIFIC DYNAMIC ACTION

The amount of energy needed to maintain the living processes of a man of average size has already been said to amount to 70 calories per hour or 1,700 calories for the day. This figure is, however, made up of two components :

- (1) The energy needed to maintain *basal metabolism*, that is, the functions of the body when lying *still* and *warm* and *without food*.
- (2) *Specific dynamic action*. For some little time after food has been eaten the cells of the body may function with *augmented* energy. This energy will be lost in the form of *heat*.

The quantity of energy wasted as *specific dynamic action* varies for each nutrient. *Protein* has the highest specific dynamic action. Hence, it follows that

in hot weather, the consumption of protein, of all nutrients, will make the body hottest.

If 100 calories be assumed to be just sufficient to fill the needs of the *basal metabolism*, the waste of energy due to *specific dynamic action* will demand that the following numbers of calories be supplied from the three food nutrients :

Protein	...	...	...	...	...	140 calories
Fat	...	...	...	...	...	114 "
Sugar	...	...	...	...	...	106 "

For a normal individual living on a mixed diet it can usually be assumed that *specific dynamic action* will amount to 10 per cent. of basal metabolism.

Hence, for a man of average size the daily requirement of energy :

For basal metabolism	=	1,546 calories
For specific dynamic action	=	$\frac{154}{1,700}$ "

THE MECHANICAL EFFICIENCY OF THE BODY

The amount of mechanical work which a man can do in riding a bicycle, or carrying bricks up a ladder, or hammering on a nail can be measured and expressed in calories. When the amount of work, expressed as calories, is compared with the energy value of the food also expressed as calories, the *mechanical efficiency* of the body can be calculated.

In the course of ordinary industrial work, the efficiency of the body is about 15 per cent.

That is to say, food containing 1,600 calories is used up when a man does 240 calories of physical work.

Since the body can only convert about 15 per cent. of the calories derived from its food into mechanical work (the percentage varies slightly for different kinds of mechanical effort) the remainder becomes wasted in the form of heat.

This is the reason why physical exercise makes an individual hot.

THE MAINTENANCE OF THE BODY TEMPERATURE IN HOT AND COLD WEATHER

Part of the energy used in maintaining the processes of the body, that is to say for *metabolism*, is used in keeping up the temperature of the body. Although it might be supposed that in cold weather more energy would be needed for this purpose and that the energy requirements for metabolism would consequently be increased, in actual fact the protection afforded by clothing keeps the metabolic rate comparatively stable all the year round.

In cold weather, if the protection of clothing is insufficient, the body temperature is maintained, partly by an increase in metabolism, but principally by an increase in *physical activity* which produces spare heat for warming the body. This increase in activity may either be *voluntary* and take the form of *stamping of the feet or beating with the arms*, or it may be *involuntary* and take the form of *shivering* which equally serves to produce warmth.

FACTORS AFFECTING THE AMOUNT OF ENERGY EXPENDED IN BASAL METABOLISM

Basal metabolism has already been described as the amount of energy needed to maintain the functions of the body when lying *still* and *warm* and *without food*.

1. **Body Surface.** The total amount of calories needed by an individual for basal metabolism is proportional to his *body surface*. The figures in the table below show that basal needs of people of different sizes may vary for average groups by the difference between 1,870 and 1,540 calories. That is to say, even when living the same kind of life there may be a difference of 330 calories in the requirement for food.

The Effect of a Man's Size on his Day's Basal Metabolic Requirement of Calories

	Height Cm.	Weight Kg.	Surface area Sq. m.	Basal metabolism plus specific dynamic action
Public school youths	180	71	1.88	1,870 calories
Conventional "mean" man...	171	60	1.77	1,770 calories
Average industrial worker ...	169	61	1.69	1,694 calories
Pre-1914 Army minimum ...	163	52	1.54	1,540 calories

In the table above, height is given in centimetres (1 cm. = 0.4 inch); weight is given in kilograms (1 kg. = 2.2 lbs.); surface area is given in square metres.

2. **Age.** The basal metabolic rate remains remarkably steady throughout life. The energy used per square metre, by young infants, is lower than normal but the amount rapidly increases and between the ages of 1 and 5 years it is higher than that needed by adults. At puberty, between, say, 12 and 16 years for boys and 11 and 15 years for girls, the basal metabolism is slightly increased. It remains steady throughout adult life with a gradual tendency to fall as old age draws on.

3. **Starvation.** During starvation or undernutrition, the basal metabolic rate becomes very much reduced. This serves as an automatic reduction in the body's daily drain on the sources of energy, such as its own fat, which remain open to it. The maintenance of life depends on more nutritional factors than calories alone. If, however, only calories are for the moment considered, whereas the maintenance needs, that is, the basal metabolism, of an adequately nourished man are 1,550 calories, after a prolonged fast of three weeks or more these needs will be reduced to little more than 1,000 calories. Hence, prolonged starvation can reduce the basal metabolism by as much as 29 per cent. Under these circumstances, a man who needs, say, 2,550 to carry out a day's sedentary work in an office, can if he must just subsist on 2,000 calories.

4. **Individual differences in energy requirement.** It is obvious that some people expend more energy and require more calories than others for the performance of the same day's activity. Although the principles described in this chapter apply to averages, some *individuals*, to take an example, get fat on a diet which leaves other individuals thin. These individual differences are usually due to different degrees of activity of certain *endocrine glands*.

5. **Food.** The metabolism is raised after food has been eaten.

6. **Exercise.** The metabolism is raised after exercise has been performed.

7. **Sleep.** The metabolism falls slightly after sleep. Since, however, exercise is taken during the day, the fall due to sleep is counteracted by the rise following exercise. For practical purposes, therefore, a standard figure can be used.

PART I

(Chapters I to V)

1. What is food ?
2. What is a nutrient ?
3. How many kinds of carbohydrates are there ; what purpose does carbohydrate serve in the body and which kinds of food contain it ?
4. Which is better, cane sugar or beet sugar ?
5. What connection is there in nutrition between glucose and starch ?
6. How many grams are there in a pound ?
7. Why do men need more food than women ?
8. What is the nutritional difference between fat and oil ?
9. What are the main sources of fat in the diet ?
10. What is the value to the body of fat in the diet ?
11. Why is protein of special importance in the diet ?
12. What is the difference between protein from animal and from vegetable foods ?
13. Which is the better source of protein, egg or cheese ; peanuts or cabbage ; white flour or wholemeal flour ; milk or meat ?
14. A cake sufficient for 40 portions is made according to the following recipe : $2\frac{1}{2}$ -lbs flour, 14-ozs. fat, 14-ozs. sugar, 1-lb. 12-ozs. dried fruit, salt, baking powder, 2 eggs (4-ozs.) and 1 pint of milk (20-ozs.). Calculate from the figures below how many calories a person will get in one portion of this cake.

	Calories per oz.
Flour	98
Fat	253
Sugar	108
Dried fruit	70
Eggs	45
Milk	17

15. Calculate from the figures below which contains more calories, an ounce of sausage or an ounce of corned beef ?

	Carbohydrate	Protein	Fat (figures in g. per oz.)
Corned beef	0	7.0	4.7
Sausage	5.7	3.9	3.4

16. What happens to starch when potatoes are boiled ? When toast is made ?
17. What happens to people who eat more calories than they need ?
18. For what purposes does an individual use calories in the course of a normal day ?
19. Which requires more calories ; walking or running ? walking upstairs or downstairs ? sitting thinking or just sitting ?
20. Which of the following are foods and which are not ? Why ? Bread, tea, tobacco, beer, butter, liquid paraffin, rust.
21. What is the difference between malnutrition and starvation ?
22. What is the nutritive value of sweetness ?
23. What is the chemical nature of fat and how do fats differ from one another ?
24. What is an amino acid ? Can amino acids be made by the body ?
25. What is the nutritional value of gelatine ?
26. Why is a hard boiled egg hard ?
27. Why does exercise make you hot ?
28. What carbohydrate occurs in sawdust ? Is it of nutritional value ?
29. What is pectin ?
30. Which of the following are proteins ? Hair, teeth, wool, sawdust, the gum on postage stamps, glue.

PART II

CHAPTER VI

INORGANIC ELEMENTS

The body contains 19 or so major inorganic mineral substances all of which must be derived from food. These substances are used for three main purposes :

- (1) *As constituents of bones* which are the rigid structures which support the muscular system of the body, and of the teeth. Some of the minerals composing this skeleton are : calcium, phosphorus, magnesium.
- (2) *As constituents of cells of the body* of which muscle, blood corpuscles, liver, etc., are composed. Minerals having this function include iron, phosphorus, sulphur.
- (3) *As soluble salts which give to the fluids of the body their composition and their stability which are both essential for life.* Among elements which serve this purpose are : sodium, potassium, chlorine.

In addition to the substances mentioned above there are a number of other minerals which must be provided by foods and which have special purposes in the body. *Iodine* is a constituent of a substance in the thyroid gland which plays a part in controlling the rate at which energy is used up in maintaining the body processes; *copper* is needed, together with iron, for the formation of blood cells; *manganese* plays a part in the gradual release of energy from foodstuffs.

Many of the minerals which have now been mentioned are needed only in small amounts and are widely distributed in many foods. Although knowledge of their functions in the body is necessary for an understanding of nutrition, the importance of considering them in practical dietetics is small. Two minerals, however, may easily be lacking and will be discussed in Chapters VII and VIII. These are *calcium* and *iron*.

Salt. *Common salt, (sodium chloride),* is a compound of sodium and chlorine. All the body fluids contain about 0.9 per cent. of salt and it is essential for life that this amount should always accurately be maintained. *Muscular cramps* are caused if there is a shortage of salt.

Salt is lost from the body in two ways :

- (1) *In the urine.*
- (2) *In sweat.*

The amount of salt passed out of the body in urine is regulated by the kidneys *but there is no means of control over the amount of salt lost in sweat.* Extra salt must, therefore, be taken in food (1) in hot climates ; (2) when work is done at high temperatures, for example, by miners in deep pits, stokers, steel workers, or (3) after strenuous exercise.

The daily amount of salt needed by an adult is about 4 grams. The whole of this may, however, be lost in sweat during 3 hours exercise in the sun. People usually eat about 15 grams daily in their food. The amount not needed is harmlessly passed out in the urine.

Besides salt added to meals in cooking or at the table, salt is also present in most foods. Some examples are listed below :

<i>Salt Content.</i>	
	<i>G. per oz.</i>
Cheese	0.3—1.4
Kippers, bloaters	0.3
Bacon	0.3
Bread	0.2
Fish	0.07
Eggs	0.07
Meat	0.06
Milk	0.06
Flour	0.01
Vegetables	0.01

Potassium. Potassium behaves chemically in a similar manner to sodium. In the body, however, whereas sodium chloride (salt) is present in the free fluids, potassium chloride becomes incorporated in the cells of the muscles and the red blood cells of the blood. There is a loss of potassium in urine at the rate of about 3 grams a day. Potassium, unlike sodium, is not lost in sweat. Most common foods contain potassium so that there is little likelihood of any deficiency in normal diets.

Although *potassium deficiency* is never likely to occur in normal European diets, this mineral cannot entirely be forgotten when considering the foods of African races and others who may live on diets including substantial amounts of tapioca or sago, which, together with fats, purified starches such as arrow-root, and tripe, are low in potassium. Figures are shown below :

<i>Normal foods</i>	<i>Potassium G. per oz.</i>
Most meat	0.10
Most fish	0.08
Bread, cereals, etc.	0.04
Milk, eggs	0.04
Vegetables, fruit	0.10—0.03
<i>Deficient foods</i>	
Tapioca	0.00
Arrowroot	0.00
Butter, margarine, fats	0.00
Tripe	0.00
Sago	0.00

Magnesium. Magnesium forms part of the composition of bones and teeth. Since, however, it is present in practically every type of food there seems no chance of any diet being deficient in it.

Sulphur. Sulphur is obtained in the diet combined as a part of other nutrients. In particular, certain *proteins* are of nutritional importance due to the sulphur compounds in them. If an appropriate choice of proteins is made the amount of sulphur needed by the body will almost certainly be obtained.

Iodine. Only very small quantities of iodine are needed by the body although these amounts are quite essential to it. Iodine is derived in the diet from the following sources :

- (1) Drinking water and water used in cooking.
- (2) Sea fish, oysters, mussels, etc.
- (3) Certain vegetables, notably watercress and onions, grown on soils naturally containing traces of iodine.

In certain parts of England, particularly in Cumberland, Yorkshire, Derbyshire, Gloucestershire and Somerset, in some parts of America, in Switzerland

and elsewhere the soil and hence the drinking water and the native vegetables are deficient in iodine and there is, in consequence, a deficiency in the diet. The signs of this shortage are cases of *goitre* among the population. Where *goitre* appears it is wise dietetic practise to use *iodised salt*, containing 1 part of iodine in 100,000 parts of salt, for cooking and on the table.

Fluorine. Fluorine is found in bones and teeth. Its distribution in food is not very well known but it is present to varying degrees in drinking water in different districts of the country. The consumption of a small amount of fluorine is thought by some authorities to improve the hardness of the teeth. Excessive amounts, however, cause chalky white particles known as mottling to occur on teeth. Of all places in England, Maldon in Essex is remarkable for the high proportion of fluorine in the drinking water. The mottling of the teeth among the population of that place is very noticeable.

Copper. Copper is present in very small amounts in almost all foods. Traces of it are necessary in the diet to enable iron, which is dealt with in Chapter VIII, to maintain the appropriate number of blood corpuscles and thus prevent anaemia. A source of copper other than the diet is supplied by copper cooking vessels and provided that only traces of metal come from utensils no harm but only good will arise from this.

Aluminium. Although very minute traces of aluminium are to be found in the human body, so far as is known it plays no part in any life process. While aluminium is, therefore, of no use in nutrition, it is certain that the small amounts normally acquired from aluminium vessels are completely harmless.

CHAPTER VII

CALCIUM AND PHOSPHORUS

The bones and teeth are largely composed of *calcium phosphate* which is a compound of *calcium* and *phosphorus*. It is, therefore, important that the diet should contain (1) enough calcium and phosphorus (2) a *satisfactorily proportion* of calcium to phosphorus.

CALCIUM

Although the bulk of the calcium in the body is found in the structure of the bones, calcium also serves other purposes :

- (1) *It is necessary for the normal clotting of the blood.*
- (2) *It is necessary for the normal functioning of the muscles.* If the level of calcium in the blood falls, muscular cramps occur.
- (3) *It is necessary for the proper growth of children.*

Diets can become deficient in both calcium and phosphorus. In England, however, *although a shortage of calcium was one of the commonest nutritional faults*, shortage of phosphorus is very unlikely.

The Calcium Content of Certain Foods

	Mg. § per oz.		Mg. § per oz.
Dried skim milk	348	Watercress	63
Cheese	230	Cabbage	18
Condensed milk	82	Turnip	16
Liquid milk	34	Cauliflower	14
Egg	17	Potato	2
Whitebait	240	White flour	5
Sardines	114	Bread	4*
Herring	28	Meat, most types	3
Cod	4		

* This figure was increased to 16 in 1942 by the addition of chalk to the National Flour.
 § A milligram is a thousandth part of a gram. Hence 1 mg. = 0.001 g.

Unless the diet contains enough of those few foods which contain substantial amounts of calcium it will almost certainly provide too little for health.

These foods are :

Cheese, milk and milk products.

Fish of which the bones are eaten.

A source of calcium other than food is provided by *water used for drinking or cooking* provided it is "hard" water.

THE NEED FOR CALCIUM

1. **Children.** Children, who are, of course, growing and forming new bones and teeth, need more calcium than adults. If their diet does not provide enough the results are :

- (i) *rickets,*
- (ii) *reduced growth.*

2. **Adults.** Insufficient calcium in the food of adults may lead to :

- (i) *bad teeth,*
- (ii) a reduction in the level of calcium in the blood will probably not occur since the body has power to withdraw calcium from its bones in order to prevent this happening.

3. **Old People.** A constant drain on the calcium in the bones to compensate for a shortage in the diet may be partly the cause of the steady demineralisation which takes place in old age and which leads to *brittleness of the bones.* Many of the "rheumatic" pains suffered by old people may be due to a long-drawn shortage of calcium affecting the joints.

4. **Expectant and nursing mothers.** Expectant and nursing mothers require more calcium than other people. The first, in order to form the bones of the child, and the second, to produce calcium in her own milk. If insufficient calcium is available in the mother's food she will draw on that stored in her own bones, and even in spite of this her *child may be born with rickets or it may readily contract rickets.*

Two outside factors affect the *precise amount of calcium* needed to protect an individual from the different effects of shortage which have been listed :

- (i) The amount of *phosphorus* present in the food together with the calcium.
- (ii) The amount of *vitamin D* in the diet. (This will be discussed in Chapter xii.)

PHOSPHORUS

Phosphorus is used by the body for a number of vital purposes. These uses may be divided into three main groups.

- 1. *Phosphorus, with calcium, is a major constituent of bones and teeth.*
- 2. *Phosphorus plays an essential part in the complex processes by which the body obtains the release of energy from the nutrients of food.*
- 3. *Phosphorus is essential for maintaining that constancy in the composition of the body fluids necessary for the continuance of life.*

Besides these main uses, phosphorus is concerned in the life and structure of all the cells of the body.

The Distribution of Phosphorus in Foods

	<i>Mg. per oz.</i>
Sweetbread, kidney, liver	170
Cheese	140
Meat, fish	70
Egg	60
Bread	40
Milk	27
Vegetables	15
Fruit	5

Except in the case of milk and milk products such as cheese, all common foods contain substantially more phosphorus than calcium. As has been said before, it is very improbable, therefore, for any normal diet to be deficient in phosphorus. This suggests that the consumption of additional phosphorus in medicine is usually unnecessary. Again, although phosphorus is concerned with the functioning of the cells of the brain, as with other cells, phosphorus eaten as food will have no direct influence on the brain as such. Brain itself contains 0.100 g. of phosphorus per oz. which is more than the amount usually present in fish. The suggestion that fish is a "brain food" is therefore unjustified.

THE RATIO OF CALCIUM TO PHOSPHORUS NEEDED IN THE DIET

Adults require for every 1 part of calcium in the diet, 2 parts of phosphorus.

Children need 1 part of calcium for each 1.5 parts of phosphorus.

These ratios, although desirable, are not vital, for two reasons :

- (1) If too much or too little phosphorus is available in proportion to calcium, further supplies of either substance can be withdrawn by the body from the bones.
- (2) A good supply of vitamin D in the diet can compensate for a wrong ratio.

PHYTIC ACID

In bran and the outer parts of cereal grains, the substance *phytic acid* occurs. Phytic acid is a compound of phosphorus. It is unavailable to the body and is excreted in the faeces. Before it is excreted, however, it becomes combined with calcium which may be derived from any other food in the diet. In considering the total amount of calcium and of phosphorus in the day's food it is important to make allowance for the presence of phytic acid in two ways :

- (1) The phosphorus contained in the phytic acid itself will not be available to the body.
- (2) Phytic acid will render unavailable a proportion of the calcium present in other foods.

The amounts of phytic acid in a number of foods is shown below. These figures will be modified in practise by the fact that a proportion of phytic acid itself is destroyed during the process of cooking, during breadmaking and during the passage of food along the digestive tract.

Phytic Acid Phosphorus

	G. per oz.
Oatmeal (dry)	0.075
Haricot beans, butter beans, dried peas (raw)	0.065
Almonds, Brazil nuts, cob nuts	0.050
Wholemeal bread (92 per cent.)	0.025
"National wheatmeal" bread (85 per cent.)	0.012
White bread (72 per cent.)	0.003

It was because many British diets were known to be short of calcium that chalk (calcium carbonate) was added to wheatmeal bread in 1942 to prevent the phytic acid withdrawing more calcium.

OXALIC ACID

Oxalic acid is an organic acid which occurs in small proportions in a number of leafy vegetables. Like phytic acid it possesses the property of combining with calcium. The only two common foods which contain oxalic acid in any quantity are *rhubarb* and *spinach*.

Spinach contains a fairly large proportion of calcium none of which appears to be available. Since the amount of calcium in rhubarb is small, rhubarb may well cause a *loss* of calcium from the body.

CALCIUM IN THE BLOOD

A small constant proportion of calcium is always present in the blood.

This is needed :

- (a) as part of the mechanism of clotting ;
- (b) for the proper functioning of the muscles.

In order that the amount of calcium in blood shall always remain constant, the bones act as a reservoir from which calcium can quickly be obtained, and into which excess calcium can be placed. The *parathyroid gland*, which is a small organ in the neck attached to the thyroid, controls the level of calcium in the blood. If the parathyroid becomes diseased or damaged, the amount of calcium in the blood may fall. Should this happen a condition of *tetany* occurs which may quickly prove fatal.

ABSORPTION OF CALCIUM

Although substantial amounts of calcium may be present in the diet, a number of factors may interfere with its absorption by the body. The influence of phytic acid and oxalic acid have already been mentioned. Another substance may be phosphorus. It has been said that 2 parts of phosphorus *are needed* to 1 of calcium for proper absorption. If, however, the amount of phosphorus in relation to calcium becomes unduly large so that the ratio 2 : 1 becomes, say, 6 : 1 or more, the absorption of calcium will be upset. A ratio of 6 : 1 may indeed produce rickets.

Two other factors which affect calcium absorption can be mentioned.

- (1) The constant use of Epsom salts (magnesium sulphate) may interfere with calcium absorption by converting calcium into calcium sulphate which is insoluble.
- (2) Very large amounts of unabsorbed fat in the intestine may prevent the body from obtaining calcium from food.

CHAPTER VIII

IRON

The substance which gives blood its red colour is built up on a basis of the metal *iron*. This iron must, in the first place be derived from food. It is, therefore, essential for health that the diet contains sufficient iron.

Once iron is absorbed by the body, it is only lost again very slowly. The red part of blood which contains the iron, is composed of a number of cells. These are the *red blood corpuscles*. The life of each corpuscle is about 6 weeks. At the end of that time, the corpuscles break up and the iron is released. It does not, however, escape from the body but *is used again* for the formation of fresh corpuscles. These new blood cells are produced in *the marrow of the bones*. In spite of the fact that iron is used over and over again, it may be lost from the body in two ways and must, therefore, be replaced by the food.

- (1) *Iron is lost by the general wear and tear of the body* and in the remains of the digestive juices passed out in faeces.
- (2) *Iron is lost from the body whenever bleeding occurs.*

If food provides insufficient iron to replace the body's losses, *anaemia* will eventually occur. Two points must, however, be remembered when the nutritional significance of anaemia is considered.

- (1) *Anaemia may be due to many other causes as well as to iron deficiency.*
- (2) *Once anaemia has arisen very much larger amounts of iron must be consumed than can be conveniently supplied in food if it is to be quickly cured. These large amounts are best given as inorganic iron in medicine.*

The distribution of iron in foods

	<i>Mg. per oz.</i>		<i>Mg. per oz.</i>
Liver, kidney	3.0	Raisins	0.5
Corned beef	3.1	Fish	0.4
Beef	1.1	Watercress	0.4
Eggs	0.8	Cabbage	0.3
Wholemeal bread	0.7	Potato	0.2
Baked beans	0.7	White bread	0.2
Mutton	0.6	Milk	0.0

Although most of the iron taken into the body is derived from the foods listed in the table above, there are, besides food, two other sources from which useful amounts of iron can be obtained.

- (1) *Nutritionally valuable amounts of iron may be present in the water used for drinking and cooking.*
- (2) *Iron can also be obtained from kitchen knives and iron utensils.*

Curry powder contains large amounts of iron. Most of this is derived from the iron vessels in which it is made.

There is a fourth source of iron, other than food, water and utensils, which is used today more by animals, particularly pigs, than by men. *Earth* contains substantial proportions of iron. If weanling pigs are kept in clean concrete styes where they cannot get earth to eat they develop anaemia. Although earth is not eaten purposely in England, this practice is followed by some African races.

THE AVAILABILITY OF IRON IN DIFFERENT FOODS

If an individual has become anaemic due to a lack of iron in the diet, equal amounts of iron, as determined by chemical analysis, will relieve the condition to different degrees if they are provided in different foods. That is to say the *availability* of the iron is greater in some foods than in others.

Iron is not necessarily absorbed into the body even if it is completely "available". *Only when the body has need of iron is it absorbed.*

THE INFLUENCE OF PHYTIC ACID ON THE AVAILABILITY OF IRON IN THE DIET

Just as *phytic acid* becomes combined with calcium and causes its consequent loss to the body, so also does it combine with iron. Thus if foods which contain comparatively large proportions of phytic acid such as nuts, haricot beans or oatmeal, form any substantial proportion of the diet, some of the iron which might otherwise have been absorbed by the body will be lost to it.

IRON AND THE LIFE OF THE BODY'S CELLS

Besides being an essential component of blood, iron fills another main function in the body. It is present in muscle cells and elsewhere as *one link in the gradual process by which the energy from food nutrients is continuously made available.*

IRON AND COPPER

It has already been stated that *copper* is needed together with iron in order that the iron may fulfill its functions in the body. The amount of copper needed is very small and in considering problems of practical nutrition it is not necessary to worry about the copper of the diet since sufficient will almost certainly be present. Iron itself, on the other hand, may easily be insufficiently supplied.

CHAPTER IX

VITAMIN A

The nutrients which are classified as vitamins are organic substances present in small quantities in foods, necessary for the life of the body, but which the body is unable to form for itself.

Vitamin A is a substance which occurs in certain fats and in the fatty part of some foods.

In the body, vitamin A serves several functions.

- (1) It is necessary for the *growth* of children.
- (2) It plays a part in *the way the eyes perceive light*.
- (3) *It protects the skin and particularly moist areas, such as the front of the eyes, the lining of the respiratory tract, throat and bronchial tubes, etc.*

A definite amount of vitamin A is necessary for the health of the body. If this amount is not obtained trouble will arise. On the other hand, however, if more vitamin is consumed than is needed there will be no *added benefit* to health.

Vitamin A activity is provided :—

- (1) By animal foods such as liver, dairy produce and eggs.
- (2) By green vegetables and carrots.

The amount of vitamin A in foods is measured in *international units*.

The distribution of vitamin A in foods is shown below.

(Average values.)

	<i>Vitamin A</i> International units per oz.
1. <i>Animal foodstuffs</i>	
Halibut liver oil	600,000
Cod liver oil	30,000
Ox liver	6,000
Butter	1,140
Cheese	370
Kidney	280
Eggs	280
Sardine	77
Herring	42
Most meats	14
2. <i>Vegetable foodstuffs</i>	
Carrots	1,730
Spinach	1,230
Dried apricots	470
Watercress	470
Tomato	280
Dried prunes	240
Cabbage	85
Green peas	47
Potato, onion	0

Fish liver oils are by far the most concentrated natural sources of vitamin A. They are used to fortify with vitamin A such foods as margarine, which do not naturally contain any. In 1940, margarine in Britain was fortified in this way with 450 international units of vitamin A per ounce.

The dairy products, milk, butter, cheese and eggs may vary in the amount of vitamin A they contain depending on the amount in the food of the cow or hen. The concentration is usually highest in the summer when green grass is available.

With green vegetables, the amount of vitamin A they contain is *proportional to their greenness*. Dark green plants, such as watercress contain greater vitamin A activity than paler vegetables such as cabbage. And in cabbage, there is more vitamin A in the dark outer leaves than in the pale inner heart. In carrots, the amount of vitamin activity is *proportional to their yellowness*.

The body can store vitamin A in the liver. Hence, if a large amount of vitamin is eaten in the autumn it may suffice to maintain the body adequately for some time during the winter. This method of supplying vitamin A is, however, wasteful as more of it must be taken as one dose than would be needed as a steady daily amount. The high vitamin A value of liver as a food is due to the use of this organ for storage by the animal from which the liver was taken.

THE AVAILABILITY OF VITAMIN A IN DIFFERENT FOODS

The assessment of the amount of vitamin A in foodstuffs is measured fundamentally by comparative tests on animals carried out in parallel with simultaneous tests with the international standard. Based on these assays there are a number of analytical methods which can also be used. Although these methods measure precisely the amount of vitamin A in foodstuffs the *availability* of the vitamin to man differs for different materials.

(1) Vitamin A *in animal foods* is more effective in the human body than vitamin A activity in *vegetable foods*.

(2) Vitamin A in carrots which possess a tight, fibrous structure, is less readily available to the body than vitamin A in green vegetables.

The assessment of the total amount of vitamin A needed daily by different individuals is usually an average figure assuming the consumption of a mixed diet. If, however, all the vitamin is derived from animal sources, less will be needed.

THE DIFFERENCE BETWEEN ANIMAL AND VEGETABLE VITAMIN A

Chemically, vitamin A in cod-liver oil and other animal foods differs from the substances which give vegetables their vitamin A-activity. The vitamin A in cod-liver oil is chemical vitamin A itself, often called *pre-formed vitamin A*. The main substance which gives vegetables their vitamin activity is the orange pigment *carotene*. In dairy produce most of the vitamin A is *pre-formed vitamin* but part is *carotene*.

When carotene is absorbed into the body it is converted into vitamin A. Rats, which are used for measuring the number of international units of vitamin A in foodstuffs, can change carotene into vitamin A very efficiently. Men are apparently not so efficient. This is the explanation of the greater effectiveness of animal sources of vitamin A over vegetable sources in the diet. Certain animals are less efficient even than man. Cats, for example, cannot convert carotene into vitamin A. Mice, however, can. The cats take advantage of this by eating mice, in whose liver the vitamin A has been stored,

CHAPTER X

THE VITAMIN B GROUP OF NUTRIENTS

The term *vitamin B* comprises a number of substances which are often, but not always, found together in the same foods.

The individual members of the group to be considered here, include the following :

- (1) *Vitamin B₁* also called *aneurin* in England and *thiamin* in America.
- (2) *Riboflavin*. This substance is sometimes called vitamin B₂, but this name is now becoming obsolete.
- (3) *Nicotinic acid*, recently called *niacin* in America.

Besides the three substances mentioned above, at least five other vitamin B-factors must be provided in food.

VITAMIN B₁

1. Vitamin B₁, like all the other members of the vitamin B group of nutrients is *soluble in water*.

2. The function of vitamin B₁ in the body is to form a part of the subtle machinery by means of which a steady and continuous release of energy is obtained from carbohydrate.

3. The signs of ill health which develop if insufficient vitamin B₁ is provided by the diet are :

- (i) A check in the growth of children.
- (ii) The development of a special type of neuritis.
- (iii) Extreme deficiency results in the disease beri-beri, seldom seen in Europe but common in the Far East where many people live largely on white rice from which most of the vitamin B₁ has been removed during its preparation.

Vitamin B₁ is distributed in foods as shown in the table below :—

	<i>Vitamin B₁</i> <i>Mg. per oz.</i>
Dried brewers' yeast	1.230
Peanuts	0.252
Bacon	0.168
Green peas	0.117
Liver	0.114
Wholemeal bread	0.087
Mutton	0.045
Egg	0.042
Potato	0.033
Beef	0.021
Cabbage	0.021
Fish	0.018
White bread	0.015
Milk	0.012
Sugar	nil

RIBOFLAVIN

1. Riboflavin, like vitamin B₁, is also *soluble in water*.

2. Its function, again like vitamin B₁, is also to form a link in the chain of processes through which the body obtains energy from food nutrients.

3. *When insufficient riboflavin is provided by the diet, the following symptoms occur :*

- (i) The growth of children is checked.
- (ii) Cracks and sores appear in the skin at the corner of the mouth.
- (iii) The tongue becomes red and sore.
- (iv) Finally, the transparent front of the eyes may become misted.

Foods in which riboflavin is provided in the diet are shown below :—

	<i>Riboflavin Mg. per oz.</i>
Dried brewers' yeast	1.37
Liver	0.85
Meat extract	0.48
Cheese	0.14
Egg	0.11
Peanuts	0.08
Beef	0.07
Wholemeal bread	0.05
Milk	0.04
Fish	0.04
Potato	0.02
White bread	0.01
Beer	0.01
Sugar	nil

NICOTINIC ACID

1. The vitamin nicotinic acid is *soluble in water*.
2. It also, like the other B-vitamins which have been described, has a function concerned with the *release in the body of energy from carbohydrate*.
3. Shortage of nicotinic acid in the diet leads to the following effects :
 - (i) Growth is checked.
 - (ii) Roughening and redness of the skin occurs, especially on parts of the body exposed to light.
 - (iii) The tongue becomes sore and red.
 - (iv) Diarrhoea and other digestive symptoms occur.
 - (v) Mental symptoms, dementia, etc., arise.
 - (vi) The disease, pellagra, marked by all or most of these symptoms, occurs when deficiency of nicotinic acid is extreme. This disease is an aggravation of many of the symptoms noted above.

The foods in which nicotinic acid is found are shown in the list below :

	<i>Nicotinic acid Mg. per oz.</i>
Dried brewers' yeast	21.8
Meat extract	17.0
Liver, kidney	3.8
Peanuts	2.6
Beef	1.3
Bacon	1.2
Cod	0.6
Wholemeal bread	0.6
Watercress	0.5
Potato	0.3
White bread	0.2
Apple	0.1
Cabbage	0.1

1. The amount of vitamin B₁ needed in the diet is proportional to the number of calories provided by any *nutrient other than fat*. In order to make use of 100 calories from carbohydrate or protein, the body requires 0.045 mg. of vitamin B₁. To decide, therefore, whether any particular food is or is not a real source of vitamin B₁ in the diet it is necessary to calculate whether it provides more than 0.045 mg. for each 100 calories.

For example :

1. *Wholemeal bread* 1 oz. provides 65 calories little of which is derived from fat.

1 oz. contains 0.087 mg. vitamin B₁.

Hence sufficient wholemeal bread to provide 100 calories also provides 0.134 mg. of vitamin B₁. This is in excess of the amount of 0.045 mg. required. So that *wholemeal bread provides vitamin B₁ in the diet*.

2. *White bread* 1 oz. provides 73 calories.

1 oz. contains 0.015 mg. vitamin B₁.

Hence, sufficient white bread to provide 100 calories contains only 0.020 mg. of vitamin B₁. This is less than the 0.045 mg. needed by the body. *White bread is, therefore, deficient in vitamin B₁*, and constitutes a drain on the diet.

If similar calculations are made, it will be found that most natural foods including potatoes, green vegetables, milk and dairy produce all add some vitamin B₁, at least, to the diet. *Almost the only foods grossly deficient in vitamin B₁ are white bread, flour and sugar*.

2. Among the everyday foods, the best sources of *riboflavin* are liver, eggs and dairy produce. In the manufacture of beer, grain is mashed in water, sugar is added and the resulting mixture fermented with yeast. The yeast, which is a living organism, takes up for its own purposes the vitamin B₁ from the grain. It therefore becomes, as can be seen from the list, an outstandingly rich source of vitamin B₁. The yeast, however, does not absorb riboflavin or nicotinic acid to such an extent. Consequently beer contains quite substantial amounts of these vitamins.

3. The principal source of nicotinic acid in the diet is meat.

Chemically *vitamin B₁* is a substance composed of carbon, hydrogen, oxygen, nitrogen and *sulphur*. In the body it also becomes combined with *phosphorus*.

Riboflavin is a yellow substance which possesses a green fluorescence in solution. The slight green fluorescence of whey is caused by the riboflavin in it. Its components are carbon, hydrogen, oxygen and nitrogen. It also combines with *phosphorus* in the body.

Nicotinic acid is also composed of carbon, hydrogen, oxygen and nitrogen. It is chemically similar to part of the substance *nicotine*, although nicotinic acid is not derived from nicotine in nature nor does tobacco smoking supply the body with nicotinic acid.

Among a number of other substances which are classified as vitamin B-factors are the following :

- (i) *Pyridoxin*, also called vitamin B₆, is a compound which plays some part in maintaining the health of the skin. Pigs whose diet is deficient in vitamin B₆ develop epileptic fits.
- (ii) *Pantothenic acid* is another vitamin, deficiency of which is also first shown by defects in the skin.
- (iii) *Biotin* is a vitamin which is interfered with by a substance present in raw egg white. If *raw* egg white is eaten in large quantities, biotin cannot function properly in the diet and symptoms of illness occur. Egg white does not exert this effect if it is cooked.
- (iv) *Folic acid* is a vitamin originally derived from leaves. It has a beneficial effect on certain types of anæmia.

CHAPTER XI

VITAMIN C (ASCORBIC ACID)

In applying the science of nutrition to the practical planning of diets a considerable amount of attention must be paid to ensuring an adequate supply of vitamin C. *A proper supply of all vitamins is necessary for an adequate diet*, but in many cases individual substances may be so widespread in their distribution and required by the body in such small amounts that no problem arises in obtaining enough. For example, *vitamin A* is present in animal foods, such as dairy produce and eggs, and in vegetable foods such as greens and carrots. *Vitamin B₁* is found in almost all foods where it is needed *except* in white flour and sugar. It is therefore not difficult to design a diet containing enough of these two nutrients, even though this is not always done.

The two facts which make it easy for a diet to be insufficiently provided with vitamin C are :

- (1) *Vitamin C mainly occurs in vegetable foodstuffs*, i.e., fruit and vegetables. Amongst animal foods are *fresh liver* which may contain it, and *fresh meat* which contains a very small amount, and milk.
- (2) *Vitamin C may easily be destroyed by cooking*, indeed, even if the best methods are used, it is difficult not to lose at least half the total amount originally present.

If insufficient vitamin C is provided by the diet, the following ill-effects will arise :

- (i) the growth of children will be checked ;
- (ii) the gums and mouth will become susceptible to infection ;
- (iii) the healing of wounds and fractures becomes slower ;
- (iv) the final result of a shortage of vitamin C is the appearance of the disease, scurvy.

Vitamin C is very easily *soluble in water*. In the plants in which it is found, however, the vitamin is enclosed within the vegetable cells. In these vegetable cells, together with vitamin C, there is an *enzyme*, which is a substance designed to work with the vitamin in carrying on the harmonious life of the plant. When, however, plant cells are destroyed by man, either by cooking, or by mechanical means, such as grating or mincing, the ordered life of the plant is disrupted and the *enzyme* destroys the *vitamin C*. This destruction can be minimised by destroying the enzyme itself. The point is discussed further in Chapter XVI.

The amount of *vitamin C* in a number of common foodstuffs is shown below :

	<i>Vitamin C</i> <i>Mg. per oz.</i>
Blackcurrants	57
Brussels sprouts	28
Cauliflower	20
Cabbage	20
Watercress	17
Oranges	16
Grapefruit	14
Lemon	12
Potato	
New	8
October, November	4
December	3
January, February	2
March	1
Lettuce	4
Onion, carrot	3
Apple, plum, pear	1

1. In green vegetables, the amount of vitamin C is highest in the spring and early summer when the plants are making rapid growth. For example, Brussel sprouts and spring cabbage harvested when they are growing most quickly in the first of the season's warm weather may contain 50 or 60 mg. of vitamin C per oz.

2. When vegetables begin to wilt, either through long storage or other causes, vitamin C is quickly lost.

3. As can be seen from the table, the vitamin C in potatoes decreases during storage. The concentration is highest in July and August when the crop is dug and thereafter steadily falls during the winter and spring. Although the amount of vitamin C in an ounce of potato is never as high as that in other foods, potatoes are usually the principal sources of vitamin C in the diet because quite large amounts of them are eaten and they are eaten every day. Before potatoes were introduced into Europe, scurvy was a common disease at the end of every winter.

Although blackcurrants, followed by oranges, lemons and grapefruit, are among the richest *common* sources of vitamin C, higher concentrations have been discovered in less common articles. For example :

- (1) *Rose hips* may contain up to 700 mg. of vitamin C per oz., that is 2.5 per cent. of the fruit consists of vitamin. The average figure for rose hips is about 170 mg. per oz. Hips cannot be eaten as such because the fine hairs surrounding the pips irritate the digestive tract. Syrups and other forms of extract can, however, be made from them.
- (2) *Unripe walnuts*, at about the stage at which they are normally pickled, contain large quantities of vitamin C. The figure to be expected is some 500 mg. per oz. Although this vitamin concentration *can* be preserved in pickled walnuts, the normal commercial pickled walnuts usually contain no vitamin C at all.

THE NEEDS OF VITAMIN C OF ANIMALS

If the human diet does not contain vitamin C, health will suffer and finally the disease of scurvy will occur. The need for vitamin C is not, however, shared by all animal species. Although guinea pigs, like men, need vitamin C to protect them against scurvy, rats can make the vitamin for themselves and can live on a diet entirely devoid of it.

THE FORMATION OF VITAMIN C

Except for a few animal foods such as liver and milk *vitamin C is only found in fruit and vegetables*. Seeds, including cereal grains and, it is important to note, dried peas and beans contain no vitamin C whatever. When seeds are sprouted, however, vitamin C develops in them. If, therefore, individuals find themselves compelled to live under circumstances in which it is impossible to obtain normal sources of vitamin C, ill-health can be avoided if dried peas or grains are moistened, allowed to sprout and then eaten in that form.

VITAMIN C IN MILK

An infant derives the vitamin C it needs from milk. Even cow's milk, which soon becomes an important item in infants' diets, contains 0.6 mg. of vitamin C per oz. Two factors, however, play a large part in determining the value of cow's milk as a source of vitamin C for children in actual practise. These factors are:—

- (1) *The influence of copper*. If minute amounts of copper become dissolved in milk from dairy utensils, pasteurising machinery or from water used to wash pails and equipment, vitamin C will be destroyed.

- (2) *The influence of light.* Milk contains riboflavin. This substance, in the presence of light quickly causes the destruction of vitamin C. If, therefore, a bottle of milk is left for an hour or so in the bright morning sunshine on a doorstep it is unlikely to retain more than a negligible amount of vitamin C.

For these reasons it is wise dietetic practice to give orange juice or some other source of vitamin C to bottle-fed infants at an early age.

CHAPTER XII

VITAMIN D

Vitamin D is a substance which is concerned in the laying down of calcium and phosphorus in bones.

Because of its function, vitamin D is of special importance :

- (1) To infants and children whose bones are in the process of growth and development.
- (2) To expectant mothers in whom the bones of a foetus are developing.

When insufficient vitamin D is present in the diet of infants and children, the disease of rickets occurs. Since, however, the formation of bone depends on

- (a) the total amount of *calcium* absorbed from the diet,
- (b) the total amount of *phosphorus* absorbed from the diet,
- (c) *the proportion of calcium to phosphorus,*

it is not easy to assess the precise amount of vitamin D which will be needed to ensure that the calcium and phosphorus are properly converted into bone.

SOURCES OF VITAMIN D

The body obtains vitamin D from two distinct sources :

- (1) *From food.*
- (2) *From sunlight.*

Foods which supply vitamin D are, with very few exceptions, animal products. The amounts present in some common foods are shown below :—

	<i>Vitamin D international units per oz.</i>
Cod-liver oil	3,000
Herrings	240
Sardines	280
Tinned salmon	170
Eggs	17
Butter	17
Cheese	10
Milk	0.3

Sunlight acting on the skin can cause the formation of vitamin D in the body itself. Thus, if children receive sufficient sunlight on their bodies, the amount of vitamin D they will need from their food will be very much reduced.

Sunlight, or another source of ultra-violet light, acting on certain foods which do not contain vitamin D, can cause the formation of the vitamin in these foods just as it does in the skin of the body. Cacao-shells, which are a by-product of the manufacture of chocolate, contain quite large amounts of vitamin D formed by the sun during the fermentation of the cocoa-beans as part of their process of manufacture.

THE NEED OF ADULTS FOR VITAMIN D

Although infants, children and expectant mothers have by far the greatest need of vitamin D, adults probably require a small amount. When supplies of calcium and phosphorus in a diet are insufficient and, in addition, the diet does not contain vitamin D, adults may develop a disease of the bones bearing some similarity to rickets. This disease is *osteomalacia*.

THE NATURE OF VITAMIN D

Vitamin D is *not* soluble in water. Like vitamin A, it occurs only *in fats* and the fatty parts of foods. Vitamin D is comparatively resistant to heat and to the conditions likely to occur in cooking and handling food.

IRRADIATED ERGOSTEROL

The substance in foods which becomes converted into vitamin D upon exposure to ultra-violet light is *ergosterol*. If ergosterol is irradiated under controlled conditions a pure crystalline vitamin can be obtained. This material is *vitamin D₂* (also called calciferol).

In order to distinguish vitamin D₂ from the vitamin found in cod-liver oil, milk, etc., the latter is called *vitamin D₃*. It can be made artificially by exposing a substance known as dehydrocholesterol to ultra-violet light.

THE COMPARISON BETWEEN VITAMIN D₂ AND VITAMIN D₃

1. *Vitamin D₂* (irradiated ergosterol, calciferol). For certain species of animals, vitamin D₂ has an activity equal to vitamin D₃. Thus, it is completely effective in preventing and curing rickets in *rats*. It is also equally effective in man.

Vitamin D₂ does not, however, possess as potent an effect when used for the prevention of rickets in poultry, which often suffer from the disease when badly fed.

2. *Vitamin D₃* (found naturally in cod-liver oil, dairy produce, etc.). Vitamin D₃ has an equal effect on bone formation in all the animals, including man, for which vitamin D₂ can be used. Poultry and other birds which are particularly subject to rickets are protected by vitamin D₃. For these species, very much larger amounts of vitamin D₃ have to be given in order to achieve the same result.

3. Both vitamin D₂ and vitamin D₃ can be manufactured. It is vitamin D₂, however, which for technical reasons is usually employed for the fortification of margarine or for pharmaceutical preparations.

QUESTIONS

PART II

(Chapters VI to XII)

1. For what main purposes are inorganic mineral substances used by the body?
2. What are bones principally made of?
3. What is the function of salt in the body?
4. How does the body lose salt?
5. Why do stokers in steamships like kippers?
6. What is iodised salt and what is it used for?
7. A shortage of two different minerals may cause muscular cramp. Which are they?
8. What purposes does calcium serve in the body?
9. Which contains more calcium: meat or cheese?
10. Why can canned salmon be a better source of calcium than fresh salmon?

11. Why do children need calcium specially ?
12. What other kinds of people have special need for calcium besides children ? Why ?
13. Why is it more necessary to worry about the amount of calcium in the diet than about the amount of phosphorus ?
14. What is the principal use of iron in the body ?
15. How is iron lost from the body ?
16. Which foods are the best sources of iron ? Is milk a good source ?
17. What sources other than food may provide iron for the body ?
18. What does vitamin A do in the body ? What kind of foods contain vitamin A ?
19. How could you tell by looking at it whether one cabbage contained more vitamin A than another ?
20. Can vitamin A be stored in the body ?
21. Vitamin B₁, riboflavin and nicotinic acid are all concerned together in one function in the body. What is it ?
22. What purposes does vitamin C serve in the body ? What foods provide vitamin C ?
23. When do potatoes contain most vitamin C and when do they contain least ?
24. What does vitamin D do ? What foods contain it ? How, otherwise than from food, can vitamin D be obtained ?
25. What is phytic acid ? What does it do and which foods contain it ?
26. Under what circumstances is iron best absorbed by the body ?
27. Vitamin B₁ is notoriously lacking in two foods : which are they ?
28. Which are the best sources of riboflavin and of nicotinic acid in the diet ?
29. What is the difference between vitamin A from animal and from vegetable foods ?
30. Why does milk from the dairyman seldom contain any vitamin C at all ?

PART III

CHAPTER XIII

THE DIGESTION OF FOODS, THE ABSORPTION OF NUTRIENTS, AND THEIR FATE IN THE BODY

Food has been defined as anything, either solid or liquid, which when it is swallowed can (i) supply the body with energy, (ii) enable the body to grow, or (iii) regulate the mechanism of the body.

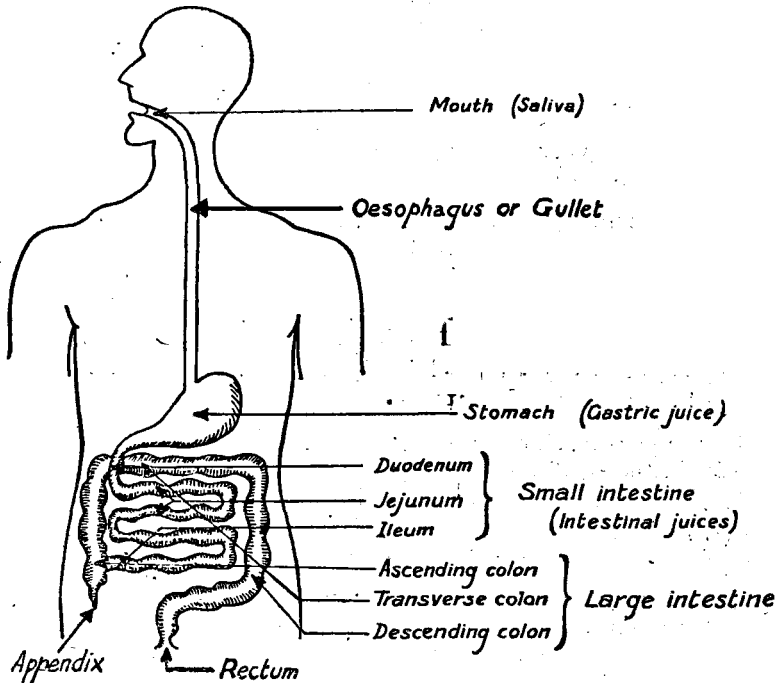
Food can do none of these things until it is *absorbed*. While a piece of bread still remains in a person's mouth, it has not exerted any of the properties of food and it can still be spat out. Indeed, substances can travel further than the mouth without necessarily being absorbed *into* the body. For example, even after poison has reached the stomach, it can still be recovered again if an emetic is given quickly enough. It can thus be said that :

- (1) *As long as nutrients remain in the digestive tract they are not IN the body and cannot exert any of their real functions as essential components of food.*
- (2) *It follows from this, that if food has exerted an influence on the body, whether it be the supply of energy, the stimulation of growth or the regulation of function, it must have been absorbed from the digestive tract into the body itself.*

Thus we can say *that the body itself*, in which the processes of life are found, includes the head, the limbs, the skeleton, the blood system and, in fact, all the parts through which blood flows. Within this living body there lies what, in spite of many elaborations, amounts to a tube, open at both ends. This tube is the *digestive tract*. As long as food is still in this tube it is *outside* the body. Only when the digested food has passed through the moist sides of the digestive tract into the blood beyond can it be said to have passed *into* the body.

1. **Digestion.** Before the nutrients in food can hope to pass through the walls of the digestive tract *into* the body, the food must be broken down into its component parts by *digestive juices* and by the *mechanical action* of the teeth and other parts of the digestive tract. *This process of breakdown is digestion.*

2. **Absorption.** The process by which separate nutrients and the broken-down products of nutrients are passed *through* the walls of the digestive tract into the blood on the other side is *absorption*. Only after absorption has taken place can the body obtain benefit from food.



THE DIGESTIVE SYSTEM.

A. THE PROCESS OF DIGESTION

1. The Mouth.

- (a) Food is mechanically broken down by chewing.
- (b) It is mixed and moistened with *saliva*.
- (c) The saliva breaks down a small amount of cooked *starch* into the sugar, *maltose*.

2. The Stomach.

- (a) More mixing and mechanical breakdown occurs in the stomach.
- (b) Between 2 and 3 quarts of *gastric juice* are produced each day by a normal stomach. This juice, for the performance of its work, contains 0.2 per cent. to 0.4 per cent. of *hydrochloric acid*. By the action of gastric juice:—
 - (i) Proteins are partly broken down.
 - (ii) Milk is curdled in preparation for digestion.

3. The Small Intestine :

- (a) *Starch* is broken down to glucose in the small intestine.
- (b) *Proteins*, partially digested in the stomach, are divided into their final units in the intestine.
- (c) *Fats* are emulsified and the glycerol broken off them so that they may become soluble in water.

4. **The Large Intestine.** Bacteria in the large intestine themselves use for food substances which have resisted digestion thus far. The action of these bacteria may break down substances such as cellulose and thereby make a small amount of them available for human absorption.

B. THE PROCESS OF ABSORPTION

1. **The Mouth.** Very little is absorbed into the body through the lining of the inside of the mouth.

2. **The Stomach.** The following substances pass in small quantities through the lining of the stomach into the blood behind :

- (a) Alcohol.
- (b) Sugar.
- (c) Mineral salts which are soluble in water, e.g. salt.
- (d) Vitamins which are soluble in water, e.g. B vitamins, vitamin C.
- (e) Water.

3. **The Small Intestine.** The greater part of the absorption of all nutrients takes place in the small intestine.

- (a) Carbohydrate.
- (b) Protein.
- (c) Fat.
- (d) Minerals.
- (e) Vitamins.
- (f) Water.

4. **The Large Intestine.** Very little absorption occurs in the large intestine. A small amount of nutrients freed by bacteria from otherwise indigestible material such as cellulose is absorbed. Otherwise, one of the principal functions of the large intestine is to absorb *water* from the indigestible residue of foodstuffs and the remains of the digestive juices which go to form *the faeces* which are finally passed out of the body.

C. THE PROCESS OF EATING

1. **Appetite.** The thought of food, the sight of it and the savoury smell of an attractive meal causes :

- (a) saliva to flow into the mouth ;
- (b) gastric juice to flow into the stomach.

2. **Digestion in the Stomach.** After it has been chewed and mixed with saliva in the mouth, the food is swallowed and passes into the stomach. Different foods stay in the stomach for different lengths of time between 2 and 4 hours, after which period the lower end of the stomach opens and allows squirts of the now semi-liquid food to pass into the small intestine.

3. **Digestion in the Small Intestine.** The small intestine is a tube, one inch in diameter and about 20 feet long.

- (a) The first 12 inches of intestine nearest the stomach is called the *duodenum* ("duodecem" is Latin for 12). Intestinal juices enter the intestine in the duodenum.
- (b) The next 9 feet of intestine are called the *jejunum* ("jejunus" is Latin for "empty." The jejunum is usually found to be empty after death).
- (c) The final 9 or 10 feet of the small intestine make up the *ileum*.

Food is moved down the whole length of the intestine by rhythmic muscular contraction of the gut walls. Absorption occurs all along the route. The final residue begins to be passed in liquid form through a valve, which prevents any reverse movement, into the large intestine about 4 hours after the meal is eaten.

4. **Passage through the Large Intestine.** The large intestine is a tube 2 inches in diameter and about 5 feet long. The first part, on the right side of the body, where the faeces travel *up*, is the *ascending colon*. The portion passing *across* the body from right to left is the *transverse colon* and the last main portion on the left side of the body, down which the faeces move is the *descending colon*. Faeces are finally expelled from the large intestine through the *anus*. It is quite normal for faeces to leave the body 24 hours or more after the meal from which they were derived was eaten.

THE ABSORPTION OF WATER

Water never passes "straight through the body." When water, or watery liquids such as beer, is drunk, about one-fifth is absorbed into the blood through the *stomach* and the remaining four-fifths through the *small intestine*. If an excess of water is taken sufficient to dilute the blood, enough will be withdrawn by the kidneys so that the proper steady composition of blood shall be maintained. This automatic control by the *kidneys* is so sensitive and rapid that within an hour or less of drinking in excess of the body's needs, the water will have been passed out again through the kidneys.

THE FATE OF NUTRIENTS IN THE BODY

1. **Carbohydrates.** Carbohydrates are partially broken down by *saliva* in the mouth, they traverse the stomach and are finally split up entirely into sugars in the *small intestine*. There they pass through into the blood. The *digestibility* of carbohydrates in a normal mixed diet is about 98 per cent.

The blood stream carries sugars derived from food to the *liver* where they are stored as glycogen (see p. 5) until the body needs them. If the liver already contains a large amount of carbohydrate, part of it may be converted into *fat* and laid down in the tissues.

During the course of bodily activity, glucose is used up by the muscles. Supplies are consequently transferred by the blood from the liver to the muscles to take the place of the glucose expended.

2. **Fats.** Fat passes unchanged through the mouth and the stomach. In the *intestine*, however, it is finely divided until completely emulsified, broken into its constituent parts and absorbed into the blood. The average *digestibility* of fat is 95 per cent.

When it is in the blood stream, more than half the fat from the food is laid down in the layers of the body's own fat. The remainder is brought to the liver where some of it may be used, together with carbohydrates for the production of energy.

3. Proteins. Proteins pass through the mouth unchanged. They are partly broken down in the *stomach* and the process is finally completed in the *small intestine* where absorption takes place. The *digestibility* of protein in a mixed diet is about 92 per cent. complete.

The components of proteins pass through the small intestine into the blood and are carried to the liver where two things may happen.

- (i) If carbohydrate has not been eaten with the protein, the protein will be used for the production of energy.
- (ii) If protein has been absorbed together with other nutrients, its constituents may be carried to any tissue of the body where there is need for them and converted into the body's own structure.

4. Minerals. (i) *Soluble salts* such as salts of sodium and potassium are readily absorbed by the *stomach* and the *small intestine*. Salts of this nature additional to the body's needs are passed out of the body by the kidneys.

(ii) *Calcium* is absorbed in the *small intestine*. The proportion of calcium in foods which is unavailable to the body travels through the large intestine and is lost with the faeces.

(iii) *Iron* is only absorbed by the body with difficulty. It passes into the blood through the walls of the small intestine when there is a need for it. Excess iron leaves the body by the large intestine. If much larger amounts of iron are eaten than the body requires, the faeces, in which the iron is passed out, become very dark in colour.

5. Vitamins. (i) *The water-soluble vitamins B and C* are absorbed in the stomach and in the small intestine. Little of these can be *stored* in the body. If more of them is eaten than is needed to saturate the blood, the excess passes through the kidneys and is lost in the urine.

(ii) *The fat-soluble vitamins A and D* are absorbed only in the small intestine. Excess of these vitamins can be stored in the liver and only in exceptional circumstances is any lost in the urine. If large amounts of undercooked carrots, to take an example, are eaten the cells of the plant may not be completely digested and part of the vitamin A may be lost in faeces.

THE DIGESTIVE JUICES

1. Saliva is derived from glands in and under the tongue and in the mouth. Thoughts of food, and the smell and taste of food cause a flow of saliva.

2. Gastric juice is derived from the stomach itself in the same way that sweat is derived from the skin. Besides *hydrochloric acid*, which has already been mentioned, gastric juice contains *pepsin* which acts specifically to split protein. *Gastric juice* flows into the stomach when saliva flows into the mouth.

3. Intestinal Juices. (i) When food has been digested sufficiently long in the stomach the semi-liquid mixture of food and acid gastric juice begins to pass into the small intestine. The effect of the *acid mixture* falling on the walls of the intestine causes a substance, *secretin*, to be passed into the blood. The *secretin* is carried by the circulation of the blood to the *pancreas*, which is an

organ connected by a tube to the *duodenum*. When the secretin reaches the pancreas it causes a digestive juice to be produced which passes into the duodenum.

(ii) A second liquid, bile, also comes into the duodenum, this time from the *liver*. Bile breaks up fat into minute globules so that it can be chemically split by the digestive juice from the pancreas.

(iii) A third juice is derived, like gastric juice, from the walls of the small intestine itself.

APPETITE, FLAVOUR AND DIGESTION

Appetite. (i) When the stomach is empty and the body is short of calories, hunger pains, due to muscular contractions of the stomach make themselves felt and there is a desire to eat.

(ii) The appetising smell of food causes a flow of saliva and gastric juice and the desire to eat even if there is no cause for real hunger.

(iii) Meat and some other foods contain *extractives* which, although they are themselves of no food value, cause a flow of saliva and gastric juice and the desire to eat.

Thus, if meals are attractive and appetising and contain tasty "extractives" there will be a flow of juices and the food will be easily digested. On the other hand, the following *factors* will cause a reduction in the amount of juices and consequently cause delay and difficulty in digestion.

(i) Unpleasant appearance and smell in the food.

(ii) Worry, fear or anger while or before eating.

Tasty food and nutrition. Although tasty food stimulates the flow of digestive juices and encourages people to eat, it does not follow that food which people dislike does not equally well nourish them provided they eat it. Indeed, individuals can if need be be given the nutrients they require by means of a stomach tube however strongly they may resent the process. The important nutritional significance of attractive food is that people eat it.

SPEED OF DIGESTION IN THE STOMACH

Some foods remain longer in the stomach than others. While it is commonly considered that foods which pass quickly through the stomach are more *readily digestible* than those which do not, it is not necessarily an advantage for foods all to leave the stomach rapidly because the more quickly the stomach empties the sooner will hunger be felt again.

Fats eaten with other foods possess the power of delaying the passage of those foods through the stomach. For this reason fats are said to possess a high *satiety value*, that is to say they satisfy the appetite longest.

The average times for a number of different foods to pass through the stomach are shown in the following list:

Average Time taken to pass through the Stomach

	Hours and minutes		Hours and minutes
Milk	1.00	Egg	2.30
Fruit	2.00	Fish	3.00
Sugar, sweets	2.00	Vegetables	3.00
Bread	2.30	Meat, (beef, mutton)	3.00
		Pork	3.30

BLOOD SUGAR

When any kind of carbohydrate is digested, it is broken down in the small intestine into glucose in which form it is passed into the blood.

The constant composition of the blood, which must always be steadily maintained if life is to continue, normally comprises a small amount of glucose.

This is the fuel for physical activity which is always in transport between the muscles and the liver where glucose is stored as *glycogen*. When a normal individual eats carbohydrate, the glucose formed from it in the intestine causes a slight rise in the level of blood sugar. This, however, is soon reduced again as the glucose becomes packed away in the liver. *Insulin*, sent into the blood by the pancreas brings about the withdrawal of glucose into the liver.

In the disease of *diabetes* there is a failure in the supply of insulin and the concentration of glucose in the blood steadily rises until at last it spills over, through the kidneys, and is lost in the urine. This is the reason why untreated sufferers from diabetes are always hungry and often thin and emaciated.

A second substance, *adrenalin*, is produced by two glands, the adrenals, situated close to the kidneys. This, in direct contrast to insulin, causes a withdrawal of glucose from the liver and a consequent rise in the concentration of glucose in the blood. This occurs when, for example, a man is angry or frightened. The increase of sugar in his blood would provide fuel for immediate and violent physical action should the reason for his anger or fear demand it.

ENERGY FROM PROTEIN

A large part of the protein absorbed by the body is used for the production of energy. Digestion in the stomach and in the small intestine finally reduces proteins to their constituent *amino acids*. These pass into the blood stream which carries them to the liver. There the *nitrogen* contained in amino acids is removed, and most of it, converted into *urea* which is passed out of the body by the kidneys in the urine. The remainder of the amino acids, containing, with the nitrogen gone, only carbon, hydrogen and oxygen, can be used as fuel.

THE NUTRITIONAL IMPORTANCE OF THE LARGE INTESTINE

1. The principal importance of the large intestine is to *absorb water from the faeces* so that too much moisture is not lost from the body when the stools are passed.

2. A second function of the large intestine is to provide a place for bacteria to act on indigestible fibres so that part of them, at least, may become available as food. This property is of no great importance to man, most of whose diet is readily digestible. For ruminating animals, like sheep and cattle, however, whose diet is very tough and indigestible the large intestine is very large indeed and is of some use to them in combination with the rumen at the other end of the digestive tract.

3. The bacteria in the large intestine give to that part of the gut a third claim to usefulness. These bacteria can make for themselves certain vitamins, notably certain of the vitamins of the B group. When the human diet becomes partly deficient in these vitamins it is possible for people to do without them to a certain degree by making use of the supply created in the large intestine by the bacteria.

CHAPTER XIV

NUTRITIONAL REQUIREMENTS

For proper health and efficiency an individual must eat sufficient of all the nutrients which have so far been discussed. These nutrients are present in different proportions in a number of different foods, it is therefore possible to design an adequate diet in a number of different ways to suit local tastes and varying food supplies. To be satisfactory however, *all these diets must contain the same full amounts of nutrients*.

1. **Optimum requirements.** The figures which are given on page 43 show the amounts of nutrients which will maintain complete dietary health in the

different types of people eating them. No further addition of nutrients would produce any improvement in health or efficiency.

2. Minimum Requirements. If less than the optimum requirements of nutrients are supplied by a diet, obvious ill-health may not necessarily appear at once. For example, to take an extreme case, if there is just too little to eat, that is to say, if there are fewer than the optimum number of calories in the diet, an individual will not immediately suffer in health although his efficiency and well-being will be affected. A diet which contains less of each nutrient than the optimum requirement but just sufficient to prevent an obvious breakdown can be said to provide the *minimum requirements*.

The optimum nutritional requirements for every class of individual are shown in the table on page 43. These figures are known today as Recommended Allowances. If, however, foodstuffs are scarce and an optimum diet unavailable, the nutritional intake for adults may be reduced for minerals and vitamins to 70 per cent. of the figures shown and little harm is likely to result. Such reduced figures are called Restricted Allowances.

THE RELATIVE IMPORTANCE OF OBTAINING THE PRECISE AMOUNTS OF EACH SEPARATE NUTRIENT

1. Calories. It is essential that the precise needs of calories be available in the diet if physical work is to be done and bodily vigour maintained over any reasonably prolonged period. A deficiency in calories will be felt immediately as *hunger*.

2. Protein. The figures in the table probably represent the smallest amounts of *total protein* which can be safely eaten if ill-health is to be avoided. Besides the total amount of protein in the diet the proportion derived from *animal* foods is also of importance in practical nutrition although not necessarily so theoretically. See p. 9. The approximate amounts of animal protein needed by different classes of people are compared with the total requirements in the list below :—

Daily requirements of animal protein

	Total Protein G.	Animal Protein G.
Children 0—5 years old	15—45	15—25
Children 5—14 years old	45—75	25—40
Adolescents 14—18 years old	75—90	40
Adults	70	25
Expectant mothers	85	40—50
Nursing mothers	100	50—75

From this table it can be seen :

- (1) That the proportion of animal protein to the total must be higher for *young children* than for adults. This is why milk is so important a food for children.
- (2) The needs of *expectant mothers* and particularly of *nursing mothers* for animal protein are particularly high. It is partly because many mothers are not able to satisfy these dietary needs that ill-health after pregnancy often occurs.

3. Fat. There is no hard and fast nutritional requirement for fat. If, however, the day's diet is lacking in fat it will tend to become very bulky since fat is the most compact and concentrated of all sources of calories. Fat is also of great value in making a diet palatable. Without it no frying is

possible; cakes and pastries cannot be made; bread cannot be buttered, etc. As a working rule, it can be said:

- (i) If the daily requirement of calories is less than 3,000, *at least 25 per cent. of the day's calories should be derived from fat.* That is to say, if 2,000 calories a day are consumed the fat eaten must not be less than 56 g. ($56 \times 9 = 504$ i.e. 25 per cent. of 2,000).
- (ii) If the day's calorie needs are more than 3,000 *at least 30 per cent. of the calories should be provided by fat.* Thus, a heavy labourer eating 4,000 calories must get 134 g. of fat if his diet is to be tolerably palatable. ($134 \times 9 = 1,206$, i.e. 30 per cent. of 4,000).

4. Calcium. The figures in the table show that 0.8 g. of calcium is needed daily by adults, and amounts up to 1.4 g. by children for full health. Here again is a reason why milk, which is rich in calcium, is particularly valuable for children.

Although the *optimum* figures given in the table are desirable in a good diet, the *minimum* amounts of calcium just to protect against the appearance of badly formed bones, bad teeth or other ill-health, can probably be set *at half the figures in the table.*

5. Iron. Although the daily optimum requirements of iron is, in the table, set at 12 mg. for both men and women, it is not easy to say how little iron could safely be eaten just to avoid anaemia. The minimum figure is, indeed, probably little lower than the 12 mg. suggested. In normal times in Britain many people eat less than 12 mg. of iron daily and there are a large number with anaemia.

Women have a greater need for iron than men since they suffer from a periodical loss of blood. Rather, therefore, than to attempt to set a *minimum requirement* lower than 12 mg., it is wiser to suggest a *higher optimum* for women at 15 mg. daily.

6. Vitamin A. The *optimum requirement* of vitamin A of 5,000 i.u. daily for adults is probably the highest figure ever likely to be required under the most unfavourable circumstances. A reasonable *minimum figure* of the amount which would just protect an individual against symptoms of deficiency is probably about *half the figure in the table*, i.e. 2,500 i.u. daily. If all the vitamin A is from animal sources, such as milk, eggs or cheese, as little as 1,500 i.u. daily might still serve as a *minimum requirement.*

7. Vitamin B₁. The *minimum requirement* of vitamin B₁ is probably about *one third* less than the figures given for the daily optimum requirement in the table. When white flour and sugar are available, a deficiency of vitamin B₁ with consequent ill-health is a common occurrence. It is, therefore, important to insure that no less than the minimum at least occurs in any diet if the optimum cannot itself be achieved.

8. Vitamin C. In the table, the desirable daily amount of vitamin C is put at 75 mg. for an adult man and 70 mg. for a woman. The *minimum requirement* for this vitamin can probably be set at 30 mg. If, however, *fever* occurs, or the body has need to heal wounds, a consumption only up to the minimum level may delay recovery.

9. Riboflavin. The *optimum figures* for riboflavin in the table are of a generous nature. Although adequate daily supplies of riboflavin are necessary for health, a *minimum level* in the diet of *half the values given* will probably prevent any signs of breakdown.

DAILY ALLOWANCES RECOMMENDED BY THE COMMITTEE ON FOODS AND NUTRITION, NATIONAL RESEARCH COUNCIL, U.S.A.

Restricted allowances are shown in brackets.

	Calories	Protein	Calcium	Iron	Vitamin A	Vitamin B ₁	Vitamin C	Riboflavin	Nicotinic Acid	Vitamin D
		G.	G.	Mg.	I.U.	Mg.	Mg.	Mg.	Mg.	I.U.
Man (70 g.)										
Sedentary	2500	70	0.8 (0.6)	12 (8)	5000 (3500)	1.2 (0.8)	75 (52)	1.6 (1.1)	12 (8)	—
Moderately active	3000	—	—	—	—	1.5 (1.1)	—	2.0 (1.4)	15 (11)	—
Very active	4500	—	—	—	—	2.0 (1.4)	—	2.6 (1.8)	20 (14)	*
Woman (56 g.)										
Sedentary	2100	60	0.8 (0.6)	12 (8)	5000 (3500)	1.1 (0.8)	70 (49)	1.5 (1.3)	11 (8)	—
Moderately active	2500	—	—	—	—	1.2 (0.8)	—	1.6 (1.5)	12 (8)	—
Very active	3000	—	—	—	—	1.5 (1.1)	—	2.0 (1.9)	15 (11)	*
Pregnancy (latter half)	2500	85	1.5	15	6000	1.8	100	2.5	18	400-800
Lactation	3000	100	2.0	—	8000	2.0	150	3.0	23	400-800
Children up to 12 years										
Under 1 year	100 per Kg.	3.5 per Kg.	1.0	6	1500	0.4	30	0.6	4	400-800
1-3 years	1200	40	1.0	7	2000	0.6	35	0.9	6	—
4-6 years	1600	50	1.0	8	2500	0.8	50	1.2	8	—
7-9 years	2000	60	1.0	10	3500	1.0	60	1.5	10	*
10-12 years	2500	70	1.2	12	4500	1.2	75	1.8	12	—
Children over 12 years										
Girls—13-15 years	2600	80	1.3	15	5000	1.3	80	2.0	13	—
16-20 years	2400	75	1.0	15	5000	1.2	80	1.8	12	*
Boys—13-15 years	3200	85	1.4	15	5000	1.5	90	2.0	15	—
16-20 years	3800	100	1.4	15	6000	1.8	100	2.5	18	*

NOTE.—A gram in the international metric system of weights and measures is about one-twenty-eighth of an ounce. A kilogram, which is 1,000 grams, is equal to 2.2 pounds avoirdupois. A milligram is one-thousandth of a gram. A calorie is a unit of measurement used to express the heat-producing or energy-producing value of food.

* Vitamin D is undoubtedly necessary for older children and adults. When not available from sunshine, it should be provided probably up to the minimal amounts recommended for infants.

NUTRITIONAL REQUIREMENTS

10. **Nicotinic Acid.** A safe daily *minimum consumption* of nicotinic acid is probably two-thirds of the optimum levels given in the table.

11. **Vitamin D.** It is not possible to make rigid estimates of the minimum safe amounts of vitamin D because :

1. Vitamin D can be formed in the skin by sunlight.
2. If the diet contains incorrect amounts of calcium and phosphorus the quantity of vitamin D needed will be increased.

GOOD AND BAD DIETS

From what has been written so far in this chapter it can be seen that if no ill-effects are to be felt :

(a) Little variation from the optimum requirements is permissible in the case of :

- (i) Calories.
- (ii) Protein.
- (iii) Iron.

(b) Some variation can be allowed between optimum and minimum needs of :

- (i) Calcium (0.8—0.4 g.).
- (ii) Vitamin A (5,000—1,500 i.u.).
- (iii) Vitamin B₁ (1.5—1.0 mg.).
- (iv) Vitamin C (75—30 mg.).
- (v) Riboflavin (2.0—1.0 mg.).
- (vi) Nicotinic Acid (15—10 mg.).

In actual practice, diets are not often found to be deficient in only *one nutrient* although this, of course, may occur. If a diet is deficient in calories it may easily be deficient in protein as well. Similarly, if it is short of protein through, say, lack of meat, it can easily be deficient also in iron and nicotinic acid, which are present in substantial amounts in meat. Again, lack of milk in a child's diet may produce a simultaneous shortage of calcium and of protein.

Deficiency of some nutrients is felt more quickly than deficiency of others :

1. A shortage of calories is *immediately* felt as hunger.
2. Shortage of protein will take *some months* to be felt although the body will begin to suffer immediately. Growth among children will show a check, anaemia may occur and a general "off colour" feeling will be suffered.
3. Shortage of water-soluble vitamins B₁, C and riboflavin, will also take a *month or two* to become felt. Then slothfulness, malaise and minor skin troubles may arise. Part of the great surge of good health felt in early summer is due to an increase in consumption of water-soluble vitamins, principally vitamin C, from the new season's vegetables.
4. A deficiency of vitamin A develops slowly and may take *9 months or a year* to show itself in people who have previously been well fed. Stores of vitamin A in the liver will protect an individual from the effects of a deficient diet for a long time.
5. Shortage of iron may also take a *long time* to show. Iron, like vitamin A, can be stored in the liver. On the other hand, if a diet which is deficient in iron is eaten, any demand on the body for iron due, for example, to bleeding or other causes may produce anaemia more readily than if an adequate diet had been eaten.

6. *Calcium and Vitamin D.* (a) In infants, serious deficiency of these nutrients will appear as rickets in a few months. (b) In adults, deficiency may not be obvious for years. The brittle bones and some of the "rheumatic" pains of old people are, however, probably symptoms of a long-drawn calcium and vitamin D shortage in the diet.

AN ADEQUATE DIET

In this chapter, the precise amounts of *eleven nutrients* needed by all types of individuals, from infants to active labourers, for an adequate diet, have been discussed. Besides these, there are other nutrients for which it is not at present possible to provide figures.

- (a) There are other vitamin B factors.
- (b) There are other vitamins associated with vitamin C.
- (c) Certain fatty acids possess the properties of vitamins.
- (d) Vitamin E and vitamin K, fat-soluble factors, also have dietary importance.

Although it is not possible exactly to assess the amounts of these and other nutrients in foods and to compute the amounts of them needed by the body, the adequacy of the diet can be safeguarded by the incorporation in it of *as wide a variety as possible of natural foods.*

Pure vitamin C can be added alone to a diet calculated to be lacking in it. It is, however, better to include oranges, watercress or other salads to supply the vitamin C. If these foods are used it may be hoped that some at least of the other nutrients may be supplied. When the pure substance is used, only vitamin C is provided.

As has been said before, *single deficiencies in diets are less common than a shortage of several nutrients together.* Deficiency of B-vitamins may cause sore tongue and cracks at the corners of the mouth. These are symptoms of *riboflavin deficiency.* If, however, pure riboflavin is given the tongue and the mouth may be cured but severe dermatitis of the face and hands may break out. These are symptoms of *nicotinic acid deficiency.* It frequently happens that sufferers have been eating a diet deficient in all B-vitamins. By chance, the symptoms of one deficiency only occur. If, however, that deficiency only is treated, symptoms of one of the other shortages appears. The correct treatment in the long run is to provide *a diet fully adequate in all nutrients.*

CHAPTER XV

THE COMPOSITION OF FOOD

The detailed composition of foods in terms of nutrients is given in the appendix and must constantly be referred to in the course of this chapter. It is always important to remember, however, that large variations may occur in different specimens of the same food. The practical implications of this variability in the case of meat have been referred to in Chapter V and are mentioned again below. Similar if perhaps less extreme fluctuations may also occur in other foods.

1. **Cereals.** All the common cereals, wheat, oats, barley, rye, maize, rice, etc. are principally sources of *carbohydrate.* The amount of this nutrient in the whole grain varies from 59 per cent. (oats) to 79 per cent. (rice). Compared with this, protein ranges from 7.2 per cent. (rice) to 13.0 per cent.

(oats) and fat from 1·7 per cent. (wheat) to 8·1 per cent. (oats). Cereal grains contain from 7 per cent. (oats) to 12 per cent. (wheat) of moisture under normal circumstances.

In *milling wheat*, some, at least, of the indigestible outer coats are almost always removed and even "wholemeal" flour usually contains no more than 92 per cent. of the whole grain. Flour contains a greater proportion of carbohydrate than the grain from which it is made. As can be seen from the appendix, the nutritional differences between white and wholemeal flour are :

- (i) White flour provides more *calories* (not many more).
- (ii) Wholemeal flour contains more *iron*,
more *vitamin B₁*,
more *riboflavin*,
more *nicotinic acid*,
more *protein* and better protein,
more *fat*.

THE FIBRE CONTENT OF CEREALS

Brown flour, and hence brown bread, contains more of a number of nutrients than white flour. Although this gives to brown flour (often called "high extraction" flour because a high proportion of the total grain is used in making it) a higher nutritive value than white, it also introduces certain disadvantages.

"High extraction" flours contain a proportion of the tough outer coats of the grain. These parts (a) contain *indigestible fibre* which reduces the digestibility of the whole flour, (b) contain phytic acid which prevents the absorption of *calcium* and also to some extent of *iron*, from the rest of the diet. Phytic acid, which is also present in oatmeal, can be neutralised by the consumption of milk or cheese or by the addition of calcium as *chalk* or some other inorganic salt. Nevertheless, its presence must not be forgotten in considering the nutritive value of grain products. The "extraction" of flour can be varied all the way from 72 per cent. (pre-war white flour) or less through 85 per cent. (wartime National flour) up to 92 per cent. (commercial "wholemeal") or 100 per cent. extraction. As the "extraction" increases the nutritive value increases to a point but the digestibility consistently falls. In preparing National flour much study was done to devise a food containing the most nutrients and at the same time the least of the indigestible parts of the grain.

2. **Dairy Produce.** (a) *Milk* is the most complete of all foods. It is however, comparatively deficient in *iron* and *vitamin C*. Beside the nutrients shown in the appendix, milk contains 4 to 5 per cent. of the carbohydrate, *lactose*, and 87-88 per cent. of water. The composition of milk may vary depending on the breed and age of the cow.

The Nutritive Value of Pasteurised Milk. Milk is a liquid and also a food of high nutritive value. Both these factors render it highly susceptible to the growth of bacteria. One organism which may be present in milk is the tuberculosis bacillus, derived from infected cows. This organism, together with almost all other harmful bacteria, is destroyed by heating the milk to 145°F. Heating milk in this way is called *pasteurisation*.

Pasteurisation has no material effect on the nutritional value of milk, as a food. It causes a reduction in vitamin C, of which milk is in any case, a poor source, and a very slight reduction in vitamin B₁.

(b) *Cream* is derived from milk either by allowing the *butter fat* to rise to the top or by mechanical separation. It thus contains 40 to 50 per cent. of fat, in place of about 3·5 per cent. in milk.

(c) *Skim milk* is milk from which most of the fat has been removed. It is a nutritious food owing to the protein, calcium and riboflavin in it.

(d) Butter is made from cows' milk by separation of the cream, followed by churning. The principal constituent of butter is the fat, which never falls below 80 per cent. by weight: other constituents are buttermilk, which becomes incorporated into the fat during manufacture, and salt, of which 1 to 2 per cent. is added for salted butter. The amount of vitamins A and D in British butter is twice as high in summer, when the cows have grass to eat, as in winter when they are fed on hay. Butter from the Southern Dominions, where the cows are fed on grass all the year round, has the same vitamin content summer and winter.

(e) *Cheese*, in general, is composed of one third protein, one third fat and one third water. As can be seen from the appendix, it is an excellent source of calcium.

Cheeses of different type differ principally because of the different organisms used to cause coagulation of protein during manufacture. *Hard cheeses* such as Cheddar, Cheshire, etc., are, in general, of higher nutritive value than *soft cheeses* like Camembert and Gorgonzola because they contain less moisture. *Cream cheese* has a high fat content.

Certain cheeses are made from milk other than that from cows. For example, Parmesan, which contains more protein than an average cheese, is made from *goats' milk* while Roquefort is made from *sheep's milk*.

(f) *Dried Milk*. Dried whole milk is of very high nutritional value and contains almost all the nutrients of liquid milk concentrated by the removal of the water. The fat in it, however, makes it difficult to store for long periods as it may turn rancid. *Dried skim milk* contains the protein, carbohydrate, calcium and B-vitamins from liquid milk. The fat and with it, vitamins A and D, have however been removed. *Condensed milk* is a third valuable product containing the nutrients from milk concentrated by the removal of part of the water. Sugar is added in the manufacture of sweetened condensed milk.

(g) *Eggs* are a good source of protein and, particularly, of iron. They also provide substantial amounts of vitamin A, B-vitamins and vitamin D.

(h) *Dried egg* contains all the nutrients present in fresh egg but concentrated by the removal of water. When dried egg is reconstituted the resulting mixture is almost identical in nutritional value with fresh egg.

3. *Meat*. (a) The lean part of meat is made up of a number of *muscle fibres* joined together side by side. The length of these fibres is different in different types of meat. The fibres are longer in old than in young animals; they are also longer in crab, for example, than in breast of chicken and, for this reason the latter is more easily digestible than the former.

The outer part of each fibre is made up of tough *connective tissue* of a gristle-like nature. When a beefsteak is pounded with a stick the muscle fibres are broken apart so that the digestive juices can more readily get between them and the meat is consequently made more *tender*.

The Effect of hanging Meat. When meat is allowed to hang, *acids* develop in it which cause the muscle fibres to soften. The meat thus becomes more tender. The acids also give the meat a stronger flavour. This method of softening meat by incipient putrefaction is commonly carried out in the case of *game*. However, although the desirable flavour of well hung game would be described as an "off" flavour for other meats, such an "off" flavour would have no ill-effect on the nutritive value of the meat.

Deposits of *fat* are found in spaces between the muscle fibres.

Each separate muscle fibre is a tube which contains :

- (i) Water
- (ii) Soluble protein
- (iii) Mineral salts
- (iv) Extractives

Extractives do not of themselves provide much nourishment but they give meat its *flavour* and they exert a powerful influence in causing a *flow of juices in the digestive tract*.

The nutrient composition of various types of meat is shown in the table in the appendix. *There is not necessarily more nourishment in expensive meat than in cheaper kinds nor has frozen meat any lower value than fresh meat.* Corned beef has, however, lost a proportion of its nicotinic acid and riboflavin. These nutrients reappear in meat extracts which are by-products produced during the manufacture of corned beef.

(b) *Liver and kidney* contains less fat than most meat. Liver, particularly, is *very rich indeed in vitamin A*.

Liver is a very good dietary source of *iron*.

(c) *Sweetbread and tripe* are useful and digestible sources of *animal protein*. Tripe contains much more *calcium* than other meats. This is derived from the lime with which it is treated during preparation.

(d) "*Lights*" and *brain* are only imperfectly digested and do not, therefore, rank as particularly nutritious foods.

4. **Fish.** (a) The muscle of fishes is as useful a source of *animal protein* as meat. Fish, however, often have a lower food value, because :—

- (a) They contain more moisture.
- (b) The amount of waste, skin, bones, head etc., is often high.

As can be seen in the table in the appendix, the proportion of *fat* in different types of fish varies widely. Fish which contain fat, often provide vitamins A and D in the diet.

- (a) *Fat fish*, herring, mackerel, salmon, eel, contain from 5 to 18 per cent. of fat.
- (b) *White fish*, cod, haddock, sole, whiting etc., contain less than 2 per cent. of fat.

(b) Those fishes of which the *bones are eaten* provide an excellent source of *calcium and phosphorus*. This group includes whitebait, sardines, and sprats. The practice of *eating the backbone* of canned salmon adds calcium to the diet.

5. **Vegetables.** (a) *Green vegetables* are of nutritional importance because of the vitamin C and vitamin A they contain. The figures given in the appendix are average values. Individual specimens may, however, vary widely in composition. *Vitamin C* is highest in the early summer. *Vitamin A* is increased in proportion to the *greenness* of the vegetable.

Green vegetables provide few calories, only a trace of fat and a small amount of protein. Owing to their high water content they are *bulky foods*. They also contain a comparatively large amount of *indigestible fibre*.

(b) *Root Vegetables.* The most important of these are potatoes. When large amounts of potatoes are eaten, the amount of *calories* obtained is substantial. The *protein* is also a useful contribution to the diet. In many diets potatoes provide most of the *vitamin C*.

Carrots have already been mentioned as exceptional among roots in containing a large amount of *vitamin A*. The *sweet potatoes* grown in America also contain *vitamin A*.

Turnips and swedes contain *vitamin C* but are otherwise of little nutritive value. They contain 91—94 per cent. water, which is more than the amount found in milk (87 per cent. water) or the average soup (90 per cent. water).

(c) *Peas and Beans*. Green peas and broad beans contain more calories and more protein than other vegetables. They also contain *vitamin C*, and green peas provide *vitamin A*.

Dried peas and beans must not be confused with fresh vegetables. They contain *no vitamin C* and *negligible vitamin A*. As will be seen from the appendix the *dried* forms are rich in *calories*, *protein*, and other nutrients. It is, however, important to remember, that before they can be used, *dried peas and beans must be soaked*. When this is done the moisture content rises from 8 per cent. to 70 per cent. and the calories, to take a single nutrient value, fall, in the case of peas, for example, from 78 to 28 per oz.

6. **Fruit.** (a) *Fresh fruit* when it is ripe contains sugar, which makes it sweet. The nutritive importance of fruit, however, is principally as a source of *vitamin C*. The figures are given in the appendix and it will be seen that except in the case of blackcurrants, oranges etc., strawberries and one or two others, fruit does not compare very favourably with vegetables as a source of *vitamin C*.

(b) *Dried fruit* such as currants, raisins, dates, figs etc., provides *calories* in the form, principally, of sugar. Prunes and dried apricots are also useful sources of *vitamin A*. *Dried fruits do not contain vitamin C*.

(c) *Nuts* are *highly nutritious*. They are rich in *protein* and *fat* and consequently form a concentrated source of *calories*. They contain *no vitamin A*, nor *vitamin C* but are unusually rich in *vitamin B₁*.

Nuts are not easily digested because they contain quite high proportions of tough fibres.

QUESTIONS

PART III

(Chapters XIII to XV)

1. What is meant by the absorption of food ?
2. A dishonest pearl-diver is trying to steal a pearl. He swallows it. Is the pearl digested ? Does it become absorbed ?
3. What is the purpose of saliva in the mouth ?
4. In which part of the digestive tract does the digestion of protein take place ?
5. What foods are absorbed through the stomach ?
6. Where does the absorption of most of the nutrients from food occur ?
7. What is the purpose of the large intestine ?
8. Beer is mostly water. If more beer is drunk than a body really needs how is the excess of water disposed of ?
9. What proportion of the carbohydrate, protein and fat from a normal diet is digested ?
10. A coalminer is eating 2,000 calories a day. Is this enough ?
11. A lady living in Cheltenham regularly eats 3,500 calories a day. What will happen to her ?
12. Who needs most protein, a child of 10, a bricklayer, an expectant mother, a girl of 15, or a boy of 20 ?
13. Why is milk specially good for children ?
14. How much *vitamin A* and *vitamin C* should a good diet contain ? How little is it safe to allow when supplies are scarce ?

15. What is the difference between white bread and brown bread ?
16. What nutrients does milk *not* contain ?
17. What nutrients does meat supply ?
18. What is the main difference between mackerel and whiting ?
19. Which provides most vitamin C, an ounce of cabbage, carrot, onion, potato or haricot beans ? Which provides most vitamin A ?
20. What part does the liver play in the digestion of food ?
21. What circumstances are likely to produce good appetite ? Why ?
22. What is " satiety value " and which foods contain most ?
23. Which will be felt first, a shortage of protein, iron, vitamin A, calories or vitamin C ? What is the final effect of iron deficiency ?
24. What nutritional disadvantages are there about brown bread that white bread does not possess ?
25. What is the difference between raw and pasteurised milk ?
26. How many grams of fat ought there to be in a diet the total calorific value of which is 4,200 ?
27. Why is it better nutritional practice to provide orange juice than pure vitamin C ?
28. What are the complete nutritional requirements of a boy of 12 ?
29. Which groups of people have the greatest need for animal protein ?
30. What is the nutritional requirement of fat ?

PART IV

CHAPTER XVI

COOKING

The process of cooking causes, in almost all cases, a direct improvement in the nutritional value of foods. In addition to its direct effect, cooking performs the important secondary function of improving the flavour and attractiveness of foods.

When food is unpleasant, people will often eat less of it than their bodies need. It is unnecessary to emphasise that nutritional health will suffer if insufficient nutrients are absorbed, and insufficient amounts will certainly be absorbed if too little is eaten. Besides encouraging people to *eat more*, well-cooked food assists in digestion and absorption by increasing the flow of digestive juices in the mouth and stomach.

COOKING METHODS

Cooking always involves the use of *heat* which may be applied in three ways.

- (a) *Baking, roasting and grilling* involve the use of *dry heat applied direct to the food.*
- (b) *Boiling and steaming* : in these cases heat is applied by means of hot water.
- (c) *Frying* calls for the high degree of heat available from *hot fat.*

THE EFFECT OF COOKING ON SEPARATE NUTRIENTS

I. Carbohydrate. Cooking is essential for the proper absorption of *starch*, which is by far the most important source not only of carbohydrate but also of calories in the diet. The starch in uncooked flour, potato, rice or oatmeal, is, as has already been described in Chapter ii, enclosed in *starch granules* which are highly resistant to the human digestive juices. When heat is applied in any of the methods of cooking—the *baking* of flour for bread, the *boiling* of potatoes, or the *frying* of a flour batter with fish—the starch granules swell up and burst and the starch itself becomes *gelatinised*, in which condition it can be *completely* digested and absorbed.

2. **Protein.** The application of heat to proteins causes *coagulation* which is most strikingly demonstrated by the white of a boiled egg. A second effect of heat on many proteins is *shrinking*. During grilling, for example, a steak shows a pronounced shrinkage due to contraction of the protein of the muscle fibres. The digestibility of moderately cooked protein is in general, greater than that of raw protein. For example, the absorption of *raw* egg is low. *Excessive* exposure to heat, however, will eventually reduce the nutritive value of protein.

3. **Fat.** Cooking has little effect on fat.

4. **Mineral Substances.** (i) *Calcium.* The effect of cooking may work both ways on calcium in foods. It is not, however, a factor of any great importance. In the case of milk, for example, heat may cause a slight reduction in the availability of calcium to the body, whereas in cereals the small amount of calcium present may become more available.

An indirect effect of cooking on the amount of calcium in foods is the effect of the calcium in "*hard*" cooking water. For example, if greens are boiled in "*hard*" water, sufficient calcium may become incorporated in them to double the amount they originally contained. This is the same effect that causes "*fur*" to accumulate in a kettle.

(ii) *Iron.* In general, cooking tends to *increase* the ease with which the body can absorb the iron from foods. A second beneficial aspect is the increase in dietary iron due to amounts picked up from *cooking water* and *utensils*. On the other hand, there may be certain losses of iron during the cooking of meat if juices containing iron are allowed to escape.

(iii) *Salt.* Salt and other soluble mineral substances are lost from foods when they are boiled. This is of little nutritional significance if, as is always done, salt is added during cooking.

5. **Vitamins.** (i) *Vitamin A* and *Vitamin D.* Cooking has *no effect* on vitamin A or vitamin D. The amount of heat used does not damage either nutrient, and since they are not soluble in water, no losses occur during the course of boiling.

(ii) *Vitamin B₁.* A proportion of the vitamin B₁ in foods may be destroyed during cooking for the following reasons:

(a) Although vitamin B₁ can stand reasonable degrees of heat, *it is destroyed at higher temperatures*, e.g. during the baking of biscuits.

(b) Vitamin B₁ is *destroyed by baking soda*. There is little loss during the baking of yeast buns or bread but almost complete destruction in soda buns or soda bread.

(c) Since vitamin B₁ is soluble in water a proportion is lost in the cooking water during boiling.

(iii) *Riboflavin, Nicotinic Acid.* Although these vitamins are susceptible to high degrees of heat and are also soluble in water, losses are small during the ordinary process of cooking. Unusually vigorous treatment, such as, for example, pressure cooking or the "*corning*" of beef causes losses of riboflavin and nicotinic acid.

(iv) *Vitamin C.* *Cooking is essential to make potatoes, often the most important dietary source of vitamin C, available to the body.* In doing this, however, it is to some degree wasteful of the vitamin which is readily destroyed by cooking processes and a proportion of which is inevitably lost during the culinary preparation of food.

Factors causing loss of Vitamin C :

- (a) Prolonged heat (long cooking).
- (b) Heat in the presence of air (keeping meals hot).
- (c) Vitamin C is very easily soluble in water (it is lost when cooking liquors are discarded).
- (d) Vitamin C is quickly destroyed by plant *enzymes* (released by grating vegetables, or by starting to boil vegetables from the cold).
- (e) Copper in traces from utensils, etc., causes destruction.

COOKING AND ITS EFFECT ON SEPARATE FOODS

1. **Cereals.** *The Baking of Bread.* When bread is made with *yeast* part of the starch is fermented to produce the gas *carbon-dioxide* which causes the dough to rise. In the course of fermentation *alcohol* is also formed. Although this alcohol evaporates and is lost during baking it has been calculated that at least 300,000 gallons of alcohol are lost each year in the ovens of London alone.

The effect of cooking on cereals :

- (a) The starch granules burst and thus render the starch in them digestible.
- (b) When yeast is used there is no loss of *vitamin B₁*. If, however, baking powder is used a substantial loss occurs.
- (c) When high temperatures are used, for example in the baking of biscuits most of the *vitamin B₁* is destroyed.

2. **Meat.** The effects of cooking on meat are :

- (a) The muscle fibres of the meat become softened.
- (b) The meat contracts and some loss of mineral salts occurs.
- (c) There is no material loss of *nicotinic acid* or other vitamins.
- (d) The iron becomes more available to the body.

3. **Fish.** The effects of cooking on fish are similar to those on meat. When fish is fried in batter the nutritional value is increased by the addition of fat and the flour and other ingredients of the batter.

4. **Vegetables.** The principal purpose of cooking vegetables is :

- (a) To soften the cellulose framework.
- (b) To break the starch granules and thus render the starch capable of digestion and absorption by the body.

Potatoes are one of the most important sources of vitamin C in the diet. Since vitamin C is susceptible to heat and also soluble in water, it is inevitable that certain losses of vitamin occur when potatoes are cooked. Nevertheless, it is important to remember that without cooking, they are uneatable. The extent of these losses are shown below :

	<i>Average loss of vitamin C</i>
1. Potatoes boiled in their skins	15 per cent.
2. Potatoes baked in their skins	20 per cent.
3. Potatoes fried	30 per cent.
4. Potatoes boiled after peeling.	50 per cent.

Green Vegetables. About 60 per cent. of the vitamin C in green vegetables is lost during cooking. Part of the vitamin is destroyed by heat, part is lost in the cooking water and part destroyed by the plant itself before its temperature is raised sufficiently high to destroy the enzymes in it. If green vegetables are boiled by putting them into *cold* water and then raising the temperature to the boil, the loss of vitamin from the third cause mentioned may be three times as high as it would have been if the vegetables had been plunged into boiling water to destroy their enzymes immediately.

STOCK

Stock is used in cooking to a very large extent. It is commonly made by boiling meat bones in water. *It is of almost no nutritional value.* The hot water only extracts a small amount of *fat* and gelatine from the bone marrow and a small quantity of *extractives* which provide flavour and cause the digestive juices to flow. Stock does, however, provide a certain amount of riboflavin and nicotinic acid.

Nutrition is a quantitative science. Not only must nutrients be present in food, but they must be present in adequate and measurable amounts. *Stock* and *soup* cannot be of substantial value unless foods supplying the nutrients, carbohydrates, fats, proteins, minerals or vitamins are put into them. Hot water and flavour have of themselves no food value. If, however, meat, vegetables, barley and peas are put into soup it can be of substantial nutritional value although it always remains a comparatively bulky food.

JELLIES

The protein, gelatine, as has already been said, is completely lacking in the essential amino acid *tryptophane*. Gelatine, however, has the property of causing a very large volume of water, in relation to the weight of gelatine, to form a gel. The maximum amount of jelly which could be eaten in one day would be about 1 pint. This would contain about 1 oz. of gelatine which would only provide about 110 calories. The nutritional value of jelly, be it "calves foot," "neats foot" or "aspic" can thus be seen to be negligible.

SALADS

The loss of about 60 per cent. of the vitamin C in green vegetables is almost inevitable during the course of cooking. This loss can be almost completely avoided by eating the vegetables raw in the form of salads. It is, however, important to remember the quantitative aspect of nutrition before recommending the use of salads as a diet.

	<i>Vitamin C</i>
1. A convenient serving of lettuce weighs 1 oz. and provides	3 mg.
2. A convenient serving of raw cabbage weighs 1 oz. and provides	15 mg.
3. A convenient serving of cooked cabbage weighs 4 oz. and provides	20 mg.

From the figures shown above it can be seen that the consumption of a substantial helping of cooked greens is a better source of vitamin C (and a very much better source of vitamin A) than a serving of *raw* greens, because the raw vegetable is very much bulkier to eat.

MEAT EXTRACTS ; YEAST EXTRACTS

Meat extracts were, until a short time ago, thought to provide only flavouring material. It is now known however that they provide substantial amounts of nicotinic acid and riboflavin (see p. 28). *Yeast extracts* also provide a meaty flavour and they have long been known to contain high concentrations of all the B vitamins.

CHAPTER XVII

MEALS

A meal can be arbitrarily defined as *an amount of food eaten during a single space of time and providing 200 calories or more.*

This definition includes a great deal more than is generally accepted as the meaning of the word "meal" which *in its popular sense*, is usually restricted to the consumption of cooked and hot food almost always eaten sitting down.

THE NUMBER OF MEALS A DAY

1. For many types of work, the efficiency of the body is best maintained by 5 or 6 meals during the day rather than by 2 or 3.
2. There is no fixed rule as to how nutrients may best be distributed through the day. Different conditions of work will affect the most suitable arrangement.
3. Although the amount of nutrients in different meals may vary, *the total amount of each nutrient eaten during the day must reach the figures for requirements if the diet is to be fully adequate for health.*

Examples of People eating Different Numbers of Meals

- I. *Three meals a day*
 - (a) Some office workers : breakfast 8 a.m. ; dinner 1 p.m. ; supper 7 p.m.
- II. *Four meals a day*
 - (a) Some coal miners : breakfast 5.30 a.m. ; snack 11 a.m. ; dinner 3 p.m. ; supper 8 p.m.
 - (b) Many industrial workers breakfast 7 a.m. ; dinner 12 ; tea 6 p.m. ; supper 9 p.m.
- III. *Five meals a day*
 - (a) Miners (Yorkshire) breakfast 4.30 a.m. ; bait 9.30 a.m. ; dinner 3 p.m. ; tea 6 p.m. ; supper 9.30 p.m.
 - (b) Some railway workers breakfast 5 a.m. ; snack 8 a.m. ; snack 1 p.m. ; dinner 4 p.m. ; supper 9 p.m.
 - (c) Shipbuilders breakfast 7 a.m. ; piece 9.30 a.m. ; dinner 12 ; tea 6 p.m. ; supper 10 p.m.
- IV. *Six meals a day*
 - (a) Many industrial workers breakfast 7 a.m. ; snack 9.30 a.m. ; dinner 12 ; snack 3.30 p.m. ; tea 6 p.m. ; supper 9.30 p.m.
 - (b) Cotton spinners breakfast 6.30 a.m. ; snack 9 a.m. ; dinner 12.30 p.m. ; snack 3 p.m. ; tea 6 p.m. ; supper 10 p.m.
 - (c) Steel rollersmen breakfast 5.30 a.m. ; snack 8 a.m. ; snack 11 a.m. ; dinner 3 p.m. ; tea 6 p.m. ; supper 10 p.m.

CALCULATING THE COMPOSITION OF MADE DISHES

In the appendix the composition is given of foodstuffs in terms of nutrients. The determination of the nutritional value of made dishes is usually a matter

of arithmetic based on the figures given in the table. For example, the nutritional value of a cake is computed below.

Ingredients	Quantities	Calories	Protein	Fat	Calcium	Iron	Vit. A	Vit. B ₁	Riboflavin	Nicotinic Acid	Vit. C	Vit. D
	Oz.	G.	G.	G.	Mg.	Mg.	I.U.	Mg.	Mg.	Mg.	Mg.	I.U.
Flour	80	7,760	262	32	2,000	56	0	5.8	3.2	32	0	0
Margarine	32	6,980	0	774	30	3	14,400	0	0	0	0	1,790
Sugar	32	3,460	0	0	0	0	0	0	0	0	0	0
Dried egg	5	810	65	59	310	15	4,250	0.6	1.8	0	0	340
Baking powder	2	0	0	0	0	0	0	0	0	0	0	0
Water	40	0	0	0	0	0	0	0	0	0	0	0
Weight of cake ...	160 §	19,010	327	865	2,340	74	18,650	6.4	5.0	32	0	2,130
Composition per oz. ...	—	119	2.0	5.4	15	0.5	116	0.04*	0.03	0.20	0	13

* Say, 25 per cent. to be deducted to allow for the effect of the soda during baking.
 § The total weight will not be the same as the sum of the ingredients owing to the loss of moisture in baking.

If the values per oz. calculated above are compared with the figures for cake given in the table in the appendix a number of differences will be found. This again exemplifies the fact pointed out at the beginning of Chapter 15 that figures for food composition given in tables are only average values. A food-stuff such as cake depends for its nourishing qualities on the *amounts* of components of high nutritional value put into it.

CALCULATING THE COMPOSITION OF MEALS

It is quite common to find that in a factory *two* "communal" meals are provided during the morning. The first, let us say, consists of a "cheese roll" and a cup of tea. Where there is an ignorance of nutrition, this could be forgotten or, at least, not considered to be a meal at all. The second, might consist of roast mutton, cabbage and potato, followed by stewed apples and custard.

The nutritional value of two such meals has been calculated below from the figures given in the appendix.

Meal 1	Weight	Calories	Protein	Fat	Calcium	Iron	Vit. A	Vit. B ₁	Riboflavin	Nicotinic Acid	Vit. C	Vit. D
	Oz.	G.	G.	G.	Mg.	Mg.	I.U.	Mg.	Mg.	Mg.	Mg.	I.U.
Roll*	3.5	252	8.4	1.4	56	1.7	0	0.19	0.10	1.0	0	0
Butter	0.3	63	0.3	7.0	1	0	342	0	0	0	0	5
Cheese	2.0	234	14.2	19.6	460	0.4	740	0.02	0.28	0.2	0	20
Tea	10.0	50	1.0	1.0	30	0	40	0	0.10	0	0	0
Total meal	—	599	23.9	29.0	547	2.1	1,122	0.21	0.48	1.2	0	25

* Calculated as bread.

Meal 2	Weight	Calories	Protein	Fat	Calcium	Iron	Vit. A	Vit. B ₁	Riboflavin	Nicotinic Acid	Vit. C	Vit. D
	Oz.	G.	G.	G.	Mg.	Mg.	I.U.	Mg.	Mg.	Mg.	Mg.	I.U.
Mutton	2.4	225	9.0	21.0	6	1.5	33	0.12	0.12	3.0	0	0
Cabbage	3.0	21	1.2	0	54	0.9	255	0.06	0.06	0.3	24	0
Potato	4.0	84	2.4	0	8	0.8	0	0.13	0.08	1.2	4	0
Apples	3.0	36	0.3	0	3	0.3	12	0.04	0	0.3	1	0
Custard	2.0	66	1.8	2.2	70	0	40	0.01	0.04	0	0	0
Total meal	—	402	14.7	23.2	141	3.5	340	0.36	0.30	4.8	29*	0

* 60 per cent. deducted from cabbage and 50 per cent. from potato and apple to allow for cooking losses.

These calculations show that *Meal 1*, which might thoughtlessly be dismissed as a mere "snack," is in many ways of far higher nutritional value than the hot *Meal 2*.

(a) It provided 50 per cent more *calories*.

(b) almost twice as much *protein*.

(c) four times as much *calcium* and almost as many times as much *vitamin*

A.

The single nutrient in which the second meal was markedly superior to the first was *vitamin C*. If the cheese roll had included chopped cabbage or watercress or been accompanied by an orange, it would have been in every way a better meal than the meat, vegetables, and sweet. This need not always be the case, of course, when "packed" meals are compared with "cooked" meals. Whether it is or not depends on the *quantities* and the nutritional composition of the items chosen for each meal.

THE OSLO MEAL

If they are given reasonable opportunity, people will eat as many *calories* as they need, because if they do not they feel hungry. Foods which provide a cheap and easy source of calories are white bread, sugar, cakes and similar items. These provide calories, it is true, but they do *not* provide animal protein, calcium, iron, vitamin A, B vitamins, vitamin C or vitamin D. If children are sent to school in the morning with only bread and butter and are given only cheap and filling foods when they come home at night, their day's diets will be inadequate. It was in order to counterbalance such inadequacy that the Oslo Meal was devised.

The Oslo Meal was made up of:—

- (a) *Milk and cheese* to provide *animal protein, calcium and vitamin A*.
- (b) *Herring or sardine* to provide *animal protein, vitamin A and vitamin D*.
- (c) *Wholemeal biscuit or brown bread* to provide *B vitamins and iron*.
- (d) *An orange and a carrot* to provide *vitamin C and vitamin A*.

This meal was devised to supply those "protective factors" in which the remainder of the diet of a poor child was most likely to be deficient.

WASTE

In studying the composition of meals, the information that is wanted is the amount of each nutrient *actually eaten*. When the nutritional value of the meals, and hence of the *total diet*, of any individual has been worked out it is then possible to compare the values with the known *requirements for health*. It is important to remember, however, that it is not permissible to calculate *directly* the nutritional value of a diet:

- (a) from the total amounts of foods brought from the shop, or
- (b) from the amounts used in the kitchen

There is always a proportion of waste for which allowance must be made. Waste may occur at three stages.

- (1) Potato peelings, bacon rind, bones from meat, crusts cut off bread, outer leaves of cabbages, etc.
- (2) Fat lost on pans, etc., batter left in mixing bowls, crumbs in bread bins, etc.
- (3) Scraps left on plates, bread, etc. wasted at table.

Before calculating the nutritional adequacy of any diets, allowances must be made for wastage unless it is possible to adopt the more satisfactory procedure of measuring *the amounts of edible food actually eaten*. The average loss often taken for cooking wastage and plate wastage is 10 per cent. The figure will, of course, vary according to circumstances. Over and above this domestic loss an additional deduction must be made for skins, bones, stones, outer leaves, shells, etc., in order to arrive at the edible weight when starting from the weight purchased. Average figures for this second loss are given in the first column of the table in the Appendix.

EATING BETWEEN MEALS

It has already been seen that in different industries in England, people may eat their day's diet in the form of three, four, five or six meals. There seems little nutritional difference between these diverse habits. Each may be equally good under different circumstances. Similarly there seems to be no important nutritional arguments for or against eating small quantities of food *between meals*, provided the day's total consumption of nutrients is not prejudiced. For example, if children eat sweets, which are largely composed of sugar and provide no other nutrient than carbohydrate, between meals, so that they have no appetite for cabbage or for meat at dinner later, the consumption of sweets may then have caused a deficiency of vitamin C or of protein which could have been obtained from the cabbage and meat.

WORKING BEFORE BREAKFAST

The efficiency of the muscles is lowest in the morning before the first meal of the day. It is, therefore, good nutritional practice to eat breakfast before starting work. The matter is primarily one of calories and it is consequently immaterial whether the meal is composed of bread and butter or cake, or whether it is bacon and eggs, provided the nutrient requirements are made up in the remainder of the day's food.

SCHOOL MEALS

The most appropriate nutritional composition for any meal will, of course, be influenced by the other meals which go with it to make the day's diet. People who plan the midday meal for schoolchildren, however, usually, assume that a simple breakfast will be eaten in the morning and a tea of bread and jam or some similar combination eaten at night. The midday dinner, therefore, ought together with school milk to provide a major proportion of the day's needs of animal protein, much of the vitamin A, most of the vitamin C and sufficient fat for the meal to be compact enough to supply with these nutrients a substantial number of calories.

A reasonable composition for a school meal, based on the assumptions given above, is as follows :

Age	Calories	Animal Protein	Fat	Vitamin A	Vitamin C
		G.	G.	I.U.	Mg.
For a child of 14 ...	800	20-25	30	3,000	50
" " " 10 ...	650	15-20	25	2,500	40
" " " 8 ...	500	12-15	20	2,000	30

Schoolchildren are growing and have very high nutrient requirements. It is consequently important to insure that their diet is adequate. Where there are reasonable grounds for doubt about a child's home diet it is advisable to plan for the school meal, together with school milk to provide two-thirds of the vitamin and mineral needs of the day and the major proportion of the animal protein required.

THE COMPONENTS OF MEALS

Hot meals are conventionally composed of at least two parts : a meat course and a pudding course. When standard meals are being devised it is important to maintain a nutritional balance between these two parts. For example, if the first course is composed of a slice of meat with cabbage and boiled potato and the second course is stewed apples, the calorific value of the meal will be

too low. A more suitable pudding would be steamed jam roll which, as it is made from flour and fat, is high in calories. Similarly, if the only garnish for the meat course is dried peas, the sweet could appropriately be composed of blackcurrants or gooseberries to maintain the level of vitamin C.

CHAPTER XVIII

DIETS

The amounts of nutrients needed daily for health by every type of individual were discussed in Chapter xiv. The figures given there showed the results to be aimed at when a diet was being planned. There are many combinations of food which can be devised to provide these specified amounts of nutrients, but experience and custom often obtain results which are satisfactory nutritionally as well as being popular and palatable.

FEEDING YOUNG CHILDREN

For the first few months of their lives infants can live very satisfactorily on their mother's milk. If they must be given cows' milk, this can easily be modified by the addition of sugar and water to provide the appropriate amounts of carbohydrate, protein and fat.

Although, as can be seen from the appendix, milk is a remarkably complete food it is not perfect in every respect for a child as it grows older, for example

(a) Cows' milk is deficient in *vitamin C*. Babies must be given orange juice or some other source of vitamin C, if milk is their main food.

(b) *Vitamin A* and *vitamin D* although present in milk are not present in sufficient amount for the child as it begins to grow and supplements such as cod liver oil must be added to it.

(c) Milk is notoriously lacking in *iron*. When it is born, a child usually possesses sufficient iron stored in its liver to keep going for some months. It is, however, important not to delay too long before beginning to feed small amounts of sieved greens, gravy and other foods in order to provide the infant with this nutrient. *Eggs*, which are rich in iron and provide animal protein, vitamin A and vitamin D, are an excellent early food for infants.

FEEDING SCHOOLCHILDREN

There are three points of great importance when considering diets for schoolchildren.

1. *Schoolchildren are growing fast* so that they have great need for protein, calcium, vitamin A, vitamin C and vitamin D. The actual figures can be seen in Chapter xiv.

2. *Schoolchildren are very active* so that, for their size, they have greater need for calories than adults. Children's big appetites almost always reflect a real nutritional need and not greediness.

3. Owing to the fact that their size and thus *the size of their stomachs is small* and at the same time their nutrient needs are large, it is important that the meals they are given shall not be too bulky. Cheese, meat, eggs, fruit and green vegetables are all important to supply children with the nutrients they need. Bread and, particularly, cake made with fat, sugar, milk and eggs are excellent as concentrated sources of calories. Of all other foods, milk, at the rate of a quart a day, is the best source of protein, calcium and vitamins A, D and riboflavin for schoolchildren. [E

Children at boarding school often grow only during the holidays and remain stationary in weight during term time while they are at school. This cannot be considered as "natural," it is, on the contrary, a sign that they are not being sufficiently well fed. If the children's activity is greater when they are at school than when they are at home their need for nutrients will be correspondingly increased.

FEEDING ADOLESCENTS

The total nutrient needs of adolescents are higher in many respects than those of any other group of people. Healthy adolescents have very big appetites and it is important that they should satisfy them with food of high nutritional value containing, particularly, adequate amounts of *protein*. Milk is a food of great usefulness for adolescents. Adolescents often find themselves leaving school and sometimes leaving home as well. A knowledge of nutrition and its application at this time, so that the needs shown by the figures in Chapter xiv may be supplied, may easily benefit the health of young people for the rest of their lives.

FEEDING ADULT WORKERS

If the figures in Chapter xiv are consulted it will be seen that heavy workers, that is to say, those who need a large number of calories, do *not* require, so far as is known, any more *protein* than anybody else. The hard worker, it seems, does not therefore require extra meat.

The arrangement of meals in different occupations has already been discussed. It depends on the length of the working shift, whether the work is indoors or out of doors, and on many other factors. In general, it seems best for the nutrients to be spaced out fairly evenly throughout the day.

An understanding of nutrition is important for the appreciation of diets found in actual practice. An example is given below :

1. Women doing light engineering at a factory in Birmingham in 1943

Meal	Calo-ries	Pro-tein	Fat	Cal-cium	Iron	Vit. A	Vit. B ₁	Ribo-flavin	Nico-tinic Acid	Vit. C
		G.	G.	Mg.	Mg.	I.U.	Mg.	Mg.	Mg.	Mg.
Breakfast, 7 a.m.	710	21	26	240	4	630	0.51	0.30	2.9	5
Snack, 10 a.m....	210	9	8	140	1	230	0.12	0.12	0.6	0
Dinner, 1 p.m....	830	30	27	350	4	1,100	0.87	1.90	5.2	30
Snack, 4 p.m. ...	240	5	9	50	1	50	0.06	0.05	0.3	0
Tea, 7 p.m. ...	570	19	21	100	4	560	0.51	1.12	3.9	31
Total day's nutrients	2,560	84	91	880	14	2,570	2.07	3.49	12.9	66

When the nutrients actually eaten in this diet are compared with the figures in Chapter xiv, which show the amounts needed for full health, the following can be seen :

Eaten
Calories, 2560

Protein, 84 g.

Fat, 91 g.

Needed for health

Moderately active women need 2500 calories a day, so that the amount eaten is the amount needed.

Since women need 60 g. of protein a day the amount obtained was fully adequate.

91 g of fat = $91 \times 9 = 819$ calories. This is 32 per cent. of the total of 2560 calories eaten. Since when less than 3000 calories are eaten, a reasonable diet can be made when 25 per cent. of the calories are provided by fat, the amount in this diet is sufficient.

Calcium, 0.88 g.	This is enough since only 0.8 mg. is needed.
Iron, 14 mg.	" " " " 12 mg. "
Vitamin A, 2570 i.u.	For the best possible diet, the amount of vitamin A needed is 5000 i.u. daily. A minimum safe figure has been set at 2500 i.u. so that the amount eaten could be expected at least to prevent ill-health.
Vitamin B ₁ , 2.07 mg.	This is enough since only 1.2 mg. is needed.
Riboflavin, 3.49 mg.	" " " " 1.6 mg. "
Nicotinic acid, 12.9 mg.	" " " " 12 mg. "
Vitamin C, 66 mg.	Here, although the ideal daily amount needed is 70 mg., a <i>minimum</i> might be set at 30 mg. Hence the amount eaten is sufficient to safeguard health.

This diet is, when compared with many others, a good one. *Breakfast* before work was a substantial meal since it provided 710 calories and 21g. of protein. The *mid-morning snack* was a piece of cake. *Dinner* was a proper hot meal containing meat, vegetables to provide vitamin C and vitamin A, and a substantial pudding to give calories. The *afternoon snack* was a scone and *tea at night* a good meal including chipped potatoes as a source of vitamin C.

HOW TO FIND OUT WHETHER A DIET IS NUTRITIONALLY GOOD OR NOT

In nutrition it is not only important *that all the nutrients needed should be present in the foods eaten*, but also that they should be present *in the amounts required* by different types of individuals.

Thus, in trying to find out whether a particular diet is adequate or not three things must be known :

- (1) *What foods were eaten.*
- (2) *How much of each food was eaten.*
- (3) *What kind of individual ate the foods, was it a man, a woman, an adolescent or a child, and was he active, very active or sedentary, or for a woman, was she pregnant or nursing a baby?*

There are two main ways of finding out about diets :—

- (1) *How much food was bought in, say, a week and how many people ate it?*
If the amount of food bought is recorded, it is important to know how much of it is eaten, how much goes into or comes out of the store-cupboard and how much of the food bought is wasted in preparing meals and on the plates.
- (2) *What weights of foods were eaten by a single individual at each separate meal for, say, a week?* This is probably one of the most precise methods of assessing the value of a diet. In carrying it out each item of every food must be weighed and recorded.

For meals served by canteens or restaurants it is, of course, possible to weigh all the ingredients of a number of meals as they are ready for serving. An estimate of the amounts of nutrients wasted in preparation can be gained by comparing the calculated nutritional value of the meals served and the number of meals with the calculated nutritional value of the supplies of food coming into the kitchen.

(3) For people running canteens who wish to find out what sort of diet their customers eat, so that they may be able to plan, at the canteen, meals to complete their nutritional requirements, a third method may be employed. A selection of the people using the canteen may be interrogated about their previous 24-hours' meals. Whenever an item of food or drink is mentioned, the people being studied must be asked to help themselves to *the same amount* from a supply which must be collected for the interview. This amount is then weighed. From these weighings it is then possible to calculate, at least roughly, *what sort of diet* the people eat and hence what nutritional value the canteen meal can best provide in order that the *complete day's food* may be adequate for health. (*Warning*: people's memories are so bad that questions ought not to be asked about meals eaten more than 24 hours before).

FEEDING PEOPLE IN BED

When people are in bed, either in hospital or elsewhere, their calorie needs and, hence, the total amount of food they can eat, become very much reduced. It therefore becomes very easy for a shortage of protein or calcium or some other nutrient to develop. In planning diets for people in bed, it is important to include:—

- (a) Plenty of protein food of high nutritional value, e.g. eggs, fish, milk etc.
- (b) Plenty of dairy produce to provide calcium, vitamin A and riboflavin.
- (c) Plenty of fruit and vegetables to supply vitamin C.

It is *not* necessary to give much of foods such as bread and butter, fatty cooked foods etc., which are rich in calories.

FEEDING ATHLETES

Provided an adequate diet is given, there is no certain way of improving athletic performance by means of food. The individual undergoing heavy physical exercise will have a very greatly increased need for calories but so long as these are provided together with the other nutrient requirements set out in Chapter xiv it is, broadly speaking, immaterial in what form the nutrients are supplied.

FOOD ALLERGIES

The principles set out in this book hold, in general, for all average individuals. There are, however, a few people who possess personal peculiarities. The most dramatic of these peculiarities is a reaction against certain foods. Some people, for example, cannot eat shell fish or strawberries without being ill. This *allergy* is, perhaps, a medical, rather than a nutritional problem.

QUESTIONS

PART IV

(Chapters XVI to XVIII)

1. What effect does cooking have on protein, carbohydrate, vitamin A and vitamin C?
2. What nutritional difference is there between yeast bread and soda bread?
3. Work out the most suitable amounts of nutrients for the following meals:—
 - (a) A mid-day dinner for coalminers who eat bread and dripping for breakfast, bread and cheese in the mine, and fish and chips for tea.
 - (b) A morning snack for girls sorting pins, who have a cup of tea before work, a dinner of sandwiches and cake and spaghetti for supper.
 - (c) A midnight meal for hospital nurses during their three-months spell of night nursing.
4. Criticise the following meal intended for a school dinner for children of 14. How could it be improved? Ingredients per 100 meals: 12½ lbs. meat, 6½ lbs. dried milk, 20 pts. liquid milk, 10 oz. cheese, 1 lb. baked beans, 3 lbs. 2 oz. cooking fat, 2½ lbs. sugar, 1½ lbs. jam, 2 lbs. raisins, 2 lbs. rice, 1 lb. oatmeal, 10 oz. barley, 6½ lbs. flour, 3 lbs. bread, 50 lbs. potatoes, 3½ lbs. dried peas.
5. Five men are planning to spend a fortnight on a yacht out of sight of land. Work out what foodstuffs they should take with them to provide a perfect diet, assuming that the yacht's storage capacity is so efficient that any kind of food can be taken.
6. What are the average daily nutrient requirements *per head* for a family composed of father, who is a postman; mother; grandfather, aged 85; John, aged 17; Mary, aged 14; Matilda, aged 7; and Alphonse, aged 4½?
7. You are in control of a canteen where it is planned to provide a dinner supplying 800 calories, at least 24 g. of protein, 200 mg. of calcium, 2,000 i.u. of vitamin A and 25 mg. of vitamin C. Work out three menus:—
 - (a) a meal of meat, vegetables and pudding
 - (b) a hot meal for vegetarians
 - (c) a sandwich meal.
8. Why are fish and chips such an excellent combination?
9. An eccentric Mohammedan wishes to live entirely on sausages and mashed potatoes. What quantity of each must he eat each day if he is an active worker? What other food must he take in order to get a perfect diet?
10. Plan a week's menu, giving quantities, for a hospital containing 100 bed-ridden men.
11. Discuss the statement "a little of what you fancy does you good".

APPENDIX
THE COMPOSITION OF FOOD

February, 1947

All values are per oz. of edible portion

	Waste	Calo-ries	Pro-tein	Fat	Car-bohy-urate	Calcium	Iron	Vita-min A	Vita-min B ₁	Ribo-flavin	Nico-tinic acid	Vita-min C	Vita-min D
	Per cent.		g.	g.	g.	mg.	mg.	i.u.	mg.	mg.	mg.	mg.	i.u.
1. Cereals.													
Barley, pearl	0	97	2.2	0.5	20.8	3	0.2	0.03	0.01	0.7	0	0	0
Biscuits—													
plain	0	107	3.4	0.9	21.3	23	0.6	0.04	0.03	0.3	0	0	0
sweet	0	136	2.0	6.8	16.8	14	0.3	0.02	0.01	0.2	0	0	0
Bread—													
white 70-72% extraction	0	73	2.3	0.2	15.6	4	0.2	0.01	0.01	0.2	0	0	0
National 85% extraction...	0	71	2.4	0.3	14.6	4*(16)	0.5	0.05	0.03	0.3	0	0	0
wholemeal 92% extraction	0	70	3.1	0.6	11.2	7	0.7	0.09	0.05	0.6	0	0	0
Flour—													
white	0	100	3.1	0.3	21.2	5	0.4	0.02	0.01	0.3	0	0	0
National	0	97	3.3	0.4	20.0	6*(25)	0.7	0.07	0.04	0.4	0	0	0
wholemeal	0	95	3.9	0.9	17.4	10	1.0	0.13	0.06	0.8	0	0	0
Oatmeal	0	111	3.4	2.5	18.6	16	1.2	0.13	0.04	0.3	0	0	0
Rice	0	99	1.8	0.3	22.2	1	0.1	0.02	0.02	0.3	0	0	0
Wheatflakes, shredded wheat	0	97	3.9	0.7	18.7	10	1.4	0.01	0.02	0.3	0	0	0
2. Dairy products.													
Butter... ..	0	211	0.1	23.4	0	4	0	1,140	0	0	0	0	17
Cheese... ..	5	117	7.1	9.8	0	230	0.2	370	0.01	0.14	0.1	0	4
	(rind)												
Egg—													
fresh	12	45	3.5	3.3	0.3	17	0.8	280	0.04	0.11	0	0	17
	(shell)												
dried	0	163	13.0	11.9	0.9	62	3.1	850	0.11	0.37	0.1	0	68
Milk—													
whole	0	17	0.9	1.0	1.2	34	0	30	0.01	0.04	0	0.3	0.3
evaporated (condensed un-sweetened)	0	40	2.0	2.3	2.7	69	0.1	90	0.01	0.10	0.1	0	1
condensed, sweetened	0	89	2.3	2.6	14.1	82	0.1	105	0.03	0.10	0.1	1	1
dried, whole	0	138	7.3	7.6	10.1	254	0.2	300	0.08	0.33	0.2	0	3
dried, skim	0	97	10.2	0.2	13.6	348	0.3	90	0.11	0.45	0.3	0	0
3. Fats.													
Cooking fat, lard, etc.	0	253	0	28.1	0	0	0	0	0	0	0	0	0
Margarine	0	218	0	24.1	0	1	0.1	570	0	0	0	0	56
4. Fish.													
Kippers	40	62	5.4	4.5	0	34	0.6	51	0.09	1.2	0	0	250
White fish, cod, etc.	45	21	4.5	0.3	0	7	0.3	0.02	0.04	0.6	0	0	0
Fried fish (white)	0	57	5.3	3.4	1.4	24	0.3	0.02	0.03	0.4	0	0	0
Fish paste	0	47	3.8	2.5	2.2	41	1.7	0.01	0.02	0.3	0	0	0
Herring	30	47	4.5	3.3	0	28	0.4	42	0.08	1.0	0	0	250
Salmon—canned	0	48	5.7	2.8	0	85	0.4	71	0.01	0.06	1.8	0	170
Sardine—canned	0	84	5.7	6.8	0	114	1.1	77	0.01	0.08	1.3	0	280
5. Meat.													
Bacon	12	128	3.1	12.8	0	3	0.3	0.017	0.06	1.2	0	0	0
Beef—													
corned	0	69	7.1	4.5	0	3	3.1	0	0.04	0.5	0	0	0
fresh, average good quality	17	89	4.2	8.0	0	3	1.1	14	0.02	0.07	1.3	0	0
stewing	25	60	4.8	4.5	0	3	1.1	14	0.02	0.07	1.3	0	0
Kidney	0	36	4.5	2.0	0	3	3.8	280	0.07	0.37	3.8	0	0
Liver—ox	0	40	4.8	1.7	1.4	3	3.9	4,260	0.11	0.85	3.8	0	0
Meat pie	0	103	3.1	6.5	8.0	4	0.6	0.03	0.03	0.5	0	0	0
Meat paste	0	45	3.4	2.3	2.6	7	1.0	0.01	0.03	0.6	0	0	0
Mutton	17	94	3.7	8.8	0	3	0.6	14	0.04	0.05	1.2	0	0
"Points" meat, spam, etc....	0	75	4.3	7.5	0	0	0.6	0.13	0.04	0.7	0	0	0
Pork	15	116	3.4	11.4	0	3	0.3	0.020	0.06	1.7	0	0	0
Sausage, pork	0	73	3.0	5.1	3.7	9	0.3	0.05	0.02	0.5	0	0	0
Shepherd's pie, etc.	0	78	2.8	5.0	5.5	8	0.2	0.02	0	0.2	0	0	0

* The figures in brackets show the calcium content after the addition of chalk to the flour at the rate of 0.06%.

	Waste	Calo- ries	Pro- tein	Fat	Car- bohy- drate	Calcium	Iron	Vita- min A	Vita- min B ₁	Ribo- flavin	Nico- tinic acid	Vita- min C	Vita- min D
			g.	g.	g.	mg.	mg.	i.u.	mg.	mg.	mg.	mg.	i.u.
6. Vegetables.													
Beans—													
baked, canned	0	25	1.7	0	4.5	16	0.7	47	0.02	0.01	0.2	0	0
haricot	0	71	6.1	0	11.6	51	1.9	0	0.13	0.08	0.6	0	0
soya, dried whole	0	114	8.5	4.3	9.4	67	2.6	25	0.24	0.06	1.2	0	0
Cabbage	30	7	0.4	0	1.4	18	0.3	85	0.02	0.02	0.1	20	0
Carrot	5-20	6	0.2	0	1.4	14	0.2	1,730	0.02	0.01	0.2	3	0
Cauliflower	30	6	0.7	0	0.8	14	0.2	0	0.02	0.02	0.2	20	0
Lentil	0	82	6.8	0	13.6	11	2.2	5	0.13	0.02	0.9	0	0
Lettuce	20	3	0.3	0	0.5	7	0.2	380	0.02	0.02	0.1	4	0
Onion	5	6	0.3	0	1.3	9	0.1	0	0.01	0.01	0	3	0
Peas—													
green	60	17	1.6	0	2.7	4	0.5	47	0.12	0.03	0.2	8	0
dried	0	85	7.0	0	14.2	17	1.3	19	0.13	0.08	0.6	0	0
Potato—													
fresh	7-25	21	0.6	0	4.6	2	0.2	0	0.03	0.02	0.3	2-8*	0
chips	0	66	1.1	2.6	9.5	4	0.4	0	0.03	0.01	0.2	2	0
Spinach	25	6	0.8	0	0.7	20	0.9	1,230	0.03	0.06	0.1	18	0
Tomato	15	4	0.3	0	0.7	4	0.1	280	0.02	0.01	0.1	7	0
Turnip	35	5	0.2	0	1.0	17	0.1	0	0.01	0.01	0.3	7	0
Watercress	15	4	0.8	0	0.2	63	0.4	475	0.03	0.02	0.5	17	0
7. Fruit.													
Apple—													
fresh	20	12	0.1	0	3.0	1	0.1	4	0.01	0	0.1	1	0
dried	0	52	0.6	0	12.5	8	0.6	8	0	0.01	0.4	0	0
Apricot—													
fresh	8	7	0.2	0	2.0	5	0.1	71	0.01	0.02	0.1	3	0
canned	0	14	0.1	0	3.5	4	0.1	47	0	0.02	0.1	1	0
dried	0	50	1.4	0	11.1	26	1.2	470	0	0.12	0.6	0	0
Banana	40	21	0.3	0	4.9	2	0.1	8	0.01	0.01	0.2	3	0
Blackcurrant	0	8	0.3	0	1.7	17	0.4	9	0.01	0.01	0.1	57	0
Date	14	68	0.6	0	16.3	19	0.4	9	0	0.01	0.1	0	0
Fig—dried	0	58	1.0	0	13.5	81	1.2	9	0	0.08	0.5	0	0
Lemon	30	5	0.2	0	0.8	20	0.1	0	0.01	0	0	12	0
Melon	45	6	0.2	0	1.3	4	0.1	8	0.01	0.01	0.2	3	0
Orange	25	10	0.2	0	2.2	12	0.1	28	0.02	0.01	0.1	16	0
Peach—canned	0	16	0.1	0	3.9	2	0.2	47	0	0	0	1	0
Pear	25	11	0.1	0	2.7	2	0.1	1	0.01	0.01	0.1	1	0
Pineapple—canned	0	20	0.1	0	4.9	3	0.2	6	0.01	0.02	0	3	0
Plum	6	7	0.2	0	1.6	4	0.1	38	0.01	0.01	0.02	1	0
Prune—dried	17	44	0.7	0	10.3	11	0.8	237	0	0.04	0.6	0	0
Raisin	8	67	0.3	0	16.5	17	0.5	5	0	0.01	0.1	0	0
8. Nuts.													
Coconut	30	100	1.1	10.2	0.9	4	0.6	0	0.01	0.03	0.1	0	0
Peanut	30	166	8.0	13.9	2.2	17	0.7	0	0.25	0.08	2.6	0	0
9. Preserves, etc.													
Chocolate, plain	0	148	1.3	9.2	15.0	7	0.9	7	0.03	0.07	0.3	0	0
Jam	0	71	0.1	0	17.6	3	0.3	2	0	0	0	3	0
Sugar	0	108	0	0	27.0	0	0	0	0	0	0	0	0
Syrup	0	81	0.1	0	20.2	7	0.4	0	0	0	0	0	0
10. Beverages.													
Beer—mild	0	10	0.1	0	1.5	3	0	0	0.01	0.01	0.4	0	0
Cocoa—as drunk with milk and sugar	0	13	0.8	0.2	2.1	22	0.1	1	0	0.03	0	0	0
powder	0	125	5.8	7.3	8.9	14	4.1	14	0.03	0.08	0.3	0	0
Tea—as drunk with milk and sugar	0	5	0.1	0.1	0.8	3	0	4	0	0.01	0	0	0
11. Cakes and puddings.													
Cakes, plain	0	82	2.3	2.0	13.6	14	0.3	0	0.04	0.01	0.1	0	0
Bun	0	85	2.3	2.2	13.9	10	0.6	0	0.04	0.03	0.3	0	0
Custard	0	33	0.9	1.1	5.0	35	0	20	0.01	0.02	0	0	0
Rice pudding	0	40	1.1	1.6	5.3	35	0	23	0.01	0.01	0	0	0
Steamed pudding	0	86	1.1	4.4	0.6	15	0.2	0	0.02	0.01	0	0	0
Yorkshire pudding	0	62	2.0	2.7	7.5	28	0.2	0	0.02	0.01	0.1	0	0

* The vitamin C content falls steadily during the months of storage.

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