Food

BY

A. H. CHURCH. M. A. OXON.

SOUTH KENSINGTON MUSEUM

SCIENCE HANDBOOK.

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SOUTH KENSINGTON MUSEUM

SCIENCE HANDBOOKS.

BRANCH MUSEUM, BETHNAL GREEN.

FOOD

SOME ACCOUNTS OF ITS SOURCES, CONSTITUENTS, AND USES.

BY

A. H. CHURCH, M.A., OXON.

Prepared at the request of the Lords of the Committee of Council on Education, and published for them

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A. H. CHURCH, M.A., OXON.,

Professor of Chemistry in the Agricultural College, Cirencester.

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PREFACE.

Scope and Uses of the Present Volume.

THIS book is meant to serve two ends. In the first place it is intended for the instruction of those visitors to the Bethnal Green Museum who may wish to study the collection of food-products there displayed. Secondly, it has been so written that its pages may be read, it is hoped with profit, apart from any such exhibition of the actual materials of food.

Origin of the Food Collection.

A few words concerning the origin and character of the Food Collection may fitly here be given. The first suggestion of such a series was made by Thomas Twining, Esq., of Perryn House, Twickenham, who planned an Economic Museum, illustrative of the materials and processes of every-day life. The Food Collection was first arranged in 1857, when it became part of the General Museum of the Science and Art Department. For some time it was under the direction of the Rt. Hon. Lyon Playfair, C.B., M.P., who has himself done much good service through his studies of the relations between Food and Work. The late Dr. Lankester was subsequently entrusted with the management of the collection. It has been recently re-arranged, enlarged, and re-described by the author of the present volume.

Nature of the Food Collection.

The Food Collection contains two distinct classes of specimens. One of these comprises all the usual and important articles of human food, whether derived from animals or plants. The other class of specimens illustrates, by what may be termed *displayed analyses*, the chemical composition of many individual food-materials, such as breadstuffs, pulse, milk, eggs, and butchers' meat. Moreover, in this part of the collection the uses of food are shown in relation to the nutrition and work of the human body. An attempt has been made to let the Food Collection tell its own story. For while each important specimen and illustration is labelled in the usual way, longer and fuller descriptions, in conspicuous type, accompany each group of related specimens. Statistics as to the production, imports, and consumption of foods are also exhibited, together with numerous drawings and diagrams. Besides these aids to a thorough grasp of the subject, a set of tables has been prepared, showing at a glance the positions, in the kingdoms of Organic Nature, of the chief animals and plants used as food.

Plan of the Present Guide-Book.

The arrangement adopted in the present volume corresponds with that of the Food Collection ; it is based on the chemical composition and physiological functions of food. Both collection and book are confessedly imperfect : in each there are deficiencies to be supplied, redundancies to be removed. The collection of necessity continually grows, but the regulation of its growth is difficult. Not only are the defects of the collection reflected in the present Guide, but there are some sections of the subject where our exact knowledge fails. We may note in illustration of this point the imperfection of our published chemical analyses of butchers' meat, fish, and poultry. Such deficiencies will be slowly made good, but the work involved is difficult and tedious. It should be stated in this place that the Guide to the Animal Products Collection will afford to the reader of the present volume the zoological details concerning the most important animals used as food. In the case of vegetable products the following pages give a certain amount of botanical information ; here the nomenclature adopted in Professor Oliver's Guide to the Kew Museums has been almost invariably followed.

Authorities consulted, and Sources of information.

In the present volume there have been incorporated some parts of the "Guide to the Food Collection" compiled by Dr. Lankester, in 1863. Advantage has also been taken of such portions of the former "Inventory of the Food Collection" as had been revised by Professors Huxley and Frankland. The well-known works and papers of Liebig, Fresenius, Payen, Gorup-Besanez, Beaunis, Moleschott, Dupré, Bouchardat and Quevenne, Lawes and Gilbert, Frankland, Playfair, Pavy, E. Smith, Lankester, Hassall, Johnston, and many other writers on Food, Dietetics, and the Chemistry of Plants and Animals have been consulted, but the responsibility of a large proportion of the numerical results given in the present volume rests with the author, inasmuch as they have been derived from or checked by hundreds of new analyses performed in his laboratory.

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FOOD.

PART I.—OF FOOD IN GENERAL.

§ I.—The Uses of Food.

In order to show clearly what is the nature of the food of man, and what the work which it has to perform in the body, we may make use of a comparison which will be familiar enough to our readers. Let us compare the complex, living machine of the human body with a locomotive engine. In the case of the engine, we have, first, its material structure; secondly, the fuel in the form of coke or coal with which it is constantly supplied; thirdly, the air which enables the coke to burn; fourthly, water; and fifthly, waste, in the shape of ashes, cinders, and gases. In the case of the human body we likewise have, first, a material structure; secondly, fuel, in the form of our daily rations of food; thirdly, air, which enters into the lungs, and serves to consume the food; fourthly, water; and fifthly, the waste-products, which are thrown out of the body by different channels. In both cases the fuel is burnt by the aid of air, the oxygen of which unites with the combustible part of the fuel, and in so doing the power of doing work or potential energy in the materials which combine is set free as heat and motion. In the steam-engine this heat is chiefly used to change water into steam, and then, by the expansion which accompanies this change, motion is produced. In the human body, the heating of water and its conversion into steam or vapour is a quite subordinate part of the work done by the heat given out during the burning of substances contained in or made from the food taken. What happens in the body is briefly this. The greater part of the carbon and hydrogen in the dry matter of food, after undergoing certain changes, becomes quietly and steadily burnt in the body into carbonic acid gas and water. This combustion may go on in all parts of the body whither oxygen has been carried from the lungs by the blood, but it occurs chiefly in the muscles. The force or energy laid up in the compounds thus burnt is given out partly as heat, which keeps the temperature of the body up to blood heat ($98^\circ{\cdot}4$ Fah.), and partly in other forms, as that of mechanical motion. All the internal and external work of the body is thus done by the stored-up force or energy of the food which is burnt or oxidized therein. This food, by digestion and assimilation, becomes indeed first of all a part of the body, and then, but not till then, to any extent, does it burn and give rise to heat and motion. There are, therefore, many differences between combustion as it goes on in a locomotive and combustion as it goes on in the body. In both structures carbon and hydrogen are burnt by oxygen, but in the body the oxidation is slow, and takes place in the very midst of water and wet matters. In the body, too, its parts are themselves, to some extent, consumed by this oxidation, and so the food has the new and additional office to perform of continually rebuilding the very machinery which it keeps warm and in motion. We have said that there are waste matters thrown out by the locomotive and by the human body. These, too, are not all the same, though they are alike in the animate and the inanimate machine. In the engine the fuel gives rise, by union with oxygen, to carbonic acid gas and water-vapour, which escape into the air; and at the same time those small portions of the fuel which escape oxidation and those which are incapable of being oxidized, together form ashes and cinders. In the human body carbonic acid gas and water-vapour are likewise produced, and then got rid of in the air which we breathe out and in the exhalations from the skin; but a good deal of the carbon and of the hydrogen of our food remains in the various substances excreted by the bowels and the kidneys. In other words, the burning or oxidation of food is not so thorough as the burning which we have assumed to take place in the locomotive engine. But we need not further contrast and compare the actions which go on in the two cases, for we have said enough to give some notion about the work which food has to do in the body, and to illustrate, or rather to indicate, the way in which it is done.

§ 2.—Composition of the Human Body.

We may now consider the composition of the human body. Everyone will allow that the body contains different kinds of materials—that it is built up of skin, and flesh, and bone, and blood, and other sorts of substances. But when we look a little more closely into these things, we soon learn that under the name of bone, for example, we have a complex, and not a simple material—it is complex as to the way in which it is constructed, and complex as to the chemical composition of its constituent parts. Here we attend to the latter point chiefly, and taking into account all the different solids and liquids which make up the mass of the body, we find that these consist of a large number of substances which are chemical *compounds*. The compounds contain sometimes two, but oftener three or four, *elements*, united together by chemical attraction in definite proportions. These compounds are very numerous, something like twenty of them having been discovered in the brain alone; but we intend here to name only those which are best known or most abundant.

As yet no complete chemical examination of the total constituents of a healthy human body has been made; we cannot, therefore, state the amounts of the several ingredients which it contains, with exactness, but the figures which follow will afford some notions on this interesting subject. In making our calculations, we assume that we are analysing (that is, *chemically* pulling to pieces) a man in perfect health, 25 to 30 years of age, 5 feet 8 inches in height, and weighing 11 stone, or 154 pounds. Throwing out of our list the minuter and less certain details, we find that

See Case 1.

The human body is made up of the following compounds:

	lb.	oz.	gr.
1. WATER: which is found in every tissue and secretion, and amounts altogether to - - - - - -	109	0	0
2. FIBRIN, and similar substances, forming the chief solid material of muscular flesh, and also occurring in blood - - - - - - - -	15	10	0
3. PHOSPHATE OF LIME: in all tissues and liquids, but chiefly in the bones and teeth - - -	8	12	0
4. FAT: a mixture of three chemical compounds; distributed throughout the body - - -	4	8	0
5. OSSEIN: the organic framework of bones, and the chief constituent of connective tissue; it yields gelatin when boiled - - - - - -	4	7	350
6. KERATIN, with other similar nitrogenous compounds, forms the chief part of the skin, epidermis, hair, and nails, and weighs about - - -	4	2	0
7. CARTILAGIN: a nitrogenous substance, is the chief constituent of cartilages; it resembles the ossein of bone, and amounts to - - - - -	1	8	0
8. HÆMOGLOBIN, a very important nitrogenous substance containing iron; it gives the red colour to the blood, and amounts to - - - - -	1	8	0
9. ALBUMEN, a soluble nitrogenous substance, is found in chyle, lymph, blood, and muscles - -	1	1	0
10. CARBONATE OF LIME is found chiefly in bone - -	1	0	350
11. KEPHALIN, with myelin, cerebrin, and several other nitrogenised, sulphurised, or phosphorised compounds, is found in brain, nerves, &c. -	0	13	0
12. FLUORIDE OF CALCIUM is found chiefly in bones and teeth - - - - - - - - -	0	7	175

	lb.	oz.	gr.
13. PHOSPHATE OF MAGNESIA, chiefly in bones and teeth	0	7	0
14. CHLORIDE OF SODIUM, or common salt, occurs throughout the body - - - - - - -	0	7	0
15. CHOLESTERIN, INOSITE, AND GLYCOGEN are compounds containing carbon, hydrogen, and oxygen, found in brain, muscle, and liver - - -	0	3	0
16. SULPHATE, PHOSPHATE, AND ORGANIC SALTS OF SODIUM are found in all liquids and tissues -	0	2	107
17. SULPHATE, PHOSPHATE, AND CHLORIDE OF POTASSIUM are found in all tissues and liquids - -	0	1	300
18. SILICA occurs in hair, skin, and bone - - - -	0	0	30
	154	0	0

In giving the foregoing list we do not pretend to do more than approximately represent the quantities of the several compounds present in the body; indeed, these quantities are for ever changing. Nor does this catalogue include every kind of material necessary to the human organism, or found in it at any given time. There will be present food in different stages of digestion; carbonic acid gas with free oxygen; and a great number of complex organic compounds, each occurring, it may be, in very small quantity, but still not on that account without importance. All these matters are either omitted from our list, or else must be considered as included under the names given to better known or more abundant compounds.

Specimens of all the important compounds which are constituents of the Human Body are shown in Case 2.

Now that we have seen of what materials, or proximate principles, as they are often called, the human body is built, we must pass on to inquire into the nature of these materials themselves. They are *compounds*, that is, are made up of two or more separate and distinct sorts of matter—that is of two or more *elements*. Water, for example, is a compound of two elements —hydrogen and oxygen; fibrin contains, besides these two elements, three others, namely, carbon, nitrogen, and sulphur; yet no one of the compounds contains all the sixteen elements necessary to the body as a whole—indeed, no single compound present has in it more than six of these. Before trying to find out how much of each element is present in the body, let us see in what compounds the several elements occur.

WATER consists of *hydrogen* and *oxygen.*
FIBRIN, ALBUMEN, OSSEIN, KERATIN, CARTILAGIN, contain *carbon, hydrogen, oxygen, nitrogen,* and *sulphur.*
HÆMOGLOBIN, all the above elements with *iron* as well.
KEPHALIN and MYELIN contain *carbon, hydrogen, nitrogen, phosphorus,* and *oxygen.*
CEREBRIN and KREATIN contain *carbon, hydrogen, nitrogen,* and *oxygen.*
FAT, CHOLESTERIN, INOSITE, and GLYCOGEN, contain *carbon, hydrogen,* and *oxygen.*
PHOSPHATE OF LIME contains *calcium, phosphorus,* and *oxygen.*
CARBONATE OF LIME contains *calcium, carbon,* and *oxygen.*
FLUORIDE OF CALCIUM contains *calcium* and *fluorine.*
PHOSPHATE OF MAGNESIA contains *magnesium, phosphorus,* and *oxygen.*
CHLORIDE OF SODIUM contains *sodium* and *chlorine.*
SULPHATES contain different metals with sulphur and oxygen.
SILICA is a compound of *silicon* and *oxygen.*

The following is a list of all the elements that are invariably found in the human body. It will be seen that there are sixteen of them in all, seven of these being metals, and the remainder (which we place first) non-metallic :

Case 1. ELEMENTS OF THE HUMAN BODY.

	lb.	oz.	gr.
1. OXYGEN : a permanent gas, the great supporter of combustion. This gas constitutes $\frac{8}{9}$ths of the weight of water and $\frac{1}{5}$th of the air. The quantity in the human body would fill a space of some 1,290 cubic feet, and would weigh about - - - - - - - -	109	2	335
2. CARBON : a solid, occurs nearly pure in charcoal. The carbon in the body is variously combined with other elements, and by its burning sets free heat, and produces carbonic acid gas -	18	11	150

	lb.	oz.	gr.
3. HYDROGEN : a gas and the lightest substance known. It occurs mainly in water ; the quantity in the human body would fill a space of some 2,690 cubic feet, and would weigh about -	14	3	150
4. NITROGEN : a gas without energetic properties. It is an essential part of all bone, and blood, and muscle. The quantity in the body would occupy about 66 cubic feet, and would weigh about - - - - - - - - - -	4	14	0
5. PHOSPHORUS : a solid. It occurs specially in various compounds of the bones and of the brain. It burns so readily in air, that it is here kept under water. In the human body we find about - - - - - - - - - -	1	12	25
6. SULPHUR : a yellow combustible solid, often called *brimstone.* Like all the preceding elements, it is found in all the tissues and secretions of the body, but always in combination. It amounts to - - - - - - - -	0	8	0
7. CHLORINE : a greenish-yellow gas, found in the body chiefly in union with sodium, the compound being common salt. The chlorine in the human body would, if free, fill a space of 1 cubic foot and 772 cubic inches, and would weigh - - - - - - - - -	0	4	150
8. FLUORINE : hardly known in the separate state, but probably a gas. It is found united with calcium in the bones and teeth. The quantity in the body would probably fill a space of 2 cubic feet and 510 cubic inches. It would weigh - - - - - - - - -	0	3	300
9. SILICON : a solid, occurring in union with oxygen, in hair, bones, blood, bile, saliva, and skin - -	0	0	14
10. CALCIUM : a metal, the basis of lime. It occurs chiefly in bones and teeth - - - - - -	3	13	190
11. POTASSIUM : a metal, the basis of potash. It is lighter than water, and when placed on it burns with a lilac flame. It occurs mainly as phosphate and chloride - - - - - - -	0	3	340
12. SODIUM : a metal, the basis of soda. It is lighter than water, and must be kept from the air. It occurs chiefly in union with chlorine as common salt, but also in other compounds in bile	0	3	217
13. MAGNESIUM : this metal is found, in union with phosphoric acid, mainly in bones - - -	0	2	250

	lb.	oz.	gr.
14. IRON: this metal is essential to the colouring matter of the blood. It occurs everywhere in the body	0	0	65
15. MANGANESE: a metal much like iron. Faint traces occur in the brain, and decided traces in the blood.			
16. COPPER: traces of this metal are invariably found in the human brain, and probably also in the blood.			

Lithium and lead have been frequently found, but not in quantities that could be weighed, in both muscles and blood. It is not certain, however, that these elements are absolutely essential parts of the human body.

We have now seen of what compounds and elements the human body is made up, and, therefore, we may now inquire what must be the quantity and character of the food which has to furnish these compounds. But our inquiry must also include another point—namely, the materials with which the machinery of the human body is kept in action. In short, we must study food not only as a constructive and reparative material, but as fuel—as the source of heat and force.

The materials of the human body, that is, the compounds of elements of which it is constructed, are, in most instances, either identical with, or similar to those compounds which are contained in food. Naturally we should expect this to be the case with animal food, but it is also true to a great degree in the case of vegetable products. And here it must be recollected that, with rare exceptions, compounds, and compounds only, not the separate elements, are capable of nourishing the body. Oxygen, indeed, is used in the free or uncombined state as an element, but the office performed by oxygen, as we have before explained, is quite different from that of the materials usually called food.

It will be convenient to introduce here a classified list of the several compounds which occur in the vegetable and animal products used as food. A classification which takes into account both the chemical composition of these compounds and the purposes which they serve in the body will be adopted.

§ 3.—Chemical and Physiological Classification of Food.

Class I.—Nutrients.

Division 1.—Incombustible Compounds.

Group i. Water—The carrier of nutritive materials and waste products: forms an essential part of all tissues.

Group ii. Salts or Mineral Matter—such as *common salt* and *phosphate of lime*, which serve to effect changes and build up certain tissues.

Division 2.—Combustible Compounds.

Group iii. Carbon Compounds, such as *starch*, *sugar*, and *fat*, which serve to keep up the heat and movements of the body by the discharge of their potential energy during oxidation in the organism. The fat of the body is formed in part from fat or oil in the food. The members of this group are often called in the following pages "heat-givers," a term which is equivalent to "force-producers."

Appendix to Group iii. *Gum*, *mucilage*, *pectose*, and *cellulose*, approach starch in chemical composition, and probably serve, in some measure, the same end.

Group iv. Nitrogen Compounds, such as *fibrin*, *albumen*, and *casein*, the chief formative and reparative compounds of food: they also may yield fat, and by their oxidation set free heat and motion. Hereafter we shall name them "flesh-formers," except where we set them down as albumen, &c., or as albuminoids.

Appendix to Group iv. The *ossein* of bones and *gelatin*; *cartilage* and *chondrin*; *keratin* and *elastin* from skin and connective tissue,—approach the albuminoids in composition, and may serve, in a measure, similar purposes in the body.

Class II.—Food Adjuncts.

Group i. Alcohol, as contained in *beers*, *wines*, and *spirits*.

Group ii. Volatile or Essential Oils, and other odorous and aromatic compounds, as contained in *condiments*, like mustard and pepper, and in *spices*, as ginger and cloves.

Group iii. Acids, as *citric acid* in lemons, *malic* in apples, *tartaric* in grapes, *oxalic* in rhubarb, and *acetic* in vinegar and pickles.

Group iv. Alkaloids, as *caffeine* in coffee and tea, *theobromine* in cocoa, and *nicotine* in tobacco.

Specimens of the compounds found in Foods are shown in Cases 2 and 3.

We may now proceed to give a brief account of each Nutrient, following the order in which these compounds are classified in the preceding Table; the Food Adjuncts will be considered further on.

§ 4.—Water.

Cases 4, 5, and 6.

This important constituent of food is the carrier of food into and through the system, and forms more than two-thirds of the whole body. Water is contained not only in the liquids drunk as beverages, but in all kinds of solid foods. Here is a list of the

Quantities of Water in 100 lb. of Different Kinds of Food.

Vegetable Food.

	lb.		lb.
Fresh oatmeal	5	Grapes	80
Maize meal	14	Parsnips	81
Wheaten flour	14	Beetroot	82
Barley meal	14	Apples	83
Peas	14	Carrots	89
Haricot beans	14	Cabbages	89
Rice	15	Onions	91
Bread	40	Lettuce	96
Potatoes	75		

Animal Food.

	lb.		lb.
Butter	10	Lean of meat	73
Bacon	22	Fowl	73
Cheese	34	Fish	74
Eggs	72	Milk	86

Although the above proportions of water seem generally large, these foods do not suffice alone to supply all the water required by man. As every pound of perfectly dry food should be accompanied by four pounds of water, it is found necessary to consume water itself, or some beverage containing little else but water.

Drinking Water.

Water for drinking must fulfil certain conditions. It must have no smell, even when warmed, but its taste must be pleasant and fresh. Seen in bulk it must not be cloudy or yellowish, but of a pale blue or bluish-green colour. Drinking water must always contain air dissolved in it. This air consists of three gases—nitrogen, oxygen, and carbonic acid gas. Boiled water, having lost its gases, is insipid and flat. 100 cubic inches of water should have from 2 to 5 cubic inches of gas in solution. Water should likewise contain certain mineral matters dissolved in it. Of these the chief is carbonate of lime, but there are also sulphates, chlorides, and nitrates of sodium, magnesium, &c., present. But these dissolved mineral matters need not exceed a few grains, and should not amount to as much as 30 grains in the imperial gallon of water, which weighs 10 lb., or 70,000 grains. It is usual to call all the different matters left behind when a water is boiled down to dryness, *impurities*, and in a chemical sense this is correct. And it may further be stated that the larger the residue left by a water on its being evaporated, the less suitable that water will prove for most of the usual purposes to which water is put. It will be "harder" than waters leaving less residue, and so will consume more soap in washing without producing a lather; it will leave more fur, or deposit, in kettles or boilers, and thus cause the waste of more fuel; and it will extract the goodness of tea, coffee, &c., less thoroughly. By evaporating a pint of any particular water carefully down in a glass dish we see what residue it leaves, and can compare it with the residues left by other waters. But this residue may be made to teach us more about the water. Boil down a pint, or better, a quart, of the water in a porcelain dish, and then

In Case 6 may be seen the colour of pure water and of various London waters.

In Case 5 several water residues are shown.

heat the dry residue gradually hotter and hotter. If the original residue is white and powdery in appearance, that is, so far, a good sign; but if it is partly white and partly yellowish or greenish, and especially if there are gum-like stains round the residue, then on heating these parts of the residue we shall probably see them darken, fuse, and burn away in part, giving out fumes having a disagreeable smell. If the blackening is considerable, much organic matter is present; but if the smell is offensive (like burnt feathers), then it is certain that the organic matter is of animal origin, and is, therefore, more likely to be unwholesome, or even poisonous.

Such strongly-heated residues of good and bad waters are shown in Case 5.

Another test for organic matter in water may be used with some facility. If a water contains substances derived from the decay of animal or vegetable matters, such as those in sewage and manure, and the refuse of plants, then it is found that such a water will destroy the beautiful purple colour of a chemical substance called *permanganate of potash.* The reason for this is as follows: The decaying organic matters of the water attract oxygen strongly when it is presented in certain states or forms. Now, a solution of the above permanganate contains much oxygen just in the right state to be so attracted and removed. By its removal from the permanganate the composition of that substance is altered, and its colour destroyed. The more organic matter in the water, the more permanganate will be decolourized. The test may be thus applied. Fill a clean white teacup with the water to be tested. Add about 60 drops, or a drachm, of weak sulphuric acid; stir with a clean slip of window glass; now pour in enough of a weak solution of permanganate of potash to render the water a rich rose colour. Cover the cup with a clean glass plate. Now, if there be much organic matter in the water, the colour will go in a few minutes, and more permanganate may be added, and still lose its colour. It must be recollected in using this test

For specimens of this test and waters tested, see Case 5.

that peaty matters and iron salts, which are not necessarily unwholesome, give the same result.*

Another mode of testing drinking waters is the following: Nearly fill a clean tumbler with the water, and then add 20 drops of nitric acid, and 5 of a solution of nitrate of silver (lunar caustic), or else a small crystal of that substance. Stir with a clean slip of glass, and if there is more than a slight bluish-white cloudiness, if there is a solid curdy substance found, then there is too much common *salt* in the water. It may be said, What harm is there in common salt? We answer, none in the common salt as such, but only in the common salt as evidence of some kinds of pollution. We will explain. Common salt (chloride of sodium) does not occur in rain-water, or pure well-water, except to the extent of a little over a grain per gallon. Of course there is more in waters from salt-bearing rocks, and in waters near the sea. But generally, at all events in a chalk or limestone district, where common salt is found in any quantity exceeding 1½ grain per gallon, which gives a mere cloudiness with nitrate of silver, the salt is derived from sewage; in other words, from the salt consumed in human food, and voided chiefly with the urine. If a water be found to contain both organic matter and common salt, it is probably contaminated by house or town sewage. If organic matter be abundant, but accompanied by a smaller quantity of common salt, then the source of pollution is rather the excrement of farm animals than of man—or it may arise merely from vegetable refuse.

For specimens of this test and waters tested, see Case 5.

Phosphates, shown by the molybdic acid test, are another sign of animal pollution in a water.

Before considering the other impurities of water, it will be better if we briefly state the several sources of drinking water.

* Rain and pure waters contain very little ammonia, sewage and many bad waters much. "Nessler's" test strikes a yellow or brown colour when ammonia occurs in sufficient amount.

Water Supply.

Water for drinking purposes is derived from five sources :—
1. Rain-water; 2. Rivers; 3. Surface-water, and Shallow wells; 4. Deep wells; 5. Springs.

1. *Rain-water* always contains some impurities, both suspended and dissolved. As it falls through the air it acquires a little ammonia, as well as nitrous and nitric acids; it dissolves nitrogen, oxygen, and carbonic acid gas; and if there be any sulphurous acid gas, or hydrochloric acid, or compounds of arsenic, &c., present in the air—as in and near large towns and manufacturing districts, it will carry these down with it. But it will also remove from the air much of the suspended matter which is always floating therein—the dust which is seen to be so abundant in air when a beam of sunlight falls across an otherwise darkened room. Thus it is that rain-water, or ever it touches a roof or the land, contains of solid impurities, organic and inorganic, nearly 2 grains in the gallon. This is the average result in the country, but the rain-water of London and large towns is far more loaded with impurities.

Here it will be as well to state that the amount of rain falling in the London district averages less than 25 inches in the year: it is less than this on the eastern coasts of England, and gradually increases towards the west till there are found some excessively rainy places, as in North Wales, Cumberland, and the north-west of Scotland, where the annual rainfall is greater than 75 inches. Let us consider what *one inch of rain* really means. If an acre of land were covered with water to the depth of only the tenth part of an inch, that layer of water would weigh more than 10 tons: thus 1 inch of rain is ten times that amount—in fact, very nearly 101 tons. A rainfall during the year of 25 inches corresponds, then, to 2,525 tons of water per acre.

If we collect rain-water as it falls in the country, we may easily render it impure in many ways. If it falls on a slate roof it suffers little change; if on one of tiles, it will take up scarcely anything save a little decaying vegetable matter from the mosses and lichens usually found on such a surface; but if it falls on a limestone roof it dissolves calcareous as well as decaying organic matters. Further, rain-water acts on leaden pipes and cisterns, becoming charged with this injurious metal.

2. *River-water.*—Directly rain-water comes into contact with the land it acquires fresh impurities. Even rain-water stored in tanks or cisterns may become decidedly unwholesome; but when, as in most parts of England, rain falls upon pasture land, arable land, or inhabited places, then its character is altogether altered for the worse. From the bones and other manures applied to farm lands, from vegetable and animal refuse, particularly the sewage-matter from human habitations, rain-water takes up, not only mineral matters, but decaying organic matters. If the water thus polluted does not have to pass through thick layers of chalk, or limestone or sandstone rock, but runs off the surface or through drain-pipes, it is charged with injurious matters. It often passes directly into rivers, which generally receive also the direct inflow of sewers, the foul discharges of factories, and the droppings of the farm animals which are pastured on the banks. Thus the use of river-water for drinking and cooking is not to be recommended. It is fraught with risk to health.

3. *Surface-well water* resembles river-water, but is likely to be still more loaded with dangerous impurities. For in a river the decaying animal and vegetable matters present become, in part at least, oxidized and rendered harmless by the dissolved oxygen of the water, aided by the suspended earthy or mineral matters. It will not, indeed, be safe to trust to such natural purification, for it is only partial at the best, and may wholly fail to remove the most deadly of the organic matters, the special poisons, for instance, of typhoid fever and cholera. With greater force the same statement may be made in regard to surface-wells. These merely receive surface soakage from the immediate locality:

they are often near privies and pigsties, and not infrequently they are in communication with a neighbouring sewer or cesspool. Many years ago the writer of these pages discovered, by means of spectrum analysis, that if a salt of the metal lithium was put into certain privies, cesspools, and leaky sewers, it could be soon detected in the water of neighbouring shallow wells in which it was not naturally present. In fact, wherever a clay or other water-bearing material keeps up the water, and there is a loose soil or gravel above, it is pretty nearly certain that the shallow wells dug in the earth will be in communication with the neighbouring cesspools. Often the level of the liquid in both will be the same. True, the sewage-water will not pour in unfiltered and turbid, but it will pour in for all that, and mingle with the natural water of the well. We cannot depend upon the purifying effect of the few feet of gravel or sand that may separate the well from the cesspool. To the eye, and even to the taste, there may be no signs of the disgusting and dangerous pollution, but the pollution may be there, nevertheless. Sometimes these waters may be taken—it may be for years—without bad results, but an epidemic may come, and then these waters may spread, and often have spread, death around. The poisons producing cholera and typhoid fever are contained in the discharges from the bowels of persons suffering from these diseases, and a small quantity of such discharges finding its way into water used for drinking, has been clearly proved to have been the cause of a frightful mortality amongst persons using these waters. There is scarcely a single shallow well in London which can be pronounced safe.

4. *Deep-well waters* are generally palatable as well as free from injurious substances. The organic matters which the rain-water has carried down with it into the rocky layers below the surface, have been so altered by their passage through great thicknesses of stone, that they have become oxidized, or in common language *burnt*. It may seem strange to talk of burning taking place in water; but the process of oxidation, whether slow or fast,

whether it occurs when a candle burns in air, or food in the body, or animal and vegetable matter in water, is essentially the same process. The new products formed are harmless, indeed they may be even useful, *but the oxidation must be complete.* The process is not completed in shallow-well waters; it generally is in deep-well waters. The final and harmless products are there. The nitrogen of the animal matters appears at last in the form of nitrates and nitrites; the carbon, as carbonic acid gas; and the hydrogen, as water. The nitrates and nitrites may be regarded as a sign of previous pollution, but they are quite harmless, and must occur in all the deep-well waters of a country like England, where so much of the land which receives the rainfall is under cultivation, and consequently manured. Most farm lands in England receive yearly in farm-yard manure alone, nearly 30 pounds of nitrogen per acre, and this must find its way into rivers, wells, and springs. Deep-well waters are usually harder than any of the waters before considered, for they will have dissolved out much calcareous, magnesian, and alkaline salt during their long course underground. They will probably, on the average, contain about 30 grains per gallon of total dissolved substances.

5. *Spring waters* are generally palatable and wholesome. They vary in hardness and as to total solid matters dissolved, according to the more or less insoluble nature of the rocks through which they have passed or which throw them out. The Rabate Fountain at Balmoral contains less than 1 grain per gallon of dissolved matter, while the average of the springs of the Lias shows 25½ grains.

Hardness of Water.

This may, perhaps, be the best place to introduce a few words about that quality of water which is usually called *hardness*, and to which we have before frequently alluded. In ordinary waters the chief hardening ingredients are salts of lime and magnesia. These decompose soaps, forming white, curdy, and insoluble compounds—lime and magnesia soaps, in fact, which contain fatty acids united with these earthy bases. The alkali in the original soap unites with the carbonic or sulphuric constituent of the lime and magnesia salts, forming carbonate of soda, which has cleansing properties, or sulphate of soda, which is quite useless. If then a water be hard from earthy carbonates, however disagreeable washing with it becomes, still the soap, though it will not lather, cleanses. But if earthy sulphates predominate, then neither lathering nor cleansing can take place until the soap has destroyed these salts. In using a hard water for washing the hands, we instinctively use but little water, rubbing the soap between the hands wetted with water but not immersed in it. But in soft water we find that a very little soap will cause the whole of the water to lather. It is not ascertained that hard waters are unwholesome because of their hardness, though much mineral matter dissolved in a water is objectionable. But for washing linen and for baths hard waters are objectionable, because of the white, useless, curdy matter which is formed with soap, and which wastes much soap, and may, if not removed by rinsing and rubbing, stick to the skin. The amount of soap destroyed or curdled by 100,000 lb. (10,000 gallons) of various waters is seen in this table.

Case 4 contains illustrations of the soap destroyed by different waters, and also of the dissolved matters they contain.

Waters.	Soap destroyed, lb.
Thames	212
Lea	204
Kent Company's	265
Caterham	84
Worthing	285
Leicester	161
Manchester	32
Preston	80
Glasgow (Loch Katrine)	4
Lancaster	1

The hardness of water may be tested by a standard solution of soap, known as Clark's Soap Test.

Organic Pollution of Water.

The organic impurities of water are even more important than the mineral impurities. Organic impurities, such as sewage contains, and to which reference has been already made more than once, should never be allowed to enter into a water used for drinking purposes. If they have entered, we can prove their actual presence by the amount of carbon and nitrogen in organic combination which the polluted water contains; while we can trace their previous entrance by the nitrates and nitrites which they yield. If we assume that average London sewage contains 7 grains of combined nitrogen per gallon (or 10 parts in 100,000), then if we find 3½ grains in a gallon of water, it may be considered that the particular sample of water examined had received animal pollution equal to just half its bulk of sewage. This pollution may not have arisen from actual house sewage, but from animal matters in decay, farmyard manure, guano, &c. Nor can we say that water which *has been* thus polluted is necessarily *now* unwholesome. Such changes may have occurred to the offensive and unwholesome nitrogenous decaying matters as to have turned them into harmless mineral compounds—mere signs of previous contamination. The preceding remarks will, it is hoped, render clear the meaning of the expressions and numbers used in the monthly reports concerning the metropolitan water supply which are published by the Registrar-General.

So far, little has been said about the visible suspended matters found in many water supplies, attention having been drawn chiefly to the invisible dissolved impurities. In settling-tanks, and by passing through filter-beds, the muddy water of the Thames and Lea may be rendered bright and clear. For if the impurities of water were suspended in it, but not dissolved, thorough filtration would remove them. But, unfortunately, perfectly clear or bright waters may be as unwholesome, or more so, than muddy ones. Yet filtration does effect some change for the better even in the worst waters, provided that the water filters slowly, and that the material of the filter is of the right sort and not rendered inert by previous use. An old filter, in which the charcoal, &c., has not been properly renewed, may *give* impurities to a water instead of removing them.*

The best materials for filters are these three :—

1. Gravel and sand, if sharp and clean.
2. Charcoal, especially burnt bone.
3. Spongy metallic iron.

The water supplied to London is filtered by means of gravel and sand, which generally cause the removal of 1 grain per gallon of dissolved matter and all the suspended particles. Animal charcoal, prepared by heating bones to redness in closed iron retorts, is very effective, when fresh, in removing much organic dissolved matter and mineral salts from water filtered through it. But its softening effect is not of long continuance. A cheap and simple filter may be made by taking a large common flowerpot, thoroughly soaking it in clean water first, and then filling it up in the following way:—Plug the hole at the bottom with a piece of sponge, not too tightly; put on this a layer of animal charcoal, then a layer of clean sand, and on the top a layer of coarse clean gravel. Many of the filters now manufactured are constructed in a similar way. Wherever possible it is best to let the water ascend through the filter. This may be done in cisterns and siphon filters.

As a filtering material, nothing equals spongy iron. This was introduced by Mr. G. Bischof, and is most effective in reducing the hardness of water (often by two-thirds its original amount), and in removing the dissolved organic matter. There

* Filters of different kinds are shown in the collection. The actual process of filtering water through sand, gravel, and charcoal is exhibited, together with samples of the materials used in the construction of filters.

is, of course, much risk in trusting to any method of filtration for removing deadly or unwholesome matters from drinking waters, but if reliance can be placed on any material for this purpose, it would probably be on spongy iron.

There are two metallic impurities which may be found in water used for drinking. One of these is *iron*, which cannot be considered injurious to health, though its presence may render the water unpleasant to the taste and unsightly. This iron arises from the iron mains through which the water is conveyed. These ought always to be coated inside and out, when freshly cast, with a mixture of pitch and heavy coal or mineral oil. The pipes are heated to 500° Fah., and then dipped into the hot mixture. The black shining varnish thus produced protects the pipes from change and the water from contamination.

For examples of the action of water on lead, see Case 5.

The other metal occurring in some waters is lead. This is derived from leaden pipes and leaden cisterns, but it is scarcely ever found except in rain-water and very soft water: in these it may be present in dangerous amount. It may be detected by the brown tint produced on adding a drop of hydrochloric acid and some hydrosulphuric acid water to the suspected water.

We may now consider the only truly *chemical* process adopted on a large scale for improving the quality of water, for filtration is, in the main, a *mechanical* operation.

There is a plan of softening hard water by the use of lime; it was invented by the late Dr. Clark, of Aberdeen. Waters from the chalk, limestone, and oolite may be made to lose most of their hardness by this process, just as effectually as by boiling. But if a water is not softened by boiling it cannot be softened by Clark's process, which is competent to remove the carbonates of lime and magnesia, but not the sulphates. Clark's process may be thus carried out in the case of the East London Company's water. Slake 18 ounces of freshly-burnt quicklime in a little water; when

For illustrations of Clark's process of softening waters, see Case 5.

the lime has fallen to powder, add enough water to make a thin cream with this powder, and stir the mixture in a pail. Then pour this cream into a cistern containing 50 gallons of the water to be softened, rinsing the pail out with more water, but not pouring out any lumps of lime that may have settled. Let into the cistern the remainder of the 700 gallons of water which 18 ounces of lime can soften, and take care that a thorough mingling of the water and lime occurs. The added lime seizes the carbonic acid gas which held the carbonate of lime in solution, and so both the original carbonate of lime and that formed in the process fall together as a white sediment. This takes some time to settle—from 12 to 24 hours—but the water may be used for washing before it has become quite clear. This process is carried out on a large scale at Canterbury, Tring, and Caterham. At Canterbury 110,000 gallons are softened daily by the addition of 11,000 gallons of lime-water, the total impurities of the water being thus reduced from 23½ grains per gallon to less than 8½. And not only are hardening matters thus removed, but organic substances as well. The process purifies, to some extent, as well as softens; and the method is not only effective, but cheap. It would require 20¼ cwt. of soap, costing £47 1*s.* 8*d.*, or 4¾ cwt. of carbonate of soda, costing £2 17*s.* 6*d.*, to soften the same quantity of water which could be treated by Clark's process for 8*d.*, the cost of 1 cwt. of quicklime.

London Water.

London, with its suburbs, may be assumed to contain about four millions of inhabitants—or four persons out of every thousand now living on the whole globe. London is supplied with water by eight private companies, which provide a daily supply of about 114 millions of gallons. The following table gives the names of these companies, the sources of the water which they supply, and the daily amount :—

Water Companies.	Sources of Supply.	Daily delivery in Gallons.
East London - -	Thames above Sunbury, and Lea	21,000,000
West Middlesex - -	Thames above Hampton - -	9,700,000
Grand Junction - -	Thames near Hampton - -	12,300,000
Southwark and Vauxhall	Thames near Hampton - -	17,500,000
Lambeth - - -	Thames near Moulsey - - -	12,500,000
Chelsea - - - -	Thames near Moulsey - - -	10,000,000
New River - - -	Lea, and springs, and deep wells -	22,000,000
Kent - - - -	Deep wells in chalk - - -	9,000,000

Some idea of the vastness of the quantity of water supplied to London may be obtained by comparing its bulk with that of a familiar building. A day's water supply would require a tank equal in area to Westminster Hall, but the walls would have to be carried up to the height of 1,140 feet, or nearly three times the height of the cross on St. Paul's Cathedral. And this quantity of water will not suffice for the increasing population as years go by. In 1850 the gross daily delivery was 44,500,000 gallons; in 1856 it had reached 81,000,000 gallons, and now stands at 114,000,000 gallons.

§ 5.—Salts, or Mineral Matter, in Food.

The importance of water as a constituent of food has obliged us to dwell upon the subject of water supply at some length. Turning again to the classified list of Nutrients on p. 9, we find next to water a group of oxidized or incombustible ingredients, called salts, or mineral matter. These occur, as we have seen, in most drinking waters, and are found also in all parts of plants and animals used as food; while one of them, common salt, the chloride of sodium, is added purposely to food—indeed is the only solid mineral substance so added and consumed.

The quantity of mineral matter contained in some important articles of vegetable and animal food is shown in this table :—

MINERAL MATTER IN 1,000 LB. OF 13 VEGETABLE PRODUCTS.

	lb.		lb.
Apples	4	Watercress	13
Wheaten flour	7	Maize	20
Turnips	8	Oatmeal	21
Potatoes	10	Peas	30
Barley	11	Cocoa nibs	36
Cabbage	12	Wheaten bran	60
Bread	12		

MINERAL MATTER IN 1,000 LB. OF 4 ANIMAL PRODUCTS.

	lb.		lb.
Cow's milk	7	Eggs (without shells)	18
Lean of mutton	17	Gloucester cheese	50

It is not to be supposed that the mineral matter entered in these tables is in all cases of the same composition. It varies greatly in the different products named. In most seeds and fruits there is much phosphate in the mineral matter, and in most green vegetables much potash. One important kind of mineral matter alone is deficient in vegetable food, and that is common salt. This compound must be added in large quantity to the food of persons living exclusively on vegetables; while, on the other hand, there is no better way of counteracting the bad effects on the human body of a salt-meat diet than the use of lemon-juice and fresh green vegetables, which are rich in potash salts.

The mineral matters found in different sorts of vegetable food are not always the same as those which form part of the body, their constituents being more or less re-arranged and re-combined after their consumption as food. A list of the most important kinds of mineral matter or salts found in or taken with food may be fitly given here.

For salt and other mineral matters in foods, see Case 7.

1. *Common salt*, chloride of sodium, appears to be essential to the life of the higher animals. Some plants contain little or the merest trace of it. Salt is diffused everywhere, and accumu-

lates in the ocean, rain steadily washing it out of soils and rocks, and rivers then bringing it to the sea. Salt occurs as rock salt and in brine springs, both of which usually contain many other saline substances or impurities. By boiling down and crystallising its solution, salt may be purified and obtained of various degrees of fineness—bay salt, kitchen salt, and fine salt. Salt should be fine-grained, white and dry, and without bitter taste, the latter defect being due to chloride of magnesium. Common salt suffers certain changes in the human body, and is not merely taken to be excreted. Its chlorine helps to furnish the hydrochloric acid of the gastric juice, and the chlorine of the chloride of potassium found in red blood-corpuscles and in muscle. Its sodium forms part of the soda salts which are the characteristic constituents of the bile, and of the phosphate of soda of the blood. Salt is much used in the preservation of animal food; sometimes nitre is added as well.*

For specimens of potash salts, see Case 3.

2. *Potash salts,* such as the phosphate, the carbonate, the chloride, and the nitrate, are either contained ready-formed in vegetable and animal foods, or are produced from other potassium compounds. Dry seeds, for instance, usually contain much phosphate of potash, while fleshy fruits and the growing parts of plants are rich in potash salts of organic acids, such as the oxalate, tartrate, citrate, and malate. These are changed by oxidation in the body into carbonate of potash, &c. &c. Potash salts in small doses are stimulating; in large doses they prove unmistakably poisonous. Nitrate of potash (saltpetre) is present in many plants, as lettuce and watercress.

For salts of lime and magnesia, see Case 3.

3. *Phosphate of lime,* with small quantities of carbonate of lime and fluoride of calcium, is an essential mineral constituent of food. Phosphate of lime is well known as bone-earth; it is a white, earthy-looking substance, nearly insoluble in water. It is always associated in all three

* In Case 7 is a small sample of the salt soil which occurs near the city of Mexico; also, salt obtained from this earth by extraction with water and boiling down.

kingdoms of nature with the carbonate, fluoride, or chloride of calcium. It is contained in seeds and fruits chiefly, and is essential to the bones and teeth, which it hardens and strengthens. But phosphate of lime is doubtless concerned in the formation, not only of bone, but of most other tissues. Magnesia salts resemble and accompany lime salts.

4. *Iron* occurs in nearly all articles of food, though in very minute quantities. The ashes of all plants used for food contain distinct traces of peroxide of iron. In vegetables it probably occurs in combination with organic acids. Milk has been found to contain 1 part of iron in 57,000 parts.

For iron salts, see Case 3.

5. Of most of the acid constituents of the mineral nutrients we have already spoken; but the sulphates have not been mentioned. It is considered that a part of the sulphuric constituent of the sulphates of the body is contained in the sulphates of drinking waters and vegetable food, but that some may be formed from the sulphur of the albuminoid and gelatinous matters consumed.

For sulphates, see Case 3.

One of the main functions of mineral nutrients is to aid in the transference, absorption, and elaboration of the oxidizable nutrients—somewhat after the same manner that a scaffolding aids the construction of a building. The same or similar offices are performed in plants by the mineral matters they contain.

§ 6.—Carbon-compounds or Heat-givers.

The third group of nutrients contains a number of oxidizable carbon-compounds, the chief of which are starch, sugar, and fat.

1. *Starch* is, perhaps, the most important of the heat-givers or force-producers in human food. It occurs abundantly in the cereal grains, especially in rice, Indian corn, and wheat; about 15 per cent. may be obtained from potato tubers; it is also found in most leaves and stems, and in many succulent fruits. Starch occurs in peculiar forms called *granules*, which are often quite characteristic of different plants. Starch

See Drawings of Starch Granules.

is a white, glistening powder, insoluble in cold water, but nearly completely dissolved by hot water. Its solution, when cold, becomes an intense blue when a solution of iodine is added to it. Starch forms about 83 per cent. of the whole weight of tapioca, from the root of *Manihot utilissima* and *M. aipi*, the mandiocca or cassava plants, natives of South America, and belonging to the Euphorbiaceæ, or Spurge order. The roots of the bitter cassava (*M. utilissima*) contain prussic acid as well as starch, the former being separated by washing the grated roots, and allowing the starch granules to settle. Another well-known starch is that which goes under the name of arrow-root. It is obtained chiefly from the the rhizome, or root-stock, of *Maranta arundinacea*, a native of the West Indies, largely cultivated in Barbadoes, St. Vincent, and Bermuda. Tous-les-mois is another starch, obtained from the tubers of *Canna edulis*. Sago is likewise a starch, mainly produced by the sago palms (*Sagus rumphii* and *S. lævis*). The trees are felled, split, and the starch washed out from the central parts. In the Moluccas sago cakes are a common article of food. In Ceylon and some parts of the East Indies a coarse sago is made from the nuts of *Cycas revoluta*, &c. The most common starches used in England as food are those from the tubers of the potato, from wheat, from rice, and from Indian corn, this latter often going under the name of corn-flour. Portland sago, or Portland arrow-root, is a starch obtained from the tubers of a species of arum; while salep or saloop, once largely consumed, and still used in Turkey and the East as food in Europe, is a starch derived from the tubers of eleven kinds of Orchis, such as *O. mascula*, *O. maculata*, and *O. morio*. The salep sold in London mostly comes from Smyrna.

For tapioca and cassava bread, see Case 8.

For arrowroot and sago, see Case 9.

For salep, see Case 9.

Inulin, from the roots of elecampane (*Inula Helenium*) and Jerusalem artichokes (*Helianthus tuberosus*), has the same composition as starch, and closely resembles it in most of its properties.

The following table gives the quantities of starch in 100 lb. of several kinds of vegetable products and preparations:—

	lb.		lb.
Sago, tapioca, arrowroot, corn-flour, maizena	83	Scotch oatmeal	63
Pearl barley	76	Millet, without husks	61
Rice	76	Peas	51
Fine wheaten flour	74	Haricot beans	49
Wheat	71	Wheaten bread	48
Rye	71	Wheaten bran	44
Buckwheat, without husks	64	Potatoes	15
Maize	64	Parsnips	3
		Vegetable marrow	0½

Some of these numbers include with the starch small quantities of dextrin, sugar, and gum—substances which subserve the same purposes in the animal system.

Starch, like all the compounds of the group of nutrients now under consideration, contains carbon, hydrogen, and oxygen only. It is never met with in commerce quite pure and free from moisture—arrowroot, for instance, containing from 12 to 16 per cent. of water, with traces of mineral and nitrogenous matters. Neither arrowroot nor any other starch can furnish the materials for the building up and repair of flesh or muscle; it is, however, next to oil and fat, the most concentrated, heat-giving, and force-producing of all the nutrients. To be digested, starch must be dissolved, or at least softened. These changes are effected by boiling in water, or baking in the presence of moisture. Thus the digestion of starch may be said to commence in its preparation by cooking. It proceeds further through the action of the saliva during mastication, a peculiar ferment called *ptyalin* which exists in the saliva being capable of changing starch into glucose, a variety of sugar. In the stomach, such parts of the starch as have escaped previous change do not alter much; but these are finally transformed into sugar in the small intestine; thence the sugar is absorbed into the blood.

For specimens of dextrin, see Case of potato preparations.

Dextrin has the same composition as starch, but it is soluble in cold water. It may be made by heating starch to 320° Fah., and by acting upon it with a small quantity of malt flour, or of nitric or sulphuric acid, for a short time. Thus prepared, dextrin often goes under the name of British gum. It is at least of equal value with starch as a food, and requires less alteration to change it into sugar previous to its absorption. It occurs to a considerable amount in bread, especially in the crust, in biscuits, and in some prepared infants' foods, as those of Liebig and Nestlé. Beer contains a little dextrin. Starch, during digestion, is partly and temporarily changed into dextrin.

2. *Sugar* is distinguished from starch by its solubility in cold water and its sweet taste. Its composition is slightly different also. But there are several kinds of sugar, which must be considered separately.

For specimens of sugar, see Cases 10 to 16.

The best known sort of sugar is that which is sold under the name of cane sugar. Much of that consumed in England is derived from the sugar beet, a variety of *Beta vulgaris*, a plant believed to have originated in the sea beet. The roots of this plant, when of good quality and small size (2 to 3 lb.), contain from 10 to 13 per cent. of a sugar identical with that of the sugar-cane. Sugar beet is largely grown in France, Belgium, and Germany. It has also been raised successfully in England on a small scale.

The oldest and best-known source of this kind of sugar is the sugar-cane (*Saccharum officinarum*), a handsome plant of the grass order, a native of Southern Asia. It grows to the height of 12 or even 15 feet. It has been long cultivated in most parts of tropical and sub-tropical Asia, and in the islands of the Indian and Pacific Oceans. From India it was brought to Europe, many centuries ago, and was afterwards introduced to and largely grown on the American continent. Our present supplies of cane sugar come from Brazil, Mauritius, and the

West Indies. To prepare this sugar the canes are cut down when they begin to flower, close to the ground, the juice thoroughly expressed from them, clarified and boiled down. "Raw" or "brown" sugar is the first product, along with molasses (except where the ingenious process called *concreting* is adopted, when no molasses are formed). By refining brown sugar—that is, re-crystallising and purifying by the aid of charcoal and lime, &c.—cleaner, purer, and drier crystalline sugars are got, and it is in these later refining processes that treacle and golden sirup are obtained. These sirupy liquids contain about 65 per cent. of uncrystallisable sugar, with some saline matters and other impurities, while the remainder is water. Sugar-candy is the purest form of sugar; white loaf sugar comes next; then the pale, dry, large-grained crystallised sugars; while all the coloured moist sugars are of inferior purity, invariably containing not only water and uncrystallisable sugar, but also mineral and organic compounds. They are not unfrequently largely infested by a small insect, the sugar-mite (*Acarus sacchari*), many thousands of which have been frequently detected in a single pound of brown sugar. Whatever may have been the case formerly, sugar is not now adulterated, save, perhaps, with the kind of artificial sugar called glucose; but sugar is often insufficiently purified.

Many other grasses besides the sugar-cane contain large proportions of sugar. For instance, sugar has been made from the stalks of maize or Indian corn, cut just before flowering. The Chinese sugar-grass, or sugar-millet (*Sorghum saccharatum*), is another sugar-producing plant. It has been introduced into and successfully grown in France, Italy, Southern Russia, the United States, and Australia. A closely-allied species, called *Imphee*, is grown by the Zulu Kaffirs, and yields not only sugar in its stems but much valuable starchy food in its seeds. The seeds, indeed, of all the kinds of *Sorghum* are very nutritious, and are used, amongst other purposes, for feeding poultry. All the derivatives of sugar—molasses, rum, wine, vinegar, &c.—have been obtained from the sugar-grass; the manufacture of sugar, &c., from this plant in the States is, however, declining.

Another source of sugar is the sugar maple, *Acer saccharinum*, with other allied species, as *A. pennsylvanicum*, *A. negundo*, and *A. dasycarpum*. These trees of Canada and the northern United States contain a sap in which about 2 per cent. of cane sugar occurs. In the spring the sap is collected and boiled down. It is stated that 1,546,000 lb. of maple sugar were produced in Pennsylvania in 1870.

Jaggary is a sugar obtained chiefly from the flowering shoots of two Indian palms, *Phœnix sylvestris* and *Caryota urens*. But many other palms, as the coco-nut and the Palmyra palm, yield abundance of a sugary juice known as "toddy" when freshly drawn or fermented, and "arrack" when distilled. From these palms, and from the *Arengo saccharifera* and *Nipa fruticans*, palms of the Indian Archipelago, as well as from the date palm, *Phœnix dactylifera*, jaggary sugar is made.

It has been stated that 700,000 tons of sugar, from beet-roots, are annually prepared in Europe, an amount which is about half of the total European import of sugar from the sugar-cane.

Many other plants besides those named above contain cane-sugar. The expanding buds of trees, as of the birch (*Betula alba*), yield a sap which by fermentation becomes birch wine, formerly made to some extent in Scotland. The following list gives, approximately, the proportions of ordinary sugar contained in a few important vegetable products, &c.

Sugar (Saccharose or Sucrose) in 100 lb. of

	lb.		lb.
Dried carob beans	51	Chinese sugar-grass	9
Sugar-cane juice	18	Maize-stem juice	7
Beet-root	11	Sugar maple sap	2

It may be added that the solubility of cane sugar is such that two ounces require but one ounce of cold water to dissolve them. Sugar has the specific gravity 1·59. It is not absorbed into the blood as cane sugar, but is previously converted, both by the acids of the gastric-juice and by the nitrogenous matters of the food during digestion, into the variety of sugar called grape sugar, or glucose.

Sugar is extensively used to preserve fruits. Fruits boiled with sugar yield jams, preserves, and fruit jellies. Many fruits may also be preserved whole in sirup of sugar, or they may be subsequently dried, when they become "candied" or "crystallised."*

Grape sugar comes next in importance to cane sugar. Just

* Collections of fruits preserved by the aid of sugar are shown.

The following specimens of sugar are shown in Cases 10 to 18 :—Raw sugar of the crop of 1871, manufactured at the Colonia de San Pedro Alcantara, Malaga, Spain.—A series of raw and refined sugars from various parts of the world, illustrating the process of sugar-refining; also a diagram of a sugar-refinery.—Two specimens of sugar-cane grown on the Grove Estate, Montserrat, West Indies.—A series of specimens of the various products obtained in the manufacture of sugar from sugar-beet, from Valenciennes.—White and brown sugar from Formosa.—Confectionery: Almonds, comfits, candy, and a variety of table ornaments made of sugar.—Various specimens of ornamental sugar-work, with samples of the materials used in making the same.—A series of fruits preserved with and without sugar, sugar confectionery, ornamental sugar-work, &c.—Lozenges of different sorts.—Samples of maple sugar.—Samples of raw and refined sugar from Cuba, Penang, Jamaica, Porto Rico, Mauritius, Bengal, and Demerara; also refiners' sugar, termed "pieces," and refuse sugar from refineries.—A collection of raw and refined sugars from the French colonies of Réunion, Martinique, Guiana, Guadaloupe, Mayotte, Tahiti, and Cochin-China.—Also a series of samples of raw sugars from Java.—Samples of raw sugar from sugar-canes grown in the neighbourhood of the Clarence River, New South Wales, Australia.

The specimens named above illustrate not only the numerous sources of the chief kind of sugar, known as sucrose or saccharose to scientific chemists, but they also show to some extent the processes of the manufacture, and the by-products obtained in the treatment of the raw material. Many of the uses to which sugar is put, such as the preservation of fruits, the manufacture of lozenges, confectionery, cordials, sirups, and wines, may also be studied in the collection.

as the latter sugar is found in many plants besides the sugar-cane, so grape sugar is abundantly distributed through the vegetable kingdom. More than this, it may be readily made from starch, dextrin, and cane sugar, by the action of weak acids. But, perhaps, a still more remarkable mode of obtaining this sugar is by means of the action of strong sulphuric acid or oil of vitriol, upon cellulose, the compound which forms the main substance of paper, cotton, linen rags, and some woods. Thus it happens that all these substances are now used for the manufacture of grape sugar, or glucose as it is called. This glucose, being immediately fermentable, may be used to strengthen the worts in brewing, and for the direct production of alcohol. So spirit may be made from old rags and waste pawnbrokers' tickets !

Honey from various localities and collected by bees from different flowers, is shown in Case 20.

Grape sugar, or glucose, exists in three forms at least. Two of these, dextrose and lævulose, make up the main bulk of honey ;* the third, maltose, occurs in malt, a sprouted grain. The variety of glucose called dextrose exists largely in sweet fruits, as the grape, and crystallises out in hard warty masses when ripe grapes are dried, as in the case of raisins and French plums. The lævulose of honey and of acid fruits will not crystallise, but can only be dried up into a glassy or resinous mass. These sugars, as well as maltose, are less sweet than cane sugar. They are immediately absorbed into the circulation when taken into the stomach. They are valuable nutrients, especially for the young, but may give rise in some disordered conditions of the stomach to an unusual production of lactic acid, two proportions of which are producible from one proportion of any of these sugars.

The quantities of glucose or similar sugars present in a few

* In Case 20 will be found a series of specimens of honey from France and French Colonies. Also Russian specimens of honey, collected by bees from different plants, chiefly wild.

important vegetable products may be seen in the following table :—

Glucose (that is, Dextrose, Lævulose, Maltose, &c.) in 100 lb. of

	lb.		lb.
Honey, or nectar of flowers	80	Tomatoes	6
Dried Turkey figs	57	Malted barley	5
Grapes	13	Cucumbers	2

Milk sugar has the composition of cane sugar, but many of the properties of grape sugar, into which it is converted when consumed as food : it also yields butyric and lactic acids. Milk sugar has comparatively little sweetness, and is less soluble than the previously-named sugars : its crystals contain one proportion of water of crystallisation. This sugar is often called lactose, and is found as one of the characteristic ingredients of the milk of mammals. In 100 parts of cows' milk there are over 5 parts of lactose.

A few other sugars of minor importance remain to be mentioned. There is *Inosite*, or muscle sugar, which has been found in the human body, in ox brain, and extract of meat. There is *Mannite*, the sugar-like substance of manna, a substance produced by several kinds of ash, chiefly by *Fraxinus ornus*. We have also the sweet substance, glycyrrhizin, found in the liquorice plant (*Glycyrrhiza glabra*), which is used as a sweetmeat and flavourer. Pomfret, or Pontefract, cakes are made from native-grown liquorice, the plant being cultivated at Pontefract, in Yorkshire. It is doubtful whether the last-named sugar-like substances, mannite and glycyrrhizin, are true nutrients. No experiments have been made with these compounds, nor with the sugar-like bodies from some seaweeds, pine-needles, &c. &c., which have been found to differ from the well-known sugars already noticed.

Preparations of liquorice in Case 19.

3. The *Oils* or *Fats* form a very distinct and important section of the group of heat-givers. Like starch and sugar, they can form

no muscular tissue, but their power of maintaining the heat and activity of the body is nearly 2½ times that of the starchy nutrients. So far as their feeding properties are concerned, oils are identical with fats, the distinction between the substances thus named referring chiefly to their condition of liquidity or solidity. *Wax*, on the other hand, though probably of similar value as a nutrient, differs somewhat from oils and fats, notably in not yielding glycerin.

Case 21 contains specimens of oils and fats.

Oils and fats may be considered as formed from a fatty acid on the one hand, and glycerin on the other. Indeed, if three proportions of one of these acids, say palmitic acid, be heated with one proportion of glycerin in a closed tube, these substances disappear, palm oil or palm fat and water being produced. This palm fat, which is a glyceride, is called palmitin, and forms, with two similarly-constituted compounds, known as stearin and olein, most of the important fixed oils and fats, whether vegetable or animal. In many of these, however, other glycerides occur, as small quantities of butyrin and caproin in butter.

The quantities o :oil or fat contained in some important vegetable and animal products are quoted in the following table :—

OIL OR FAT IN 100 LB. OF

	lb.		lb.
Palm-nut (pulp)	72	Coco-nut (kernels)	36
Brazil-nuts (seeds)	67	Hemp seed	32
Almonds (kernels)	53	Walnuts (kernels)	32
Ground-nut (seeds of *Arachis hypogæa*)	52	Gold of pleasure (seeds)	32
Sesame (seeds)	51	Cotton (seeds)	24
Palm-nut (kernels)	47	Sunflower (seeds)	22
Poppy (seeds)	45	Fresh Scotch oatmeal	10
Olives (kernels)	44	Maize (seeds)	5
Cacao (whole seeds)	44	Millet (seeds)	5
Olives (pulp)	39	Wheaten bran	4
Linseed	38	Peas (seeds)	3
		Wheaten flour	1

FAT IN ANIMAL PRODUCTS.

	lb.		lb.
Butter - - - - - -	87	Cheese (Gloucester) - - -	30
Bacon - - - - - -	65	Eggs (yolk and white) - -	11
Mutton-chop (average) - -	35	Cows' milk - - - - -	4

Oils are most abundant in the fruits and seeds of plants, and are present in insignificant quantities in their roots, stems, and leaves.

Of the vegetable oils extracted and used as oil in preparing and cooking food, olive oil, expressed from olive pulp, is the most important, at all events, in Europe. It is obtained from the fleshy exterior of the fruit of the olive (*Olea Europea*). Walnut oil (from *Juglans regia*) is also an agreeable and wholesome substitute for olive oil. Many kinds of fruits, nuts, or seeds are eaten mainly on account of the oil they contain. Amongst these may be named: almonds, chestnuts, walnuts, hazel-nuts, Brazil-nuts, pecan-nuts, hickory-nuts, pistachio-nuts, beech-nuts or mast, cashew-nuts, sapucaya-nuts, souari-nuts, pine seeds, &c.

Case 21 contains samples of many vegetable and animal oils, butters, and fats.*

Oils and fats are but little changed during digestion. They are divided into minute particles or globules, and then form what is called an *emulsion*—such as may be produced by shaking some olive oil and gum water in a bottle together. This emulsification is mainly caused by the pancreatic juice; the finely-divided globules of oil and fat are then absorbed by the *villi* of the small intestine. These structures (which are limited to the region in question) seem to pick out from the chyme, or intestinal contents, the fatty globules, which are then transferred to the branches of the lacteals in the *villi*; thence the fat reaches the alkaline blood, where it becomes saponified.

* Black and white sesame seed from Formosa, with samples of oils obtained from each. In the same case is a sample of the oil from the Dugong (*Halicore australis*), from Brisbane, Australia; with other important animal and vegetable oils used as food.

Besides its great use as a giver of heat, and therefore of mechanical force or energy, fat performs an important function in the body as the chief material of the adipose tissue. This fatty layer, where it exists beneath the skin, keeps in the warmth of the body; while such stores of fat as exist in this form throughout the organism may be re-absorbed into the blood, and keep up the animal heat and activity during abstinence from food.

Appendix to Group III.—In the different parts of plants which are eaten as food there will be found many oxidizable or combustible carbon compounds which are neither starchy, saccharine, nor oily. As some of these compounds are known to be closely related to starch or sugar, and, indeed, have the same composition in 100 parts, there is some ground for believing that they may serve the same purpose in the animal economy. And this conjecture is confirmed by many experiments, especially upon the lower animals.

Case 3. *Gum*, met with in many trees, as the apple, the plum, and some sorts of acacia, is near cane sugar in its composition. It is usually accompanied by a little lime and potash, and is found dissolved in the juices of many stems and fruits. Gum arabic and gum senegal are two good examples of this substance. Gum arabic is considered to be a mixture of arabate of lime and bassorin.

Case 3. *Mucilage* is found in the bulbs of the onion, in quince seeds, and in linseed. It forms a jelly with water, but does not dissolve to a thin liquid like gum arabic. As the mucilage of linseed suffers changes resembling those of starch when the seed is allowed to sprout, it may be that it undergoes solution and absorption in the body also.

Case 3. *Pectose* is found in many roots, as the turnip, and in many fruits as the pear and peach, especially while they are unripe. When boiled with water, it rapidly changes into vegetable jelly, to one variety of which the name of pectin has been given. Similar changes occur in the ripening of fruits. The firmness of various jams and preparations of fruit—as damson, plum, and red-currant jelly—is due to substances belonging to the pectose series. In the present handbook we have given these substances under the single name of "pectose;" partly to avoid needless complexity, and partly because of the imperfection of our methods of analysis, which do not yet enable us to give exacter particulars. There is good reason for believing that the substances belonging to the pectose group are capable of digestion and absorption in the human body.

Case 3. *Cellulose* has the same composition as starch and dextrin, and is nearly related to these compounds. It is, however, insoluble even in hot water. Cellulose is nearly pure in cotton, and in the cell-walls of many of the fruits, stems, and roots which are eaten as food. It is doubtful whether cellulose is digestible in the human organism, though it has been shown that it is digested by herbivora. But cellulose varies much in softness, texture, &c., and it is very likely that newly-formed cellulose may be changed and absorbed in part in the digestive process, while the firmer and older tissues containing the same substance may not be altered. These firmer tissues are, moreover, often of a different composition, for the cellulose is associated in many of them with certain yellowish substances, which are richer in carbon than cellulose, though their exact nature is not yet made out. It will be convenient to group them together under the name *lignose*. Lignose is specially abundant in hard woods, like box, while cellulose makes up the greater part of soft woods, like pine. The fruit of the apple contains a good deal of cellulose and a mere trace of lignose; while in wheaten bran both compounds are abundant.

We are now in a position to consider the relative values of the several heat-giving and force-producing nutrients which have been described; but a few words may be first introduced as to some points of difference between these compounds.

The rate at which these different heat-givers are digested and assimilated differs greatly; and, as we have already seen, these processes of digestion are not performed by the same agencies and in the same regions of the organism. The greater part of the alimentary canal is the seat of such changes, yet portions of certain nutrients—especially when they are consumed in undue proportions and quantities—escape digestion. To give an example of how an important nutrient differs according to its source in the vegetable kingdom we may cite the case of starch. It has been found that uncooked starch from Indian corn may be completely turned into sugar by the action of the saliva in 3 minutes, oat-starch in 6 minutes, wheat starch in 40 minutes, and potato starch in 3 hours—the quantities, &c., being the same in each case. But after thorough cooking ali starches require nearly the same time. Common sugar is rapidly and perfectly changed into grape sugar before assimilation; while the latter, of course, needs no alteration to fit it for absorption. Fats, we have seen, are modified mechanically rather than chemically.

The following numbers represent the proportions by weight of carbon, hydrogen, and oxygen in 100 parts of the several members of this, the third group of nutrients :—

	Starch, Dextrin, Inulin.	Cane Sugar, Milk Sugar, Mucilage, Gum.	Grape Sugar, Fruit Sugar, Muscle Sugar.	Oils and Fats (Average).
Carbon	44·4	42·1	40·0	76·4
Hydrogen	6·2	6·4	6·7	12·3
Oxygen	49·4	51·5	53·3	11·3

The weight of carbon in 1 lb. of each of the above substances is shown as follows:—

Carbon in 1 lb. of—	oz.	gr.
Starch and allied compounds	7	52
Cane sugar and allied compounds	6	322
Grape sugar and allied compounds	6	175
Oils and allied compounds	12	98

It should be recollected that in the case of the oils and fats, not only is the carbon available for the production of heat and force within the body, but the hydrogen, or most of it, may be similarly used. A good notion of the relative values of the above-described four classes of carbon-compounds in their heat-giving and force-producing capacity may be gathered from the results obtained in Dr. Frankland's experiments. He burnt these compounds in oxygen, and determined the actual amounts of heat they severally set free. Now, we know that heat and mechanical energy or work may be changed the one into the other. And it has also been proved that heat and work have a definite quantitative relation to one another, so that the heat required to warm 1 lb. of water 1° Fah. may be changed into the amount of mechanical power requisite to lift 772 lb. 1 foot high. Thus, we may express the total heat producible by the complete combustion or oxidation of 1 lb. of these food-constituents in the form of so many pounds or tons raised 1 foot high :—

	Tons raised 1 ft. high.
Starch (arrowroot)	2,427
Cane sugar	2,077
Grape sugar	2,033
Oil (cod-liver)	5,649

According to Helmholtz, the greatest amount of mechanical work, *outside the body*, which a man could be enabled to perform by the combustion within the body of 1 lb. of each of the above substances would be about one-fifth of the amount given in the above table. This subject has been already referred to on p. 2, and will be again the occasion of some further remarks when the questions of the daily supply of food and of different dietaries are under discussion.

§ 7.—Nitrogenous Compounds or Flesh-formers.

The fourth group of nutrients in food is marked out from those previously considered by the presence of the element *nitrogen*—the element which forms 79 parts, by measure, in 100 of common air; which is present in nitre, nitric acid, and ammonia; and which is so much more abundant in animals than in vegetables. These nitrogenous compounds have been variously termed—

Albuminoids,
Proteids,
Flesh-formers.

When, in the following pages, we are speaking of the constituents of different foods in their relations to the nutrition of the body, the term "flesh-formers" will be used; when these compounds are referred to from a merely chemical point of view, they will be described under the general name of "albuminoids," except in those instances where the prevailing kind of albuminoid in any food-stuff is characteristic and well known, when its specific name will be used. Thus the chief albuminoid in wheat grain will be called *fibrin*, on account of that name having been assigned to that one of the three kinds of albuminoids which specially abounds in the cereal grains. So *casein*, another kind of albuminoid, will be given in the analysis of peas, and *albumen* in that of the turnip. Where the nature of the albuminoid is not precisely known, the general term "albuminoids" will be employed. And where the nitrogenous matter is not proved to be actually and truly albuminoid, then it will generally be described as "nitrogenous matter" simply. But it is time to give an account of the several members of this group.

Case 3. 1. *Albumen*, the main solid constituent of white of egg, gives its name to the whole group. The blood of many animals contains this component. It is a common ingredient of most vegetable juices, and is found in considerable quantity in certain seeds. It exists in two states, one soluble in water, the other insoluble. The soluble form may be easily changed into the insoluble by heating its solution to about 120° Fah., or by the addition of nitric acid. It is considered by some physiologists to be the most easily digested of all the flesh-formers. 100 parts of pure dry albumen contain, carbon 53·5, hydrogen 7·0, nitrogen 15·5, sulphur 1·6, oxygen 22·4.

Case 3. 2. *Fibrin*, like albumen, occurs in vegetables as well as animals. Wheat grain, for instance, contains about 10 or 11 per cent., and beef muscle, free from fat, &c., about 15. The clot of blood contains much fibrin. The fibrin from different sources is not identical in properties or composition; indeed, some so-called fibrins may really be mixtures of two or more slightly different compounds. The most important animal fibrins are blood-fibrin, and the myosin and syntonin of muscle.

Case 3. 3. *Casein* is the third albuminoid of general occurrence. Three-fourths of the nitrogenous matter in milk are casein; there is casein in the yolks of eggs; the so-called legumen of peas and other pulse is either identical with, or nearly related to, casein. Casein is distinguished from other albuminoids by the ease with which even acetic or other weak acids coagulate it; and by its less easy and rapid digestibility when of animal origin: vegetable casein is now said to be quickly digested.

In the muscular tissue or flesh of many animals eaten as food, and in the various liquids of their bodies, other albuminoids besides the three named are to be found. For the purpose now in view, it is sufficient to know that these matters are in all likelihood of equal value with the better-known albuminoids, as flesh-forming nutrients. One of them, however, is of peculiar character, on account of the presence in it of a small quantity of iron (0·42 per cent.). This compound is the red colouring matter of the blood—*hæmoglobin*, a most important substance, intimately concerned in the nutrition and aeration of the blood. Perhaps the digestive ferment of the saliva (*ptyalin*) and that of the gastric juice (*pepsin*) may also be ranged amongst the albuminoids.

Appendix to Group IV.—Amongst the nitrogenous nutrients found in the parts of animals consumed as food are several compounds, of which we cannot affirm that they are true flesh-formers.

They are probably turned to some account in the human body, but every constituent in that complex organism may be made without their aid; for persons living wholly on vegetable foods do not consume these substances at all. These nitrogenous nutrients are familiar to us under such names as gelatin and isinglass (which are indeed the only nitrogenous nutrients separately sold), but there are other varieties of them, which should be briefly noticed here.*

Case 3. *Ossein* is that constituent of bones to which their strength and elasticity is due; it is found also in connective tissue. It is insoluble in cold water and weak acids—indeed the best way of preparing ossein is to place a clean piece of fresh ox or sheep bone in a mixture of 1 part of hydrochloric acid and 9 of water. After some time all the earthy matter of the bone will have been dissolved out, nothing being left but an elastic mass of ossein (with a little fat), retaining the shape of the original bone.

Ossein contains rather less carbon, and rather more nitrogen, than the true albuminoids. Though insoluble in cold water, it is slowly dissolved by boiling water, becoming thereby converted into gelatin, a substance of the same composition, but slightly different properties. The change of ossein into gelatin takes place more readily when the water in which the bones are boiled is heated a few degrees above the boiling-point. This can be done by preventing the escape of steam—that is by heating the bones and water under pressure. The simple arrangement known as Papin's Digester answers this end perfectly, and enables

* Isinglass is most prized when obtained from the sound or swimming bladder of the sturgeon (*Acipenser* of several species). It is chiefly imported from Russia. Varieties of this substance, illustrating its qualities, manufacture, and application to ornamental purposes, are exhibited.—Ivory dust and shavings are sometimes used for making jellies.—Samples of these substances and of others used for similar purposes are shown in the collection.—Samples of jelly made from calves' feet, and flavoured with various fruits.

the full amount of nutritive matter to be dissolved out of bones which are intended to be used as stock for soups.

Many other substances besides bones may be made to yield gelatin by long boiling with water. These are tendons, conjunctive tissue, calves' feet, fish scales, stag's horn. Isinglass, though not actually gelatin, is rapidly transformed into that substance by boiling water, yielding one of the purest and most characteristic forms of gelatin known. Isinglass consists of the membrane of the swimming bladder of the sturgeon (*Acipenser* of various species). Much so-called isinglass is merely gelatin prepared from some of the materials we have named, or from the cuttings of parchment and vellum. Thus "Warranted Calves' Foot Jelly" may have been made from old legal documents! Gelatin sometimes contains sulphuric acid.

Case 3. *Cartilage* does not yield gelatin when boiled, but an analogous substance called *chondrin*. This material contains less nitrogen (4 per cent. less) than gelatin; it possesses somewhat different properties, and yields different products.

Elastin and *keratin*, and similar matters from elastic tissue, skin, epidermis, &c., are included in the present sub-group; they are of small or doubtful value as nutrients. They, as well as *mucin*, the nitrogenous constituent of mucus, are almost entirely unacted upon by the gastric juice.

We are now in a position to compare the relative values of the several flesh-formers and allied compounds included in the nitrogenous nutrients.

The albuminoids suffer no chemical change during mastication. But when they come in contact with the gastric juice in the stomach, their digestion commences. This juice contains two active ingredients, an acid or a mixture of acids, together with a neutral nitrogenous substance called *pepsin*.

This pepsin is a digestive ferment; by its aid, if acid be present and the temperature be suitable (about 98°), albuminoids are all converted into substances bearing the name of peptones.

These are all soluble in water, and are not removed from the solution by acids, alkalies, or salts; they are all soluble, even in alcohol, if not very strong; and they are diffusible. Casein before it becomes a peptone, is curdled; vegetable casein is rapidly changed and dissolved by gastric juice deprived of its pepsin. Fibrin, whether animal, as that in muscular flesh, or vegetable, as the so-called gluten of wheat grain, is rapidly broken up by the gastric juice, swelling up, and finally becoming a ropy, opaline liquid. Albumen, when soluble, is transformed into peptones without being previously curdled by the gastric juice; when insoluble, it is more slowly acted upon. The conversion of albuminoid nutrients into peptones, which can be absorbed into the circulation, is completed in the intestine, where several secretions aid in the processes of change.

Little is known about the digestion and uses of gelatin and allied compounds. It is, however, certain that solution of gelatin, after having been acted upon by gastric juice, no longer solidifies to a jelly on cooling. Before these compounds can enter the circulation, they must be altered, since when introduced into the blood artificially they are excreted unchanged.

The composition of the several nitrogenous nutrients is compared in the following table, where the weights of the carbon, hydrogen, nitrogen, sulphur, and oxygen in 100 parts of each important variety are shown :—

	Albumen.	Fibrin of blood.	Fibrin of muscle.	Casein.	Gelatin.	Chondrin.
Carbon	53·5	52·7	54·0	53·8	50·8	50·0
Hydrogen	7·0	6·9	7·3	7·1	7·1	6·6
Nitrogen	15·5	15·4	16·1	15·7	18·3	14·5
Sulphur	1·6	1·2	1·1	0·9	0·6	0·4
Oxygen	22·4	23·8	21·5	23·5	23·2	28·5

Thus the actual weight of carbon in 1 lb. of any average albuminoid may be set down as 8 oz. 245 gr. Before considering what amount of work or actual energy this carbon and the hydrogen present correspond to, it would be as well to state the various uses to which the albuminoids are put in the human body. For they serve—

1st. For the building up and repair of the nitrogenous tissues of the body, especially of the basis of flesh, that is, muscular fibre. As no other ingredient of food can fulfil this office, it is right that the albuminoids should bear the expressive name of flesh-formers.

2nd. The albuminoids contain 10 per cent. more carbon than starch and sugar, and some part at least, though never the whole, of this carbon is available as a source of heat and work in the body, especially when the supply of the usual heat-givers is deficient.

3rd. The albuminoids serve for the formation of a large number of nitrogenous substances which are found in most parts of the body, but especially in brain and nerve-substance. These compounds are rich in nitrogen, and sometimes contain sulphur and phosphorus as well.

4th. The albuminoids may contribute fat to the body. It is easy to obtain artificially the main constituents of fat by the action of chemical agents upon the albuminoids, compounds rich in nitrogen being formed at the same time: similar changes may and do occur in the body.

The variety of offices performed by the albuminoids, when compared with the carbon compounds called heat-givers, which have been studied in the preceding section, is due in part to their complex character. This complexity arises from two causes—for these compounds are made up of 5 different elements instead of 3, while a very much larger number of atomic proportions of their elements are present than is the case with starch—probably several hundreds, instead of 21. But another reason for the variety of uses to which the albuminoids are put in the body arises from the presence of nitrogen, an element which confers a character of instability, of proneness to change, upon most of the compounds of which it forms part. The processes of life and growth, as well as of putrefaction and decay, occur in the presence of nitrogen compounds.

There is no need to enlarge further now upon the 1st, 3rd, and 4th items of service named in the foregoing list as rendered by the albuminoids. But it may be useful if we introduce here a few remarks as to the relation of the albuminoids to the performance of work. It used to be thought that work—hard bodily exertion, as in ascending a mountain, in pedestrian feats, or in hammering iron—was done by the actual destruction of muscular substance itself. If this be true, we ought to find the proof of that destruction of muscle in an excessive excretion of the waste nitrogenous product known as urea, which is got rid of by the kidneys. But this is not the case, the excretion of urea not corresponding in amount to the work done. Yet during the performance of hard work an ample supply of albuminoids is found to be needed, probably by reason rather of the *rate* than of the *extent* of chemical change which violent exercise and hard work cause in the body.

As to the function of nitrogenous matter in furnishing supplies of heat, and, therefore, of actual energy to the body, we have to remark that Dr. Frankland has experimented with pure albumen. Burnt in oxygen it set free an amount of heat which may be expressed in this way:—1 lb. of this nitrogen-compound, during complete oxidation, liberates an amount of heat corresponding to

	Tons raised 1 ft. high.
Albumen - - - - - - - - -	2,643

At first sight it would seem from this number that the albuminoids are more efficient force-producers (when so used in the body) than most of the true heat-givers, whose main office it is to furnish heat and energy to the system. But a special deduction must be made from these figures, for when nitrogenous matters are oxidized *in the body*, a small portion of the carbon and hydrogen which they contain is carried away, with its potential energy unexpended, in the urea, &c., formed in the organism and excreted by the kidneys and intestine. Now, by determining the amount of potential energy remaining in that amount of urea which 1 lb. of albumen may be assumed to yield, Frankland concluded that a deduction of one-seventh must be made from the above number. Thus the available heat set free from the oxidation of 1 lb. of albuminoid matter within the body corresponds to 2,266 tons raised 1 ft. high, not to 2,643 tons. Albumen, then, ranks between starch and sugar as a heat-giver and force-producer. It may be well to remind our readers once more that only about one-fifth of this energy at the utmost can be available for work outside the body (see p. 40).

§ 8.—A Day's Ration.

Thus far we have considered the uses of food, the composition of the human body, and the several compounds which are necessary for its nutrition. Let us now go on to study in some detail a day's ration—its composition, its work, and the changes which it undergoes in the body.

The daily supply of food and the daily waste of the human body have been often made the subject of experiment. It will be understood at once that even with healthy adults the amount of food required will vary according to many circumstances. To begin with, there are peculiarities belonging to each individual; then there are differences in the amount of work performed; the heat or cold of the weather, as well as the condition and quality of the several kinds of food taken—all these things will influence the total quantity of food required in the twenty-four hours, as well as the proportions of the chief components which it should contain. But we may arrive at something like an average daily diet by taking the case of an adult man in good health, weighing 154 lb., and measuring 5 feet 8 inches in height. Simply to maintain his body, without loss or gain in weight, his ration of maintenance, or food, during the twenty-four hours should, under ordinary conditions, contain at least something like the following proportions and quantities of its main ingredients:—

THE AVERAGE DAILY DIET FOR AN ADULT SHOULD CONTAIN—

Case 22.

——	In 100 parts.	Each 24 hours.		
		lb.	oz.	gr.
Water - - - - - - -	81·5	5	8	320
Albuminoids, or flesh-formers -	3·9	0	4	110
Starch, sugar, &c. - - -	10·6	0	11	178
Fat - - - - - - -	3·0	0	3	337
Common salt - - - -	0·7	0	0	325
Phosphates, potash salts, &c. -	0·3	0	0	170

On adding the figures of the second column together it will be seen that the total daily ration is here assumed to weigh (meat and drink included) 6 lb. 13 oz. 128 gr. Of this amount 1 lb. 4 oz. 245 gr. is actual dry food substance, the remainder, more than 5½ lb., being water. In reality, the weight of dry food substance eaten will exceed that just named, chiefly for the following reason. We eat our food in the shape of a number of mixed animal and vegetable products, which contain many ingredients besides the water, albuminoids, starch, sugar, fat, and mineral salts named above. There is, for instance, always some fibrous material, called cellulose and lignose, in the parts of plants on which we live; there are also present other substances, as colouring matters, which have little or no feeding value. These are excluded from the above table, but always present in our food. Even in animal food, materials like membranes, connective tissues, and gelatin are present; but these are not to be regarded as essential or necessary components of a daily ration, as their use in nourishing the body is limited and doubtful.

This seems the proper place to give an example of an actual dietary—that is, to show what amounts of common articles of food must be taken each day in order to furnish the body with its average supply of necessary aliment. Were we to mix the pure water, albumen, starch, fat, and salts, shown in our table, together, even in the right proportions, the mixture would not be a perfect food, for it would be wanting in at least one particular—it would not be pleasant in *taste.* Our food must be palatable, that we may eat it with relish and get the greatest nourishment from it. The flavour and texture of food—its taste, in fact—stimulates the production of those secretions—such as the saliva and the gastric juice—by the action of which the food is digested or dissolved, and becomes finally a part of the body, or is *assimilated.* As food, then, must be relished, it is desirable that it should be varied in character—it should neither be restricted to vegetable products on the one hand, nor to animal substances (including milk and eggs) on the other. By due admixture of these, and by varying occasionally the kind of vegetable or meat taken, or the modes of cooking adopted, the necessary constituents of a diet are furnished more cheaply, and at the same time do more efficiently their proper work. Now, if we were to confine ourselves to wheaten bread, we should be obliged to eat, in order to obtain our daily supply of albuminoids, or "flesh-formers," nearly 4 lb.—an amount which would give us nearly twice as much of the starchy matters which should accompany the albuminoids—or, in other words, it would supply not more than the necessary daily allowance of *nitrogen,* but almost twice the necessary daily allowance of *carbon.* Now, animal food is generally richer in albuminoid, or nitrogenous constituents, than vegetable food; so by mixing lean meat with our bread, we may get a food in which the constituents correspond better to our requirements; for 2 lb. of bread may be substituted by 12 oz. of meat, and yet all the necessary carbon as well as nitrogen be thereby supplied. As such a substitution is often too expensive, owing to the high price of meat, cheese, which is twice as rich in nitrogenous matters (that is flesh-formers) as butchers' meat, may be, and constantly is, employed with bread as a complete diet, and for persons in health, doing hard bodily work, it affords suitable nourishment. Even some vegetable products, rich in nitrogen, as haricot beans, may be used in the same way as meat or cheese, and for the same purpose.

Such a mixed daily diet as we have been referring to might be furnished by the following foods if consumed in the quantities here given :—

		oz.	
1.	BREAD	18	*Altogether these quantities will contain about* 1 *lb.* 5¾ *oz. of dry substance, though they weigh in all* 6 *lb.* 14½ *oz.*
2.	BUTTER	1	
3.	MILK	4	
4.	BACON	2	
5.	POTATOES	8	
6.	CABBAGE	6	
7.	CHEESE	3½	
8.	SUGAR	1	
9.	SALT	0¾	
10.	WATER, alone, and in Tea, Coffee, Beer	66¼	

It will be seen that the weight of this daily ration exceeds by 1 oz.—even when the solid matter contained in beverages is omitted—that given before (on p. 49); this excess is mainly owing to the fact, previously mentioned, that in all articles of food actually used there are small quantities of matters (cellulose, &c.) which cannot be reckoned as having a real feeding value. And it must not be forgotten that the several common proximate principles which can and do supply the greater part of the heat of the body have not all the same value for such a purpose. Of starch and dextrin we should require rather less than of sugar for the production of the same amount of force, while 1 oz. of fat or oil will go nearly as far as 2½ oz. of starch. This allows of much variation in our daily food, since we may replace, to a certain extent, a portion of the fat in our rations by its equivalent quantity of starch or dextrin or sugar—or we may diminish the starch and increase the fat. In the former case the dry substance of our food might come to weigh 4 or 5 oz. more than the 20½ oz. mentioned before; in the latter case it would weigh less.

Suppose, for instance, we were to take, daily, no more than 3 oz. of fat in any form, we should have to add about 2½ oz. of starch or sugar to compensate for this reduction, thus consuming 14 oz. of the latter instead of 11½.

Here it may be asked—"Which of the articles of the above mixed diet give the several components of food which we require each day?" A sufficient answer to this inquiry may be gained by referring to the composition of the several articles of food named, as given in this Guide, and as shown in the Cases of the Food Collection. Here it will be enough to state that the bread consumed chiefly supplies starch, but along with this a good deal of albuminoid substance; the milk gives fat, albuminoids, and a sugar, having nearly the same value as starch; the cheese contains much fat and albuminoid substance; the bacon and butter chiefly furnish fat; while the other articles in the list either give further supplies of these food-components, or else the mineral matter or salts which are required. The first seven articles in the list will likewise contain about 1 lb. 6½ oz. of water, which, with that supplied in various beverages, will furnish the 5 lb. 8¾ oz. daily necessary.

Before considering different foods and dietaries, it will be as well if we now pay some attention to the *waste* of the body. We will endeavour to answer the question: What becomes of our food after it has been digested and assimilated, and has done its work in our bodies? We have seen what is the amount, and what the composition of the daily in-goings, or food; let us see what is the amount and the nature of the out-goings, or waste. Before we can make the comparison, we must recur for a moment to the general nature of the final change which food undergoes in the body. That change, we have before shown, is in the main one of burning, or, as it is called in chemical language, *oxidation.* It is the uniting of certain elements contained in the food—chiefly carbon and hydrogen—with oxygen, brought into the lungs by the act of breathing. The air, then, is, in a sense, part of our food, and forms a large part of the daily in-come of the body. As the oxygen taken in unites with the carbon and hydrogen of the food, we must not expect to find that the proximate principles constituting the main mass of our daily food will be found in any quantity in the daily waste. How then can we compare the in-goings and the out-goings? Why, by considering the amounts of the chief *elements* of which the proximate principles consist, and comparing them with the amounts of the same elements which are discharged in the oxidized waste of the body. In accordance with this way of representing the facts, we now give in a tabular form the daily supply and waste of the human body. First, we set down the weight of the several elements which make up the necessary daily food or

Case 23.

DAILY SUPPLY.

	lb.	oz.	gr.	lb.	oz.	gr.
Oxygen in the air breathed - - - -	1	10	115			
Oxygen in starch, albuminoids, and fat -	0	7	370			
Total oxygen - - - - -				2	2	47
Carbon in fat, starch, albuminoids - - - - -				0	9	400
Hydrogen in the same - - - - - - - -				0	1	170
Nitrogen in albuminoids - - - - - - -				0	0	291
Common salt - - - - - - - - - -				0	0	325
Phosphates, potash salts, &c. - - - - - -				0	0	170
Water - - - - - - - - - - - -				5	8	320
Total daily supply - - -				8	7	410

It will be here seen that four elements only are set down in the separate form *as elements* in the above table. These are oxygen, carbon, hydrogen, and nitrogen, so far as these elements enter into the composition of, that is, form part of, the proximate principles which we consume as our food, and which we change into new compounds in the body. The salt and other minerals of the food, together with the water we consume, are not so changed, and therefore these substances are not resolved into their elements in the table of Daily Supply, nor in that which follows, representing

Case 23.

DAILY WASTE.

	lb. oz. gr.	lb. oz. gr.
Oxygen in the carbonic acid gas given out by the lungs	1 7 325	
Oxygen in the carbonic acid gas given out by the skin	0 0 111	
Oxygen in the organic matter given out by the kidneys and intestine	0 0 357	
Oxygen in the water formed in the body	0 9 130	
Total oxygen in waste		2 2 47
Carbon in the carbonic acid gas given out by the lungs	0 8 320	
Carbon in the carbonic acid gas given out by the skin	0 0 40	
Carbon in the organic matter given out by the kidneys	0 0 170	
Carbon in the organic matter given out by the intestine	0 0 308	
Total carbon in waste		0 9 400
Hydrogen in the water formed in the body, and given out by the lungs and skin	0 1 70	
Hydrogen in the organic compounds given out by the kidneys and intestine	0 0 100	
Total hydrogen found in the water formed, and in the organic matter of the waste		0 1 170
Nitrogen in urea and other waste given out by the kidneys	0 0 245	
Nitrogen in waste given out by the intestine	0 0 46	
Total nitrogen in waste		0 0 291
Common salt given out by the skin	0 0 10	
Common salt given out by the kidneys	0 0 315	
Total common salt in waste		0 0 325
Phosphates and potash salts given out by the kidneys (chiefly)		0 0 170
Water taken in as such, and given out by the lungs, skin, kidneys, and intestine, in addition to that formed in the body		5 8 320
Total daily waste		8 7 410

These figures, then, represent the daily balance-sheet of the income and expenditure of a human body—not exactly and perfectly, but with a fair approach to truth. During the changes, mainly of oxidation, or burning, which are shown by the new compounds found in the waste and not in the supply, it is calculated that an amount of force is available, in one form or another of heat or mechanical work, which may be expressed as 3,950 tons raised 1 ft. high.

Let us briefly restate the main facts concerning the food of man which we have been discussing in the preceding pages.

1. Food is required to increase or repair the materials of the body; to keep it warm, and to endow it with a renewal of working power.

2. The materials of the human body are arranged in many compound substances. These are made up of 16 elements; the same elements generally arranged in similar compounds being found in food.

3. Food substances, or nutrients, fall into two groups—the incombustible or oxidized, and the combustible or oxidizable. Water and salts belong to the former; starch, sugar, fat, and compounds like the albumen of eggs, to the latter.

4. Incombustible nutrients serve several purposes, forming a permanent part of the body, and also acting as a means of carrying on the processes of nutrition.

5. Combustible nutrients are burnt more or less completely within the body by means of the oxygen taken into the lungs. The power of doing work, or potential energy, stored up in these nutrients and in the oxygen, is thus changed into the actual energy of heat and mechanical power. Thus the warmth of the body is maintained, and work done both internal and external.

6. Combustible nutrients increase or replace the fat, muscle, &c., of the body.

7. The daily waste of the body must be met by a daily supply of nutrients in the daily ration of food. In an adult the supply and waste are equal in amount, but different in the nature of the compounds, though identical if the elements are considered.

8. The daily ration must contain the various nutrients required in due proportions of flesh-formers, heat-givers, saline matter, and water. The ratio may be expressed in numbers thus :—

Water.	Flesh-formers.	Heat-givers, as Starch.	Salts.
25	1¼	5½	0¼

PART II.—OF VEGETABLE FOODS.

Although repeated reference has been made already to different vegetable products, we have not given as yet any account of the chemical composition of particular kinds of plants, or of those parts of plants used for human food. But as the compounds which make up nearly the whole of every vegetable have been described, and their respective uses as nutrients discussed, the way has been cleared for the study of some of the most important actual foods, such as wheat, peas, cabbage, and turnips. The review of these vegetable foods having been completed, foods of animal origin—milk, cheese, eggs, bacon, and butchers' meat—will also be described in Part III. from a chemical point of view. And then in Part IV. will be given some account of the composition and characteristics of alcoholic liquors, tea, tobacco, and various condiments and spices—of the accompaniments of food or "food-adjuncts," as we have named them.

§ 1.—The Cereals.

Naturally we give the first place to the breadstuffs—wheat, oats, rice, and other grains—the fruit of certain plants belonging to the Grass Order, or *Graminaceæ.**

* Cases 24 to 36 inclusive. A collection of many of the varieties of wheat, oats, and barley cultivated in Great Britain, and various foreign countries—in the straw and ear, and also in grain.—A collection of samples of wheat, barley, maize, oats, &c., from the Argentine Republic, South America.—Samples of wheat, barley, oats, rye, and maize, grown in localities bordering on the line of the North Pacific Railway, United States.

WHEAT.

French, *Blé.* German, *Weizen.* Italian, *Frumento.*
(*Triticum vulgare.*)

Wheat is an annual grass, of unknown origin. Numerous varieties of it are now in cultivation in nearly all temperate countries. It flourishes between the parallels of 25 and 60 degrees of latitude. It is more extensively grown in the northern than in the southern hemisphere.

There are more than 150 named varieties of wheat, but in many cases the distinctions between them are very slight. The most important differences are those which refer to the *composition* of the grain; but it will be found that these do not always agree with the outward characters of the grain or the ear. Wheats are generally characterised by some such terms as the following: Red or white, in reference to the colour of the grain; bearded or beardless, that is with or without an awn; winter or summer, the former being sown in autumn, the latter in spring; soft or hard, the soft wheats being tender and floury, the hard being tough, firm, and horn-like in appearance. This last distinction is the most important, as it corresponds to a real difference of chemical constituents and of feeding value. We shall recur to this point presently.

Cases 24 to 29.*

The average yield of an acre of land should be about 30 bushels of wheat grain, the bushel weighing 60 lb. In wet seasons the weight of a bushel of wheat grain may be as low as 55 lb.; while in good years it may rise to 64 lb. A plump, rounded, white, smooth grain, without wrinkles, gives the heaviest weight per

* Various samples of wheat grown in South Australia in 1872.—Frame containing 104 varieties of wheat cultivated in Great Britain and elsewhere.—Samples of the various products obtained from wheat, and the quantities of flour, pollard, and bran obtained from half a peck of wheat. Wheat is subject to the attacks of several forms of fungi, as seen in the diagrams. They are known to the farmer by the name of *rust*, *mildew*, *smut*, and *bunt*.

bushel. Wheat grain varies in specific gravity between 1·29 and 1·41, the harder wheats being the denser. The proportion of grain to straw is greatest in dry years—perhaps the average may be stated as 4 to 10.

The composition of wheat grain shows some variations, but they are limited to the relative proportions of starch and nitrogenous matters. Soft, white, and tender varieties of wheat, consisting entirely of opaque grains, may not contain more than 8 or 9 per cent. albuminoids; while hard and translucent sorts, such as those grown for the manufacture of macaroni, have been found to contain from 18 to 20 per cent. The starch in these latter grains is proportionately reduced. But differences in the composition of wheat grain show themselves with the same variety of wheat, when it has been grown under different conditions, in fine, dry seasons the starch being increased and the albuminoids diminished, and the reverse being the case in wet summers. Even in the grains from a single ear, the same differences may be often seen—analysis showing sometimes 4 per cent. more albuminoids in some of such grains than in others.

It is difficult to fix upon a set of figures which shall fairly represent the average composition of wheat grain. But the following analysis may be taken as showing the proportions of the main constituents in a good sample of white English wheat :—

Composition of Wheat.

Case 37.

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water - - - - - - - - - - -	14·5	...	2	140
Albuminoids, chiefly fibrin - - - - - -	11·0	...	1	332
Starch, with trace of dextrin - - - - -	69·0	...	11	17
Fat - - - - - - - - - - -	1·2	...	0	84
Cellulose and lignose - - - - - - -	2·6	...	0	182
Mineral matter, or ash - - - - - - -	1·7	...	0	119

According to this analysis, wheat contains 1 part of flesh-formers to 6½ parts of heat-givers, reckoned as starch. And if we assume that all the albuminoid matter present could be so used, not more than $1\frac{3}{4}$ oz. of the dry nitrogenous substance of muscle or flesh could be produced from 1 lb. of wheat grain, such as is represented by the above analysis. The long, hard, translucent wheats grown in some of the hotter parts of Europe, might furnish twice as much flesh-forming material from an equal weight of grain. Macaroni, vermicelli, pâtes d'Italie, and similar preparations are made from highly nitrogenous wheats.

Cases 40 and 41.*

Some notion of the importance of wheat as a food-stuff may be gathered from the following figures. In 1875 there were about 3,350,000 acres under wheat in Great Britain. But the produce of all this land did not suffice for the needs of the people, and the produce of about 4,500,000 acres in foreign countries had to be brought to the United Kingdom—the United States and Russia contributing most of this foreign supply. Altogether, something like 5,000,000 tons of wheat are annually consumed in Great Britain. Then, too, it should be remembered that large quantities of wheaten flour and other preparations of wheat reach this country from abroad.

There are several reasons why wheat is preferred to other cereal grasses for use as food. The grain is easily separated from the *paleæ* or chaff, which do not adhere to it as in the case of barley, oats, rice, &c. Then the yield of fine white flour, when wheat is ground in the mill, is very large. Wheaten flour, too, is readily made into a light and spongy bread. The chemical constituents of the wheat grain are likewise so proportioned as to render this food well fitted for the general sustenance of man, both as regards its flesh-forming and heat and force-producing character.

Mill-Products.

But wheat grain is nearly always prepared by some mechanical

* Samples of macaroni, vermicelli, and other Italian pastes, made from the flour of hard wheat, grown in Algeria.—Macaroni, vermicelli, semolina, &c., prepared from wheaten flour, from Portugal, Italy, France, &c.

process or other before it is eaten as human food. Frumity, however, once popular in England, and still occasionally seen in Yorkshire, was made from whole wheat grains soaked in water and then boiled in milk. By grinding wheat between millstones *meal* is produced; and this, by sifting, winnowing, and re-grinding, is separated into a number of mill-products differing, not only in the size of the particles of which they are made up, but also in their chemical composition. To understand this we must examine the structure of the wheat grain, which is in reality a fruit, consisting of a seed and its coverings. All the middle part of the grain is occupied by large thin cells full of a powdery substance, which is nearly white and opaque in soft wheats. This part contains much starch—indeed, nearly all the starch of the grain. Outside the central starchy mass is a single row of squarish cells, filled with a yellowish material very rich in nitrogenous—that is, flesh-forming—matter. Beyond this again there are six thin coverings or coats containing much mineral matter. This mineral matter contains both potash and phosphates. It should be added that the outermost coat of the above-named six coats is the least valuable, and in some processes of milling is removed by a previous operation. In Child's "Decorticator," for example, this thin bran, together with the germ of the grain, is first of all removed. In the process of Mège Mouriés, also, this thin and poor outer coat is removed, but by a different plan—the grain being first damped and then rubbed. What then will be the effect of grinding upon grain having the structure just described? Grinding may be described as a process in which squeezes and blows are united. In pressing or squeezing wheat you may powder the interior, and yet not break up the exterior part; by blows you may divide the grain into a number of small fragments—a coarse meal, in which the white central portion of the grain is not reduced to powder. Now there are several modes of milling or grinding wheat, differing mainly in the preponderance of one or other of these two actions of squeezing and cracking. By alterations in the distance between the stones, and by differences in the modes of scoring them, as well as in their direction and rate of motion, mill-products of different qualities are obtainable. The methods of "high-milling" have, indeed, become so complicated that it would be impossible to describe here the scores of operations, including many re-grindings and siftings, to which the grain is submitted. But we may at least say that, though a very fine white flour is certainly produced by this system, it is far smaller in quantity and less nutritious than fine white flour obtained by the ordinary English system. However, one advantage is said to belong to the more elaborate system, and that is that the various mill-products are not injured by over-heating during the treatment to which they are subjected.

In the ordinary process of milling the wheat meal is produced in one grinding, and is then separated into three or more different products. In some flour mills the separation of the various qualities is far more thoroughly carried out than in others. The following is a classified list of the chief products of a flour mill, with the average quantities of each product obtained from 100 lb. of good white wheat:—

		lb.
Flour	1. Finest flour	42
	2. Seconds flour	18
	3. Biscuit flour	9
	4. Tails, or tailings	3
	5. Middlings, or fine sharps	8
Bran	6. Coarse sharps	3
	7. Fine pollard	3
	8. Coarse pollard	6
	9. Long bran	3

It must be recollected that the above quantities are merely given as rough approximations, while the names applied vary in different parts of the country and in different mills. The first three qualities, or *wires*, for instance, are often sold together as "fine flour," while the quantity of this product is further raised (to 80 per cent. of the wheat taken) by re-dressing the tailings and re-grinding the middlings—which latter may be said to form a kind of link between flour and bran. There are some mills where only three different degrees of fineness are recognised—flour, middlings, and bran.

As the chemical differences between the various mill-products are not all of equal value, we may select a few facts regarding their components from the number which have been accumulated. The cellulose and lignose, as well as the mineral matter and fibrin, are least in the fine flour. The fibrin is greatest in the pollard, and the mineral matter in the long bran. It will thus be evident that fine flour is inferior to pollard in bone-forming and flesh-forming nutrients. The following table makes this clear, showing how rich in these nutrients all those mill-products are which consist chiefly of the coverings of the seed. The toughness of these coverings is, of course, the reason why they are not reduced to a fine powder during the processes of milling.

Case 37.

One pound of

	Fibrin.			Mineral Matter.	
	oz.	gr.		oz.	gr.
Fine flour contains	1	297	...	0	50
Tails ,,	1	389	...	0	76
Middlings ,,	2	105	...	0	147
Coarse sharps ,,	2	246	...	0	294
Fine pollard ,,	2	210	...	0	399
Coarse pollard ,,	2	196	...	1	17
Long bran ,,	2	182	...	1	60
Thin bran ,,	1	290	...	0	182

The thin bran named in this table is not obtained in ordinary flour mills; it forms the outermost coating of the grain, and may be removed by damping and then peeling the grain.

It may be useful to give a more complete analysis of fine flour as obtained from white soft wheat:—

Case 37.

	In 100 parts.		In 1 lb.	
			oz.	gr.
Water	13·0	...	2	35
Fibrin, &c.	10·5	...	1	297
Starch, &c.	74·3	...	11	388
Fat	0·8	...	0	57
Cellulose	0·7	...	0	49
Mineral matter	0·7	...	0	49

One pound of good wheaten flour, when digested and oxidized in the body, might liberate force equal to 2,283 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform is 477 tons raised 1 ft. high.

For one part of flesh-formers in fine wheaten flour there are 7¼ parts of heat-givers, reckoned as starch.

One pound of wheaten flour cannot produce more than about 1⅔ oz. of the dry nitrogenous substance of muscle or flesh.

Instead of giving analyses of all the other mill-products before named, we will cite one additional analysis only, that of a rather coarse bran :—

Case 37.	In 100 parts.		In 1 lb.	
			oz.	gr.
Water	14	...	2	105
Fibrin, &c.	15	...	2	175
Starch, &c.	44	...	7	17
Fat	4	...	0	280
Lignose and cellulose	17	...	2	316
Mineral matter	6	...	0	422

In comparing these numbers with those before given as representing the composition of fine flour, it will be seen that bran not only contains more fibrin and mineral matter than fine flour, but also more fat. The fibrous matter, which is indigestible, forms ⅙ of the bran, but not $\frac{1}{100}$ of the fine flour.

For 1 part of flesh-formers in bran there are not quite 4 parts of heat-givers, reckoned as starch.

One pound of wheaten bran contains flesh-formers equal to rather more than 2⅓ oz. of the dry nitrogenous substance of muscle or flesh.

In bran there is a remarkable substance called *cerealin*, which acts like a ferment in causing the change and solution of other substances, and it may therefore aid in the processes of digestion when brown or whole-meal bread is eaten.

There are many preparations of wheat which we can do little more than mention. Such are semolina and semola, which are made in grinding wheat (and other grains also, as those of the oat). They consist of small fragments of the interior of the grain, and are usually prepared from hard wheat rich in flesh-formers. It is from the same kinds of wheat that the macaroni, vermicelli, and the infinite variety of Italian pastes are prepared. Wheat groats, or grits, are distinguished from semola by the presence of the husk of the grain in large or small proportion.

BREAD.

French, *Pain.* German, *Brod.* Italian, *Pane.*

Of all the cereals wheat yields the best bread. This is due mainly to the peculiar character of the nitrogenous matter of wheat. This nitrogenous matter, of which the main constituent is a kind of fibrin, may be obtained in a separate form by making a little flour into a thick dough with water, and then washing the starch out of the mass by means of a stream of water. A grayish-yellow, tough, and elastic mass is left, which can be drawn out into threads. This substance is often called gluten; it is a mixture, but its chief ingredient is the albuminoid, or flesh-forming matter, fibrin. It confers upon a prepared mixture of flour and water, or dough, the property of yielding a sponge, which becomes firm, or sets, at the heat of the baking-oven. The bubbles which make the dough light are produced in different ways, but they are always filled at first with carbonic acid gas. The bubbles become larger as the dough begins to get hot in the oven, and finally they are fixed in shape and size by a higher degree of heat.

There are three ways of turning dough into bread. In the first of these the carbonic acid gas necessary to produce the spongy texture is made within the dough by means of *leaven*, or *yeast.* Leaven is not much used in this country—its action is similar to that of yeast. Leaven consists of flour and water—sometimes mixed with salt and boiled potatoes—it is kept till it has begun to suffer change. This change commences in the fibrin, which produces a substance—a kind of ferment—which turns some of the starch of the flour into glucose, and then this into alcohol and carbonic acid gas. According to some authorities, it is the small quantity of glucose previously existing in the flour which is thus fermented. The action of beer yeast is the same. Yeast, whether fresh or partially dried, has the power of decomposing a warm solution of glucose or maltose—the sugars of fruits and malt. In its growth, the yeast plant, mixed with the dough, breaks up these sugars, changing them into carbonic acid gas and alcohol. The alcohol escapes during baking, and so does most of the carbonic acid gas; but the latter has made innumerable bubbles in the dough previous to its escape, and thus the bread has been *vesiculated.* Leaven, assisted by a little yeast, is much used abroad, as in Paris, for making bread. Immense and increasing quantities of German, or dried yeast—carefully prepared by washing, &c.—are now imported into England. From a sack of flour weighing 480 lb. about 95 quartern or 4-lb. loaves may be obtained. These will lose weight, much water being given off from the bread after it has left the oven till it is cold—but the loss continues for long, the 4-lb. loaf at last being reduced to little more than 3 lb. New bread contains from 38 to 43 per cent. of water, sometimes even 45 per cent., and usually at least 40 per cent. The flesh-formers in white bread amount to 7 or 8 per cent.; the starch, gum, and sugar, to 48 or 50 per cent.; and the mineral matter (which includes the common salt added to the dough) to 1¼ per cent. The chief chemical difference between bread and the flour from which it has been made consists in the presence of much dextrin in the bread, along with some soluble starch. The crust contains more dextrin than the crumb.

But it is easy to make bread without yeast or leaven, the carbonic acid gas necessary being set free within the dough by means of the chemical reaction between a strong acid and a carbonate. This process yields *unfermented*, or chemical bread; and one plan of this kind, which was patented by Dr. Whiting in 1837, has been much used. The materials used to produce the carbonic acid gas are bicarbonate of soda and hydrochloric acid (spirits of salt). But it is necessary to make sure that these materials are free from injurious impurities; and it must also be remarked that the quantity of salt which is produced by the union of the bicarbonate of soda and the hydrochloric acid is excessive. It is true, however, that with care in the preparation of the dough less soda and acid will suffice, so that we may produce a light and agreeable loaf with about half the quantities of these substances usually recommended. Unfermented bread may also be made with sesqui-carbonate of ammonia without any acid, this compound expanding or raising the "sponge" and then escaping at the heat of the oven.

Baking powders contain tartaric acid and carbonate of soda, and the bread made with them differs only from the unfermented bread of Dr. Whiting in the presence of tartrate of soda—an aperient salt—instead of common salt. Similar powders, coloured yellow with turmeric, are sold under the name of *egg powders*. It is scarcely necessary to say that they have nothing in common with eggs save colour.

There is another process of making bread without leaven or yeast, or even any saline matter. It is known as Dr. Dauglish's process, the bread produced being called "aerated." Here the requisite carbonic acid gas is prepared beforehand in a condition of perfect purity, and in a separate vessel. This gas is then forced into water, which becomes highly charged with it, like soda-water. The flour is mixed with this aerated, or carbonated water in a strong iron vessel, under pressure. The dough thus formed rises when introduced into the oven, for the gas with which it has been charged expands and escapes on being withdrawn from the pressure of the mixing vessel, and still more on being heated. Aerated bread differs much in taste from ordinary fermented bread. Perhaps it is less generally liked, but it certainly preserves, in a remarkable degree, the odour and flavour of the original pure wheaten flour from which it was made.

Before leaving this extremely important subject of bread, a few words on brown bread may not be out of place. Brown bread, as usually made and sold by bakers, is merely ordinary white bread, containing a dash of pollard or fine bran. Now, this is not a satisfactory mixture, for the more valuable middlings, sharps, and fine pollard should not be excluded. Indeed, whole wheaten meal is now specially prepared by grinding up these products again and adding them to the flour, and the mixture is used for the manufacture of a true brown bread, preserving *all* the valuable constituents of the grain in due proportion. But it must not be thought that whole-meal bread or any other kind of brown bread does actually furnish more nutriment than white bread. It may be, and often is, richer in nutrients, but the presence of numerous rough, branny fragments so stimulates the action of the intestines, that the material is hurried along the digestive tract without that complete digestion and absorption of its nutritive matters which white bread undergoes. Thus bread from flour from which all coarse particles have been excluded is preferred, not unreasonably, by men who have hard bodily labour to perform. But there are, on the other hand, many persons to whom whole-meal bread and biscuits are exceedingly useful in aiding the action of the bowels. Any deficiencies in the amount of phosphates, &c., in white bread, are made up by the use of eggs, milk, and other foods of animal origin.

According to Dr. Frankland's experiments, 1 lb. of bread-crumb, if digested and oxidized in the human body, might liberate force equal to 1,333 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform is 267 tons raised 1 ft. high.

Case 38. The following recipes give some notion of the quantities of the several materials required to make a 2-lb. loaf, by the different processes just described :—

I.—Ordinary or Fermented Bread.

	lb.	oz.
Flour	1	8½
Water, about	0	10
Yeast	0	0½
Potatoes	0	1½
Salt	0	0⅛

It may be noted that more water than the above is often employed : that the small quantity of boiled potatoes here named, though generally thought to improve the bread, is not necessary ; and that ¼ oz. of salt is not an unusual proportion in the 2-lb. loaf.

II.—Aerated or Dr. Dauglish's Bread.

	lb.	oz.
Flour	1	7½
Carbonated water	0	10
Salt	0	0¼

III.—Unfermented Bread.

	lb.	oz.	gr.
Flour	1	8	0
Water	0	10	0
Bicarbonate of soda	0	0	220
Hydrochloric acid	0	0	246

IV.—Whole-Meal Bread.

	lb.	oz.
Whole wheaten meal	1	9
Water	0	10
Yeast	0	0½
Salt	0	0⅛

There are several substances found in bread, or, rather, in the bread of some bakeries, which have no business there. They are chiefly introduced to whiten the loaf, to enable damaged or inferior flour to be used, or to cause the bread to retain more water than usual. Alum and sulphate of copper (blue vitriol) are employed for the former purposes, boiled rice and potatoes for the latter. The two chemical substances, alum and sulphate of copper, are dangerous adulterants when added to a material in daily use like bread. A little pure lime-water answers the same purposes, and there is no reason to think it can be productive of the least harm. The case of boiled rice and potatoes is less serious. These materials are, of course, perfectly wholesome in themselves, indeed the latter material is often advantageously employed in making bread at home, on the small scale; but when these substances are used in order that 100 loaves may be got from a quantity of flour which should yield no more than 95, and when we know that this difference is caused by the larger quantity of water in the bread prepared with the addition of potatoes or rice, then these additions are justly described as adulterations.

From what we have just said, it must not be assumed that the adulterants found in bread are the additions, in all cases, of the baker. Millers are known to employ several substances for the purpose of whitening, or otherwise improving the flour, or for fraudulently increasing its weight. Rice meal, bean meal, corn-flour, or Rivett wheat flour, and the flour of Dari (a sort of millet), have been frequently detected in the products of the flour mill. But these materials, though cheaper than wheaten flour, cannot be said to be such serious adulterations as those of a mineral character. Chalk, dolomitic limestone, powdered gypsum, china clay, and even heavy spar or barytes have been employed for this purpose. All of these mineral matters are useless, having no value as food; some are even injurious. Fortunately they can all be easily detected by chemical tests, while the adulterants named before (rice, &c.), require very careful examination in a good microscope. The mere fact that a sample of wheaten flour left, on being burnt, more than its proper proportion of ash would point to adulteration with some of the earthy matters which have just been named.

Case 38. In times of scarcity, all sorts of vegetable matters have been mixed with wheaten flour and meal in order to eke out a limited supply of these nutritious matters. During the siege of

Paris a coarse bread was made containing but little wheat, the main ingredients being potatoes and beans, with oats, rice, and rye, together with a good deal of fibrous vegetable matter in the shape of chaff and straw. In Norway and Sweden the sawdust of non-resinous woods, like beech and birch, is boiled in water, baked, and then mixed with flour to form the material for bread. And in England, during the seventeenth century, a very tolerable bread was made from a mixture of the pulp of boiled turnips with wheaten flour.

Biscuits.

Case 39. Biscuits are usually distinguished from bread by two differences: they are not vesiculated, and they are baked until they contain scarcely any water, sometimes not even 5 per cent. There are, of course, some exceptions to this rule, especially in the case of fancy biscuits. The word "biscuit" means twice cooked or baked, and is thus not applicable to the generality of biscuits now made. There are, however, some biscuits which have really been twice in the oven; such are rusks, which are made from flour, milk, butter, and sugar, first lightly baked as a kind of bread, then cut into slices and again put into a sharp oven, so as to scorch both sides. Afterwards they are thoroughly dried by a lower degree of heat continued for some hours.

Most kinds of biscuits consist of a basis of flour and water, with slight additions of butter, sugar, and flavouring substances. Unleavened, or Passover cakes, consist of flour and water alone. Diet, digestive, and bran biscuits contain or consist of bran. Abernethy biscuits contain caraway seeds. Cracknels are glazed with white of egg. Macaroons and ratafias are flavoured with sweet and bitter almonds. Ginger, lemon, and orange-peel, and many other flavourers and spices, are used as ingredients in fancy biscuits and cakes. All plain biscuits may be considered as more nutritious than bread, in the proportion of 5 to 3. They are most digestible when not very dense, and when they have been browned by baking, so as to turn much of their starch into dextrin.

Oats.

French, *Avoine*. German, *Hafer*. Italian, *Avena*.
(*Avena sativa.*)

The oat belongs to the same order as the wheat—that of the grasses or graminaceæ. The native country of the plant from which our cultivated varieties are derived is unknown. The oat is hardier than wheat, and ripens in higher latitudes. In Great Britain there were, in the year 1875, no less than 2,664,000 acres devoted to this crop, as against 3,342,481 under wheat. Though chiefly grown as food for horses, there are two forms in which it is largely used for human food—these are oat-cake and oatmeal-porridge. As the husk adheres to the oat grain firmly, it is necessary to dry it in a kiln, in order to loosen it. Afterwards the kiln-dried oats are submitted to a process of milling, which removes the husk, and leaves the nutritive part of the grain, as groats or grits, which are then ground and constitute *oatmeal.* Oatmeal varies in composition a good deal, especially as regards the proportions of water, fat, and fibrin, or flesh-forming matter. When quite fresh, and before exposure to the air, its water does not exceed 5 per cent. and may be less; the fat or oil amounts to 7, and in the best samples to 10 per cent.; while the fibrin may be 14 to 17 or 18 per cent. Scotch oatmeal is the best and richest; it forms as porridge or oatcake a very nourishing though somewhat laxative food. It is much richer in flesh-formers than ordinary wheaten flour. Oat flour cannot alone be made into bread. As oats in the husks are not used as human food, we need not give the complete analysis of the whole oat grain, which differs from that of oatmeal, mainly in containing more cellulose and lignose. * A careful analysis of a fresh sample of Scotch oatmeal showed the following results :—

COMPOSITION OF OATMEAL.

Case 42.	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	5·0	...	0	350
Fibrin, &c.	16·1	...	2	252
Starch, &c.	63·0	...	10	352
Fat	10·1	...	1	269
Cellulose and lignose	3·7	...	0	259
Mineral matter	2·1	...	0	147

According to Frankland, 1 lb. of oatmeal, when digested and oxidized in the body, might liberate force equal to 2,439 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform is 488 tons raised 1 ft. high. It is, however, probable that the sample which was used in this experimental trial was decidedly inferior to fine Scotch oatmeal, the composition of which is given above.

For one part of flesh-formers in Scotch oatmeal, there are 5⅓ parts of heat-givers, reckoned as starch, but the actual quantities of both flesh-formers and heat-givers are unusually large.

One pound of oatmeal cannot produce more than about 2½ oz. of the dry nitrogenous substance of muscle or flesh.

One hundred pounds of oats (weighing 45½ lb. the bushel) commonly yield the following proportion of oatmeal, &c. :—

	From 100 lb. of oats.
Oatmeal	60 lb.
Husks	26 ,,
Water	12 ,,
Loss	2 ,,

* Samples of oats in the straw, and of different varieties of the grain, may be seen in Cases 30, 31, and 32.

BARLEY.

French, *Orge.* German, *Gerste.* Italian, *Orzo.*
(*Hordeum vulgare.*)

Case 42.* Barley belongs to the natural order of the grasses. The plant was originally a native of western temperate Asia. It is hardier than wheat or oats, and may be grown in high northern latitudes. It is not extensively cultivated in America; in Great Britain, 2,509,701 acres were devoted to this crop in the year 1875. Barley was largely used in ancient times as human food. Most of that grown in England is now converted into *malt* for making beer. Some is ground into meal and used for feeding pigs; while much is milled, yielding pot or Scotch barley and pearl barley. The whole grain is subjected to a rasping or paring process, by which the fibrous coats of the grain are more or less completely removed. Pot barley is the coarsest product, and retains something of the original shape of the grain. Of this product about 63 lb. are obtained from 100 lb. of barley, but only half this amount of the finest pearl. Patent barley is pearl barley ground into flour. Pot and pearl barley are used in soups, puddings, &c. It will be seen from the annexed analysis that pearl barley is inferior to wheaten flour in flesh-formers.

COMPOSITION OF COMMON PEARL BARLEY.

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	14·6	2	147
Fibrin, &c.	6·2	0	434
Starch, &c.	76·0	12	70
Fat	1·3	0	91
Cellulose	0·8	3	56
Mineral matter	1·1	0	77

For 1 part of flesh-formers in pearl barley there are no less than 12¾ parts of heat-givers, reckoned as starch.

* In Cases 33 and 34 samples of barley are shown.

One pound of pearl barley cannot produce more than 1 oz. of the dry nitrogenous substance of muscle or flesh.

Barley flour does not yield a light bread, but it may be used for bread-making when mixed with wheaten flour.

Rye.

French, *Seigle.* German, *Roggen.* Italian, *Segale.*
(*Secale cereale.*)

Case 42. Rye, like wheat, oats, and barley, belongs to the grasses. It was formerly extensively grown in Great Britain, and is still cultivated to some extent, especially in the eastern counties of England ; but in most parts of this country rye is used as green fodder only. The grain of rye is employed mainly for malting purposes, but its flour may be made into bread. Rye bread is dark-coloured, heavy, and sourish, but it keeps moist for a long time. It is a favourite food in many parts of Northern Europe, and is known as black bread. A palatable bread may be made from a mixture of 2 parts of wheaten flour and 1 part of rye flour.

Rye grain is peculiarly liable to the attacks of a fungus, which produces the ergot of rye. The whole substance of the grain is altered and blackened, while a remarkable compound called *ergotine* is produced. This substance renders ergoted grain unwholesome, and sometimes even dangerous.

The following table shows the

Composition of Rye Flour.

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	13·0	...	2	35
Fibrin, &c.	10·5	...	1	298
Starch, &c.	71·0	...	11	157
Fat	1·6	...	0	66
Cellulose	2·3	...	0	161
Mineral matter	1·6	...	0	112

For 1 part of flesh-formers in rye flour there are 6½ parts of heat-givers, reckoned as starch.

One pound of rye flour cannot produce more than 1 4/5 oz. of the dry nitrogenous substance of muscle or flesh.

Rice.

French, *Riz.* German, *Reis.* Italian, *Riso.*
(*Oryza sativa.*)

Cases 43 and 44. Rice is a grass, a native of India. It is extensively grown in India, China, and the East generally; also in Carolina and Central America. It is likewise cultivated with success in the southern parts of Europe. Rice requires a high temperature and abundance of water to bring it to perfection; indeed the fields in which the crop is grown are irrigated. Many varieties of rice are cultivated, but they do not differ materially, as far as the composition of the grain is concerned. Rice is more largely grown and consumed as human food than any other cereal. It is said to be the main food of one-third of the human race. Alone, however, it is not a perfect food, being deficient in flesh-formers and mineral matters.

Rice is imported into this country from Carolina, Patna, Bengal, Arracan. When enclosed in the husk rice is known as *paddy*. By careful milling this husk is removed, and the pearled grain thus cleaned is what is generally known as rice. The rice husk, or *shude*, is harsh and fibrous in texture, and contains much lignose and silica. It is largely used in adulterating many articles of human and cattle food. Rice is used both in the form of the cleaned rice of the shops and ground into flour. Much starch is extracted from rice. Rice starch is readily changed into a kind of sugar, accompanied by some dextrin, when it is warmed with very weak sulphuric acid.

Composition of Cleaned Rice.

	In 100 parts.		In 1 lb. oz.	gr.
Water	14·6	...	2	147
Fibrin, &c.	7·5	...	1	87
Starch, &c.	76·0	...	12	70
Fat	0·5	...	0	35
Cellulose	0·9	...	0	63
Mineral matter	0·5	...	0	35

For 1 part of flesh-formers in rice there are more than 10 parts of heat-givers, reckoned as starch.

One pound of rice cannot produce more than $1^1/_5$ oz. of the dry nitrogenous substance of muscle or flesh.

According to Frankland, 1 lb. of rice, when digested and oxidized in the body, might liberate force equal to 2,330 tons raised 1 ft. The greatest amount of external work which it could enable a man to perform is 466 tons raised 1 ft. high.

Rice is most usefully employed as food when it is consumed along with substances rich in nitrogenous or flesh-forming matters. Thus it may be used with meat, eggs, and any kind of pulse, as peas or beans. Rice should not be boiled, but merely steamed till tender, for it yields to boiling water a considerable part of its nitrogenous and mineral constituents—those compounds, in fact, in which it was already deficient. But this objection to boiling rice does not, of course, apply to its use in soups. Rice cannot be substituted for green vegetables for any length of time without an unhealthy condition of the body, and sometimes scurvy, being the result.*

* Samples of rice are shown in Case 44 from Central Africa, Carolina, Cochin China, Damietta, Egypt, Greece, India, Java, Madagascar, Peru, Portugal, Russia, Spain, and Turkey; also a specimen grown in the Royal Botanic Gardens, Kew.

Maize, or Indian Corn.

French, *Blé de Turquie.* German, *Mais.* Italian, *Granturco.*
(*Zea Maÿs.*)

Case 43.* Maize belongs to the grasses. It is a native American plant, but was soon introduced into the Old World. It is now largely grown in Southern Europe, North Africa, and North America. It is the *corn* of the United States, where numerous preparations of the grain are in use. The whole ear is spoken of as a *cob*; the pearled grains are called *samp.* Broken or split maize is known as *hominy*, while grains which have been heated or roasted so as to burst them are designated by the term *pop-corn.* Ground maize forms, when boiled, a very common and favourite food in the United States, being called *mush.* In Italy it goes under the name of *polenta*, while the more finely prepared meal is termed *polentina.* Maize will grow and often ripen its cobs in England, but it cannot be relied on as a field crop. Several varieties, and possibly more than one species, of maize are in cultivation. These differ much in the size, shape, and colour of the grain, and in other particulars as well; but in their composition there is not much variation—

Composition of Maize.

	In 100 parts.		In 1 lb. oz.	gr.
Water	14·5	...	2	140
Fibrin, &c.	9·0	...	1	193
Starch, &c.	64·5	...	10	140
Fat	5·0	...	0	350
Cellulose and lignose	5·0	...	0	350
Mineral matter	2·0	...	0	140

* Numerous varieties of maize, including the whole ear or cob, the separated grain, and many preparations therefrom, are shown in Case 35. The following is a list of the countries furnishing most of these specimens: British Guiana, Egypt, France, Greece, New South Wales, Peru, Portugal, Queensland, Russia, Senegal, Spain, United States, Venezuela. Some specimens of maize grown near London are also shown in this Case.

For 1 part of flesh-formers in maize there are 8½ parts of heat-givers, reckoned as starch.

One pound of maize cannot produce quite 1½ oz. of the dry nitrogenous substance of muscle or flesh.

Maize was not consumed to any great extent in the British Isles till the year of the potato famine, 1846, when considerable quantities of the grain and meal were imported. Since then large and increasing quantities of maize reach England, to be used, not only as human food, but for horse keep. Many preparations of maize are now popular articles of food under the names of corn-flour, oswego, maizena, cornena, &c. It must be distinctly understood that these products are not flour, but nearly pure starch, and that they contain mere traces of bone-forming and flesh-forming materials. When used with milk, however, their deficiencies are to some extent supplied, although, even then, there must necessarily be an excessive proportion of heat-giving to flesh-forming nutrients in the mixture. In 1 lb. of the so-called "corn-flour" from maize, we found but 18 grains of flesh-formers; in 1 lb. of the similar preparation known as "oswego," 69 grains were present.

Maize is poorer than wheat in flesh-formers, but richer than rice. It contains more fat than wheat, barley, or rice. Mixed with wheaten flour, it yields an agreeable bread. It may be used for biscuits, puddings, porridge, cakes, &c.

MILLET.

French, *Millet.* German, *Hirse.* Italian, *Miglio.*
(*Panicum miliaceum*, &c.)

Case 43. Very many different plants belonging to the grasses yield the grain known as millet. The *Panicum spectabile* of Brazil grows seven or eight feet high, while other species on the

Amazon are quite as luxuriant. *P. cernuum* is the millet of Texas; in India, *P. pilosum* and *P. frumentosum* are grown. In Central and Southern Europe several other species are cultivated.

Millet grain is used for human food chiefly in hot countries. It may be made into a kind of bread, quite equal, as far as its composition goes, to wheaten bread.*

A sample of one of the millets grown in Europe, the grain of *Panicum miliaceum*, gave, when the husk had been removed, the following results on analysis :—

COMPOSITION OF MILLET.

	In 100 parts.		In 1 lb. oz.	gr.
Water	13·0	...	2	105
Fibrin, &c.	15·3	...	1	283
Starch, &c.	61·6	...	10	231
Fat	5·0	...	0	315
Cellulose	3·5	...	0	280
Mineral matter	1·6	...	0	98

For 1 part of flesh-formers in millet there are about 5 parts of heat-givers, reckoned as starch.

One pound of millet cannot produce more than 1⅔ oz. of the dry nitrogenous substance of muscle or flesh.

Case 43. *Dari* or *Durra* is the grain of certain species of sorghum, and is largely consumed as food in some countries. It is imported into this country in some quantity, and used for feeding cattle, poultry, &c. The grain is white, and larger than millet.

COMPOSITION OF DARI.

	In 100 parts.		In 100 parts.
Water	12·2	Fat	4·2
Fibrin, &c.	8·2	Cellulose and lignose	3·1
Starch, &c.	70·6	Mineral matter	1·7

* In Cases 31 and 43 are various samples of millet from Canada, Germany, Persia, Portugal, Spain, India, Egypt, Senegal, Tripoli, Bohemia, and Russia.

The grain of many other grasses is used as food. We may cite as an instance the Russian preparation known as manna kroup, consisting of groats from the grain of the common grass, *Poa fluitans.*

Buckwheat.

French, *Sarrasin.* German, *Buchweizen.* Italian, *Grano Saraceno.*
(*Polygonum Fagopyrum.*)

Case 43. This plant, though not a grass, may be fitly considered here. It is largely grown in temperate countries for its starchy seeds, which resemble the grain of the grasses in composition. Buckwheat is probably a native of Western Asia or Russia: it belongs to the order *Polygonaceæ*, which includes the rhubarb and the dock.

Buckwheat is an annual of quick growth and easy cultivation. It is sown in Britain for feeding game and poultry, and is also grown for green fodder.

The seed of buckwheat is enclosed in a husk containing much indigestible fibre. When this husk, amounting to about 20 per cent., has been removed, the richness of the seed in nutritive matters is very considerable.

The published analyses of buckwheat deprived of its husk being very discordant, new analyses have been made with the following results:—

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	13·4	...	2	63
Fibrin	15·2	...	2	189
Starch	63·6	...	10	77
Fat	3·4	...	0	238
Cellulose and lignose	2·1	...	0	147
Mineral matter	2·3	...	0	161

For 1 part of flesh-formers in cleaned buckwheat there are about 4¾ parts of heat-givers, reckoned as starch.

One pound of cleaned buckwheat contains flesh-formers equal to rather more than 2⅓ oz. of the dry nitrogenous substance of muscle or flesh.

§ 2.—Pulse—Peas, Beans, &c.

There is a marked difference in chemical composition between the seeds of leguminous plants on the one hand, and the grain of the cereals on the other. This difference mainly consists in the far higher proportion of albuminoids, or flesh-formers, in the former. In consequence of this difference, the ratio of flesh-formers to heat-givers in the seeds now under consideration is about 1 to 2½, instead of 1 to 5, as in wheat, or 1 to 10, as in rice. This fact suggests the proper mode of using pulse, which should generally be eaten with other foods rich in starch, sugar, fat, oil, or non-nitrogenous nutrients. Beans and rice, beans and bacon, are examples of such mixtures.

The albuminoid which predominates in pulse is called *legumin* or *vegetable casein*. It occurs in leguminous plants generally, both in their green parts and in their ripe seeds. It appears to be more soluble and more easily digested in the unripe fresh seeds than after they have become ripe and dry; but it is usually considered a less valuable flesh-former than albumen or fibrin. Its resemblance to the animal casein of milk is so decided, that in some parts of China cheeses are made from the seeds of beans and peas. The resemblance between different species of pulse is so great that we need not describe in detail all the cultivated sorts,* but may select as examples the garden pea, the haricot bean, and the lentil.

Peas.

French, *Pois*. German, *Erbsen*. Italian, *Piselli*.

(*Pisum sativum*.)

Case 46. The cultivated garden pea is probably derived from a plant native of countries bordering the Black Sea. It has been long

* In Cases 31, 32, and 34 are samples of different kinds of beans, peas, chick peas, vetches, and lentils, from many countries.

grown in England, and, like the French bean, is eaten unripe and green, as a fresh vegetable, and ripe, in the form of dried peas, split peas, and pea meal. Split peas have had the tough envelope of the seed removed.

Unripe or green peas contain a considerable quantity of sugar, while the albuminoid matter in them is more easily digested than that in the same seeds when quite ripe. Dry, ripe peas, even when ground, require long but slow boiling, to render them fit for use; they constitute a valuable food, however, when properly cooked, in the form of pease-pudding and pea-soup. In common with other leguminous plants, and indeed with all products, animal as well as vegetable, which are rich in casein, peas are liable to occasion flatulence and colic. Peas and many other legumes contain a bitter substance, which predominates in some varieties so greatly as to render them unpalatable. This substance may, however, be removed in some measure by soaking the seeds or coarse meal in water containing a little common washing soda for some time: the liquor is then poured away.

COMPOSITION OF PEAS.

	In 100 parts.	In 1 lb. oz	In 1 lb. gr.
Water	14·3	2	126
Casein, &c.	22·4	3	255
Starch, &c.	51·3	8	91
Fat	2·5	0	175
Cellulose and lignose	6·5	1	17
Mineral matter	3·0	0	210

For 1 part of flesh-formers in peas, there are only 2½ parts of heat-givers, reckoned as starch. One pound of peas contains flesh-formers equal to 3½ oz. of the dry nitrogenous matter of muscle or flesh.

According to Frankland, 1 lb. of dry peas, when digested and oxidized in the body, might liberate force equal to 2,341 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform, is 468 tons raised 1 ft. high.

One of the most economical and nutritious articles of diet is pea-soup. One gallon may be made from—peas, 16 oz.; meat, 16 oz.; pot barley, 1 oz.; onions, 1½ oz.; salt, 1½ oz.; sugar, 1½ oz.; black pepper, 40 grains; and water, 4 quarts. The peas should be first steeped in 3 pints of the water (cold) for 12 hours; the meat should be gently simmered in 5 pints of the water for 3 hours. The peas should then be put in a bag and boiled with the meat for 1 hour. The contents of the bag should then be pressed into the liquor, the skins which remain in the bag being removed. The salt, pepper, onions, and barley should now be put in, and the whole boiled for 1 hour, water being added, from time to time, to make up the gallon. Water in which bones, fresh meat, or such vegetables as carrots and parsnips have been boiled, may be substituted for the whole or part of the fresh water used, and the resulting soup will be still more nutritious. But even the best soups cannot be regarded as complete substitutes for the more solid foods—bread, cheese, potatoes, and meat.

One pint of this soup will contain something like the following quantities of—

Case 47.

	oz.	gr.
Water	17	0
Casein, &c.	0	270
Starch, &c.	1	0
Sugar	0	56
Fat	0	257
Gelatin	0	147
Mineral matter	0	103

The field pea is *Pisum arvense*, and is generally thought to be the origin of all our cultivated varieties, although these are now grouped under the generic name of *P. sativum*. But there is a very distinct kind of pea, known as the chick pea, which belongs to a different genus—it is the *Cicer arietinum*. Chick peas are eaten in Spain, and very extensively also in the East, being generally parched or lightly roasted.*

* Chick peas from Moldavia, Turkey, Portugal, Spain, and India are shown in Case 31.

Haricot and French Beans.

French, *Haricots.* German, *Wälschen Bohnen.* Italian, *Fagiuoli.*
(*Phaseolus vulgaris.*)

Case 46. The French bean, the kidney bean, and the numerous varieties of haricots, are all derived from a plant which was introduced from India. This vegetable was and is largely grown in Italy and France, where its pods are usually allowed to ripen and the seeds to dry. In this country the pods are gathered when green and unripe, and eaten as a fresh vegetable; this is the case, also, to some extent, on the Continent, where the green pods are preserved in several ways so as to be available throughout the year. The dried seeds of this plant, known as haricot beans, when carefully and thoroughly cooked, are worthy of more extended use in England; they are universally appreciated in France. They should be eaten with starchy foods, like rice, or with bacon.

Composition of Haricot Beans.

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	14·0	2	105
Casein, &c.	23·0	3	297
Starch, &c.	52·3	8	161
Fat	2·3	0	161
Cellulose and lignose	5·5	0	385
Mineral matter	2·9	0	203

For 1 part of flesh-formers in haricot beans there are only 2½ parts of heat-givers, reckoned as starch.

One pound of haricot beans might produce nearly 3¾ oz. of the dry nitrogenous substance of muscle or flesh.

The scarlet-runner (*Phaseolus multiflorus*) closely resembles the French bean, and is used green in the same way. It is believed to be a native of Mexico. The ripe beans are not wholesome.

The broad or Windsor bean is, when young, an agreeable and wholesome food. It is the seed of a distinct plant derived from the field bean, or *Faba vulgaris.*

Lentils.

French, *Lentilles.* German, *Linsen.* Italian, *Lenti.*
(*Ervum lens.*)

Case 46. This leguminous plant is extensively grown for human food in the southern parts of Europe. Numerous varieties exist, but they do not differ much in composition and nutritive value. This plant was cultivated by the Hebrews and other ancient nations. It is thought that the red pottage of Esau was made from the well-known red variety of lentil.

Besides a bitter substance there is a good deal of useless fibrous material in the covering of lentil seeds. When this covering is removed the meal which lentils yield is of great richness. It generally contains more casein than either peas or beans, but rather less than lupines. The preparations so much advertised under the names of "Revalenta," "Ervalenta," &c., contain lentil-meal, generally mixed with some barley or other flour, and common salt. They are sold at many times the value of the meals of which they are composed.

Composition of Lentils.

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	14·5	2	140
Casein, &c	24·0	3	367
Starch, &c.	49·0	7	408
Fat	2·6	0	182
Cellulose and lignose	6·9	1	45
Mineral matter	3·0	0	210

For 1 part of flesh-formers in lentils there are about 2¼ parts of heat-givers, reckoned as starch.

One pound of lentils contains flesh-formers equal to 3¾ oz. of the dry nitrogenous substance of muscle or flesh.*

* Many samples of lentils, from Algeria, Egypt, France, Portugal, Réunion, Spain, Tripoli, and Turkey, are shown in Case 34.

Ground or Pea Nuts.

(*Arachis hypogæa.*)

Case 46. The pods of this most curious leguminous plant are ripened below the soil. The plant is probably of American origin, but is grown in many hot countries, and is widely cultivated along the West Coast of Africa. It flourishes in a rich soil, and may grow to 2 feet in height. The Arachis somewhat resembles a large kind of clover in appearance; it has small bright yellow pea-like flowers, borne on long stalks; these, after flowering, curl down and force the immature pod into the soil.

The seeds of the ground nut when green and unripe are roasted, and have a very pleasant taste. When ripe they are extremely oily, and require an admixture of starchy matter.

Composition of Ground Nuts (shelled).

	In 100 parts.	In 1 lb. oz.	gr.
Water	7·5	1	97
Casein	24·5	3	403
Starch, &c.	11·7	1	382
Oil	50·0	8	0
Cellulose and lignose	4·5	0	315
Mineral matter	1·8	0	126

Ground nuts, after the greater part of the oil has been expressed, yield a cake much used in this country for feeding cattle. But in many tropical countries these nuts are consumed as human food.

Many other leguminous seeds and pods are eaten besides those named above. Such are, the pigeon pea (*Cajanus indicus*), of India; a plant nearly allied to the ground nut (*Voandzeia subterranea*); and numerous Indian and Chinese species of *Dolichos*.

§ 3.—Roots and Tubers

Cases 48, 51, and 52. It will have been noticed that the vegetable products (corn and pulse) already considered contain but a moderate portion of water, generally something like 14 per cent., or 2 oz. in the pound. But it will presently be seen that all fresh and moist vegetables, whether roots, leaves, or fruits, contain much more water. Potatoes, indeed, are richer in nutrients than many other moist vegetables, but even they contain 75 per cent. of water, or 12 oz. in the pound. White turnips, on the other hand, contain from 91 to 93 per cent., or nearly 15 oz. in the pound. Another point of difference between the drier foods already studied, and those to which attention is about to be directed, lies in the presence of more considerable proportions of albumen amongst the flesh-formers of moist roots and tubers. We give the first place to the potato.

POTATOES.

French, *Pommes de terre*. German, *Kartoffeln*. Italian, *Pomi di terra*.

(*Solanum tuberosum*.)

The potato belongs to the nightshade order, which includes a very large number of poisonous plants. The tubers, which are enlargements of the underground stem, form, next to the grain of the cereals, our most important vegetable food. The potato plant has been found wild in Chili, Peru, and Mexico. It was brought to Ireland by Sir John Hawkins, in 1565; to England by Sir Francis Drake in 1585, and in the following year by Sir W. Raleigh. Gerarde figured the plant in his "Herbal," published in 1597. But this vegetable did not become popular until towards the close of the eighteenth century.

Many varieties of the cultivated potato exist, but variations in chemical composition shown by this tuber depend more upon its size and maturity than upon the variety. Since the year 1845 the potato has been the subject of a disease, known as the potato murrain, which causes the foliage to die off suddenly and the tubers to decay. The murrain prevails in damp warm summers, when there is a heavy rainfall in June or July, and when the rain falls on many days. Such conditions are favourable to the growth of the parasites, mildew, or fungus, which is the immediate cause of the disease. Good drainage, with plenty of air for the plants, and no excess of decaying matter in the soil, are amongst the best means of moderating the attacks of the fungus, which generally goes by the name of *Peronospora infestans*, but has been lately described as a *Phytophthora.*

Slightly diseased potatoes may be utilised in many ways. If cut at once in thin slices or granulated, they may be dried in hot-air chambers, and will keep for years. They again absorb water when placed in it, and may be cooked in the usual manner. The starch, even in badly diseased potatoes, is but little affected, and may be obtained from the pulped tubers by washing them on a cloth in a stream of water.

From potatoes many products are obtained. These are made from the starch of the tuber, which is a good and cheap substitute for arrowroot. This starch, by roasting, becomes dextrin, or British gum. By boiling with weak sulphuric acid, potato starch is changed into glucose or grape sugar, and this, by fermentation, yields alcohol. Large quantities of spirits are made from potato starch, and are sold under the name of British brandy.

The peel or rind of potato tubers contains a poisonous substance called *solanine.* This is destroyed or dissipated when the potatoes are boiled or steamed.

Large quantities of potatoes are now imported into England from abroad.

The potato being rather deficient in flesh-formers, cannot be used as a complete food, but is best employed as an addition to pulse, lean meat, or other nitrogenous foods.*

* Numerous specimens of starch and starchy preparations made from the potato are shown in Cases 49 and 50. These include imitation sago, tapioca, macaroni, and vermicelli. Glucose, and dextrin from potato starch are also shown. The specimens are from Brazil, France, Holland, Prussia, and Sweden.

COMPOSITION OF POTATOES.

Case 49

	In 100 parts.		In 1 lb. oz.	gr.
Water	75·0	...	12	0
Fibrin and albumen	2·3	...	0	161
Starch	15·4	...	2	210
Dextrin and pectose	2·0	...	0	140
Fat	0·3	...	0	21
Cellulose	1·0	...	0	70
Mineral matter	1·0	...	0	70

For 1 part of flesh-formers in potatoes it would appear that there are 10 parts of heat-givers, reckoned as starch. But it is doubtful whether the flesh-formers are not much exaggerated in the above, as in all published analyses. Recent experiments tend to show that the ratio of flesh-formers to heat-givers is nearer 1 to 20 than 1 to 10. According to Frankland, 1 lb. of potatoes, when digested and oxidized in the body, might liberate force equal to 618 tons raised 1 ft. high. The greatest amount of external work which it would enable a man to perform is 124 tons raised 1 ft.

TURNIPS.

French, *Navets.* German, *Weissen Rüben.* Italian, *Navoni.*
(*Brassica rapa.*)

Case 48. The turnip belongs to the Order of the Cross-flowers, or *Cruciferæ*, so called because of their four petals being arranged as a cross. The Swedish turnip, which is rather more nutritious than the common turnip, is said to have sprung, not from *Brassica rapa*, but from another plant, *B. campestris*, which also gave rise to rape and colza.

The turnip, like many other plants of the same order, contains a pungent essential oil. The root is very watery, and contains but little nourishment. Unlike the potato, the turnip contains no starch, but, instead, a jelly-like matter, belonging to what is called the *pectose* group. It appears, from recent experiments, that turnips contain no more than one-half per cent. of flesh-formers, instead of the 1 per cent. usually assigned to them.

COMPOSITION OF WHITE TURNIPS.

	In 100 parts.		In 1 lb. oz.	gr.
Water	92·8	...	14	371
Albumen	0·5	...	0	35
Pectose	4·0	...	0	210
Fat	0·1	...	0	7
Cellulose and lignose	1·8	...	0	126
Mineral matter	0·8	...	0	56

For 1 part of flesh-formers in turnips there are 8 parts of heat-givers, reckoned as starch.

CARROTS.

French, *Carottes.* German, *Möhren.* Italian, *Carotte.*
(*Daucus carota.*)

Case 48. The wild carrot grows abundantly on our southern coasts. It belongs to the Umbellifer Order, which includes many edible plants, as celery, parsnip, and parsley ; and many poisonous ones, as hemlock. The wild carrot, which is of pungent odour and disagreeable taste, has become much milder and more succulent by cultivation. The cultivated plant is said to have been introduced into England during the reign of Elizabeth.

Carrots, unlike parsnips, contain no starch. They are more watery than parsnips of the same size, but they are more generally liked. The carrot is grown in all the quarters of the globe.

Well-grown carrots (weighing about 8 oz.) contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	89·0	...	14	105
Albumen	0·5	...	0	35
Sugar	4·5	...	0	315
Gum and pectose	0·5	...	0	35
Fat	0·2	...	0	14
Cellulose and lignose	4·3	...	0	301
Mineral matter	1·0	...	0	70

For 1 part of flesh-formers in carrots there are 10 of heat-givers, reckoned as starch.

One pound of carrots cannot produce more than 1/12 oz. of the dry nitrogenous substance of muscle or flesh.

According to Frankland, 1 lb. of carrots, when digested and oxidized in the body, might set free a force equal to 322 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform, is 64 tons raised 1 ft. high.

Parsnips.

French, *Panais.* German, *Pastinaken.* Italian, *Pastinache.*
(*Pastinaca sativa.*)

Case 48. The garden parsnip is a cultivated variety of the wild parsnip, a native umbelliferous plant, like the carrot. The cultivated variety has been grown since Roman times.

The parsnip contains less water than the carrot. There is a good deal of starch, with some sugar, present in this root.

The parsnip is often eaten with salt fish and salt beef, but its peculiar taste and texture are disliked by many persons.

Both spirits and beer are occasionally prepared from parsnips.

The chief constituents of parsnips are shown in accordance with the following analysis :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	81·0	...	12	420
Albumen	1·2	...	0	84
Sugar	3·0	...	0	210
Starch	3·5	...	0	245
Pectose and dextrin	2·2	...	0	154
Fat	1·5	...	0	105
Cellulose and lignose	5·6	...	0	392
Mineral matter	1·0	...	0	70

For 1 part of flesh-formers in parsnips there are 10 parts of heat-givers, reckoned as starch.

One pound of parsnips cannot produce quite 1/5 oz. of the dry nitrogenous substance of muscle or flesh.

Beet Root.

French, *Betteraves.* German, *rothen Rüben.* Italian, *Barbabietole.*
(*Beta vulgaris.*)

Case 51. The sea-beet (*B. maritima*), common on our southern shores, is thought to be the origin of the garden-beet, the sugar-beet, and the field-beet or mangold-wurzel. The red garden-beet has been long grown in England. Its root, which is of a rich red colour, is boiled, and then sliced and eaten in salads or alone. The plant belongs to the Goose-foot Order (*Chenopodiaceæ*).

The garden-beet contains nearly as much sugar as the best sugar-beet, which is so largely grown for making sugar in France, Belgium, Germany, &c.*

The quantity of flesh-formers in beet-root is but one-third of the amount usually assigned to this food, the greater part of the nitrogen present existing as nitrates, &c.

Roots of garden-beet contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	82·2	...	13	67
Albumen	0·4	...	0	28
Sugar	10·0	...	1	262
Pectose	3·4	...	0	238
Fat	0·1	...	0	7
Cellulose and lignose	3·0	..	0	210
Mineral matter	0·9	...	0	63

For 1 part of flesh-formers in beet-root there are more than 30 parts of heat-givers, reckoned as starch.

Jerusalem Artichokes.

French, *Topinambours.* German, *Erdäpfel.* Italian, *Tartufoli.*
(*Helianthus tuberosus.*)

Case 51. Jerusalem artichokes are the tubers of a kind of sunflower, which is thought to have been a native of Mexico

* A series of products obtained in the manufacture of sugar from beet-root is shown in Case 10.

or Brazil. The plant has been cultivated in England, though not largely, since the beginning of the seventeenth century. Jerusalem artichokes may be grown for many successive years on a poor, dry soil, and yet give a fair crop. The tubers should be left in the ground till required for use.

There is no starch in the Jerusalem artichoke; on this account, unlike the potato, it does not become floury when boiled. Instead of starch, the tubers of this plant contain a substance resembling starch known as *inulin*, as well as much sugar.

The tubers of Jerusalem artichokes contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	80·0	...	12	350
Albumen	2·0	...	0	140
Sugar, inulin, and pectose	14·4	...	2	133
Fat	0·5	...	0	35
Cellulose	2·0	...	0	140
Mineral matter	1·1	...	0	77

For 1 part of flesh-formers in Jerusalem artichokes there are 7 parts of heat-givers, reckoned as starch.

One pound of Jerusalem artichokes cannot produce more than about ⅓ oz. of the dry nitrogenous substance of muscle or flesh.

Onions.

French, *Oignons.* German, *Zwiebeln.* Italian, *Cipolle.*
(*Allium Cepa.*)

Case 51. The onion is a native of the Levant. It belongs to the Lily Order. The large and mild onions imported from Spain and Portugal are used as a vegetable food, but this bulb is commonly regarded as a mere flavourer. The strong smell and taste of onions, as of the garlic and the leek, are due to a pungent volatile oil, rich in sulphur; but the quantity of this oil is very minute, and is not represented in the analysis given here.

Onions have a feeding value very near that of white turnips.

Burnt, or rather scorched, onions are used for colouring soups

Moderate-sized English onions contain on an average the lowing proportions of their chief constituents :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	91·0	...	14	245
Albumen	1·5	...	0	105
Mucilage and pectose	4·8	...	0	336
Fat	0·2	...	0	14
Cellulose and lignose	2·0	...	0	140
Mineral matter	0·5	...	0	35

For 1 part by weight of flesh-formers in fresh onions there are about 3½ parts of heat-givers.

One pound of onions cannot produce quite ¼ oz. of the dry nitrogenous substance of muscle or flesh.

SWEET POTATO.

Batatas edulis.

Case 51. This plant belongs to the Convolvulus Order. It is probably a native of the warmer parts of the American continent, where it has long been extensively grown. It is also cultivated in Algeria and in Southern Europe. It has been called the Spanish potato.

The chief difference between the tubers of this plant and those of the true potato lies in the presence of sugar in the former.

The tubers of the sweet potato, and those of the different kinds of yam, resemble one another somewhat closely as to their constituents and feeding value, but they are the produce of plants belonging to widely different natural orders.

The sweet potato contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	74·0	...	11	368
Albumen	1·5	...	0	105
Starch	15·0	...	2	175
Sugar	3·0	...	0	210
Pectose and gum	2·2	...	0	154
Cellulose	2·8	...	0	196
Mineral matter	1·5	...	0	105

For 1 part of flesh-formers in the sweet potato there are 13 parts of heat-givers, reckoned as starch.

One pound of sweet potatoes cannot produce quite ¼ oz. of the dry nitrogenous substance of muscle or flesh.

YAM.

(*Dioscorea alata.*)

Case 52. The tubers of several species of twining shrubs belonging to the genus *Dioscorea* are known as yams. The yam is grown in most tropical and some sub-tropical countries. It flourishes in Japan, the East and West Indies, the South Sea Islands, and is an important article of food. The tubers sometimes weigh 30 and even 40 lb.

A kind of yam from China (*D. batatas*), called in French *Igname de Chine*, is cultivated with some success in France and Algeria; the produce has been known occasionally to exceed 23 tons of tubers per acre.

There is much resemblance both as to chemical composition and taste between the yam and the common potato.

Yams contain on an average—

	In 100 parts.		In 1 lb. oz.	gr.
Water	79·6	...	12	322
Albumen	2·2	...	0	154
Starch	16·3	...	2	196
Fat	0·5	...	0	35
Cellulose	0·9	...	0	63
Mineral matter	1·5	...	0	105

For 1 part of flesh-formers in the yam there are 7½ parts of heat-givers, reckoned as starch.

One pound of yams cannot producemore than ⅓ oz. of the dry nitrogenous substance of muscle or flesh.

A few other roots of less importance, which are sometimes used as accompaniments of meat, may be named here.

The parsnip-chervil (*Anthriscus bulbosus*), a native of France, has an edible root like a small carrot.

Rampion (*Campanula rapunculus*) is much grown in France, for the sake of the roots, which are boiled till tender.

Skirret consists of the small tuberous roots of a large, coarse, umbelliferous plant (*Sium Sisarum*) from China. They are boiled for use.

§ 4.—Leaves, Stems, Stalks, and whole Plants.

The cabbage, with the numerous plants botanically connected with it, does not differ widely in nutritive value from the turnip. But it should be recollected that important mineral matters, as potash salts and phosphates, together with vegetable acids, flavouring substances, and a variety of active principles, are present in notable quantities in many of the succulent vegetables which we are about to consider. The asparagine in asparagus, the nitrate of potash in lettuces, and the pungent essential oil in watercress are instances in point. It will, therefore, be convenient to group these and many other plants together, not because they resemble one another much, but because they all form agreeable and wholesome accompaniments to more solid and nutritious articles of food. It should be added, that the great majority of the plants in this section are distinguished from those previously considered by the presence of *chlorophyll*, the green colouring matter of leaves; its nutritive value is not known, however, as yet.

Cabbage.

French, *Chou.* German, *Kohl.* Italian, *Cavolo.*

(*Brassica oleracea.*)

Case 52. The wild plant, one of the *Cruciferæ*, from which the cabbage sprung, grows upon the southern and western coasts of England, Wales, and Ireland. The same native plant is also the origin of Scotch kail, Brussels sprouts, savoys, red cabbage, and the cauliflower and broccoli.

The popular German food, sauer-kraut, is made from sliced cabbage, sprinkled with salt, pressed and fermented.

The inner and younger leaves of the cabbage contain much more water than the older leaves outside. On the whole, this vegetable may be considered more nutritious than the turnip.

The chief constituents of cabbage are shown in accordance with the following analysis :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	89·0	...	14	105
Albumen	1·5	...	0	105
Sugar, starch, and gum	5·8	...	0	406
Fat	0·5	...	0	35
Cellulose and lignose	2·0	...	0	140
Mineral matter	1·2	...	0	84

For 1 part of flesh-formers in cabbages there are about 4⅔ parts of heat-givers, reckoned as starch; broccoli and cauliflower are rather richer in flesh-formers than cabbage. One pound of cabbage contains flesh-formers equal to nearly ¼ oz. of the dry nitrogenous substance of muscle or flesh.

According to Frankland, 1 lb. of cabbage, when digested and oxidized in the body, might set free force equal to 261 tons raised 1 ft. high. The greatest amount of external work which it would enable a man to perform is 52 tons raised 1 ft. high.

Besides the cabbage and its many varieties, the green leaves of several other plants are eaten after having been boiled. Spinach (*Spinacia oleracea*), a native of Western Asia, is used in this way, and is a wholesome vegetable; it contains much nitre. The leaves of some of the smaller varieties of beet (*Beta vulgaris*) are sometimes substituted for spinach. The mountain spinach, or orache (*Atriplex hortensis*), was once much grown in this country, and is still cultivated in France; it is a native of Tartary. The young shoots or tops of the common stinging nettle (*Urtica dioica*) are not unlike spinach when properly boiled and dressed. The leek (*Allium Porrum*) is another green and succulent vegetable, which is esteemed especially by the Scotch and Welsh. The whole plant, bulb and leaves, is eaten. It should be blanched by earthing up. It may be simply boiled, or introduced in place of onions (which it resembles in flavour and composition) into soups and stews.

The next plant in this section, and one which we may describe more fully, is sea-kale, which is rendered mild and agreeable in taste by being earthed up.

SEA-KALE.

(*Crambe maritima.*)

Case 52. The sea-kale is a native perennial Crucifer. It is found, though rarely, in a wild state, upon some of our sandy and shingly coasts. It has been cultivated in England for more than 200 years, and was introduced to the Continent from this country.

Cultivated sea-kale is larger and more succulent than the wild plant, and has a more agreeable taste. It is earthed up, and the blanched stems and leaf-stalks then produced are eaten, after having been boiled.

Sea-kale usually contains no sugar, but a good deal of mucilage and some starch.

Freshly-cut sea-kale contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	93·3	...	14	406
Albumen	2·4	...	0	168
Mucilage and starch	2·8	...	0	196
Cellulose	0·9	...	0	63
Mineral matter	0·6	...	0	42

Sea-kale contains a good deal of nitrogenous matter of one kind or another, but it is probable that the proportion of flesh-formers to heat-givers is not exactly shown in our analysis, which, indeed, gives the ratio 1 to 1, or thereabouts.

The CARDOON is a perennial composite (*Cynara Cardunculus*), a native of Southern Europe. It is much like the common artichoke, but the part eaten is the blanched stalk of the young leaves. It is a very handsome plant.

The ARTICHOKE (*Cynara Scolymus*) is a native composite from Barbary and Southern Europe. The fleshy receptacle of the flower, the fleshy scales of the involucre, and the blanched leaf stalks are eaten after having been boiled. They have a delicate flavour and agreeable texture, but contain little nutritive matter. The young buds are sometimes pickled.

ASPARAGUS (*Asparagus officinalis*) is a wild seaside English plant, made more succulent by cultivation. It is remarkable as containing a crystalline alkaloid, *asparagine*, which is thought to possess diuretic properties.

The next articles of vegetable food which we shall notice in the present section are the vegetable marrow and the tomato. In both these plants it is the fruit which is eaten, but as these fruits are not valued because of that usual ingredient of fruits—sugar—but are used to accompany meat and other foods with which salt is eaten, they may be suitably considered here.

VEGETABLE MARROW.

(*Cucurbita ovifera.*)

Case 53. The vegetable marrow is thought to be a variety of the common gourd (*Cucurbita maxima*), a plant which appears to have given rise also to the pumpkin and the squash. The vegetable marrow is now largely grown in England. It delights in a rich and open soil, with abundance of moisture.

Although the fruit of the vegetable marrow is very watery, yet it contains more nutritive matter than its close ally, the cucumber. In vegetable marrows, when fit for cooking, starch as well as sugar occurs.

Peeled and properly cooked, young vegetable marrows form a wholesome and agreeable food, of delicate flavour and pleasant consistence.

Peeled vegetable marrows contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	94·8	...	15	73
Albumen	0·6	...	0	42
Sugar	2·0	...	0	140
Starch	0·6	...	0	42
Fat	0·2	...	0	14
Cellulose	1·3	...	0	91
Mineral matter	0·5	...	0	35

For 1 part of flesh-formers in the vegetable marrow there are about 4 parts of heat-givers, reckoned as starch.

TOMATOES.

French, *Pommes d'amour*. German, *Liebesäpfel*. Italian, *Pomi d'oro*.

(*Lycopersicum esculentum.*)

Case 53. The tomato, or love apple, is a plant belonging to the Nightshade Order—an order which includes the potato, the capsicum, and tobacco. It is most probably a native of Mexico.

The fruit of the tomato requires a good deal of heat to ripen it thoroughly. The plant should be trained on a sheltered wall. They require good soil, and abundance of water. The tomato is now much more grown in England than formerly, several varieties, some with yellow and others with red fruit, being cultivated.

Ripe tomatoes, which have a pleasant acidulous taste, are used in sauce and in other ways with cooked meat. Unripe tomatoes make a good pickle.

Ripe tomatoes contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	89·8	...	14	161
Albumen	1·4	...	0	98
Sugar	6·0	...	0	420
Malic acid	0·7	...	0	49
Cellulose and pectose	1·3	...	0	91
Mineral matter	0·8	...	0	56

For 1 part of flesh-formers in tomatoes there are about 4 parts of heat-givers, reckoned as starch.

Fungi and Mushrooms.

The value of cryptogamic plants generally as food is ill understood; and especially is the real nature of the several constituents in the numerous kinds of fungi which have been eaten safely, still in some measure doubtful. A delicate and agreeable flavour is possessed by the common mushroom (*Agaricus campestris*), and by several allied species—by the morel (*Morchella esculenta*), and by the truffle, an underground species (*Tuber cibarium*); but none of these plants can be regarded as substantive articles of diet. They are used chiefly as flavourers in the form of sauces, like ketchup, or, as in the case of truffles, as stuffing for animal food. The truffle, it should be stated, is sought for by means of dogs trained to scent it; in France pigs are employed. Amongst other edible fungi (many of which are often called toadstools) may be named the champignon (*Marasmius oreades*), the chanterelle (*Cantharellus cibarius*), the orange agaric (*Lactarius deliciosus*), the edible boletus (*Boletus edulis*), and many other species. But it is hazardous for persons who are not well acquainted with fungi to attempt to distinguish between those which are harmless and those which are poisonous. Serious and even fatal mistakes have thus arisen. We give some details concerning the common mushroom, as an example of this kind of food.*

Mushrooms.

French, *Champignons*. German, *Schwämme*. Italian, *Funghi*.
(*Agaricus campestris*.)

Case 54. This is the fungus or mushroom generally eaten in England, although several other species are used as food on the Continent, and occasionally in this country also.

* In Case 54 are shown two specimens of a fungus (*Mylitta australis*) called "native bread," from Tasmania; also dried edible fungi from Tahiti, preserved fungi, and various preparations of the common mushroom. Numerous drawings of British edible and poisonous fungi are exhibited near this Case.

The common mushroom, the champignon, and the morel, are nearly identical in chemical composition; the truffle contains more than twice as much solid matter. Mushrooms are highly nitrogenous; they also contain much fat.

Mushrooms may be stewed, broiled, or pickled. When salted and pressed, they yield ketchup, an agreeable sauce.

The chief constituents of mushrooms are—

	In 100 parts.		In 1 lb. oz.	gr.
Water	90·0	...	14	175
Albuminoids, &c.	5·0	...	0	350
Carbohydrates, &c.	3·8	...	0	266
Fat	0·7	...	0	49
Mineral matter	0·5	...	0	35

Though mushrooms contain, when dry, about half their weight of nitrogenous matter, its nature and feeding value have not been ascertained.

Lichens.

Case 55.

Although several kinds of lichen have been turned to account in the arts (as in dyeing), very few are used as food. *Tripe de roche*, or rock tripe, is one of these, however—or we should say that the several plants to which this name is given have been occasionally used as food by distressed Arctic voyagers. Lung lichen (*Sticta pulmonaria*), several kinds of *Peltidea*, and the reindeer moss (*Cladonia rangiferina*), are also edible. But the best known of all these cryptogamic plants is the lichen commonly called Iceland moss. It may be taken as illustrating the composition of all the edible species.

Iceland Moss.

(*Cetraria islandica.*)

Case 55. This plant is not a moss, but a lichen. It grows abundantly in high northern latitudes, upon otherwise barren rocks: it is also found in the mountainous districts of Great Britain, Ireland, and even of Southern Europe.

Iceland moss is but little used in Iceland. When employed there, it is ground, mixed with flour, and added to soups.

Iceland moss chiefly consists of a substance called *lichenin*, which closely resembles starch. One part of lichenin yields a jelly with twenty parts of boiling water. There is an acid in Iceland moss, to which its bitter taste is due; this may be removed by soaking the moss in a weak solution of carbonate of soda.

Iceland moss yields much sugar when boiled with weak sulphuric acid; the sugar thus formed may be fermented, and a spirit distilled from the fermented liquor.

Iceland moss contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	10·0	...	1	262
Albuminoids	8·7	...	1	172
Lichen-starch	70·0	...	11	88
Lichen-acids, &c.	6·3	...	1	3
Cellulose	3·5	...	0	245
Mineral matter	1·5	...	0	105

For 1 part of flesh-formers in Iceland moss there are 8 parts of heat-givers, reckoned as starch.

One pound of Iceland moss cannot produce more than $1^2/_5$ oz. of the dry nitrogenous substance of muscle or flesh.

Sea-weeds.

Sea-weeds belong, like the fungi and the lichens, to the great sub-kingdom of the *Cryptogamia*, or flowerless plants. The exact nutritive value of those kinds which are eaten is not made out, but they are not capable alone of sustaining life for any length of time. They have proved useful in times of scarcity to the poorer inhabitants of some maritime countries; they have been used in Ireland when the potato crop has failed. But sea-weeds are rather to be regarded as occasional dainties, and as affording an agreeable substitute for ordinary vegetables. One kind described more fully further on, is made into a jelly for consumptive patients. Besides this we name,

Laver or sloke (*Porphyra laciniata* and *P. vulgaris*) is found on the English coast. It is salted, and dressed with vinegar, pepper, and oil.

Green laver (*Ulva lactuca* and *U. latissima*) resembles the purple laver, but is inferior.

Tangle, or red ware, also called by other names, is *Laminaria digitata* and *L. saccharina*. It requires thorough boiling, and is then to be eaten with butter, pepper, and lemon-juice.

Badderlochs, hen ware, honey ware, murlins (*Alaria esculenta*). The part of the plant which is eaten is the thick midrib which runs through the frond and the fruit-bearing appendages.

The dulse of the south-west of England is the *Iridæa edulis* of botanists. It is said to resemble in its flavour roasted oysters.

Dulse of the Scotch, dellisk, dellish, duileisg, water-leaf (*Rhodymenia palmata*). The Icelanders use it as an article of diet, under the name of the sugar fucus. It is also used to flavour soups, ragouts, and other dishes.

Several other sea-weeds are employed as food. Ceylon moss is *Plocaria candida*. In China the people are very fond of them, and many kinds are collected and added to soups, or are eaten alone with sauce. One of these, a species of Nostoc, the *Plocaria tenax*, is called Chinese moss. The Corsican moss should be *Gracilaria Helminthocorton*, but is generally *Laurencia obtusa*. It is found on the coasts of the Mediterranean. Another sea-weed was recently imported into London under the name of Australian moss (*Eucheuma speciosum*), but it tastes too strongly of the sea to be pleasant. *Durvillæa utilis* is another sea-weed, used at Valparaiso as food. *Sphærococcus lichenoides* is found on the south coast of England, and has been used in pickles and soups.

The commonest edible seaweed is called

IRISH MOSS.

(*Chondrus crispus.*)

Case 55. Irish moss (really a sea-weed) is one of the few marine plants which is commonly used as human food in Europe. It is abundant on our rocky coasts. Irish moss is collected on the north and north-west shores of Ireland; some is imported from Hamburg.

The true Irish moss, or carraigeen, is *Chondrus crispus*, but other species, such as *Gigartina mamillosa*, are frequently collected with it. Both these kinds, as well as several similar edible sea-weeds, have about the same nutritive value, which is considerable.

The chief constituent of Irish moss is a kind of mucilage, which dissolves to a stiff paste in boiling water. There is also a little iodine and much sulphur in it. Before boiling it in water or milk, Irish moss should be soaked in cold water for an hour or so.

Irish moss is used as a food, and as a remedy in chest diseases. It is sometimes given to farm animals.

Irish moss, as sold, contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	18·8	...	3	3
Albuminoids	9·4	...	1	221
Mucilage, &c.	55·4	...	8	378
Cellulose	2·2	...	0	154
Mineral matter	14·2	...	2	119

For 1 part of flesh-formers in Irish moss there are about 5½ parts of heat-givers, reckoned as starch.

SALADS.

Salad plants are very numerous; but in former times many green vegetables were eaten uncooked which are now entirely forgotten. In 1669, Evelyn gave a list of 73 plants so used. His

"Discourse of Sallets" includes a large number of weeds, the present neglect of which is not to be regretted; yet some few of the green, fresh herbs which he names, might be introduced again with advantage. In France, the variety of salads in common use is much greater than in England, and it must be added, that the skill in preparing them for consumption is more marked. Too much care cannot be bestowed in the thorough cleansing of salad herbs, especially in the case of watercresses, with which many internal parasitic or entozoal animals are often introduced into the human body. Salad plants generally contain but little nourishing food of the heat-giving and flesh-forming kinds. But they are useful as being comparatively rich in saline matters, especially in potash salts, which are generally extracted from cooked vegetables in the process of boiling. They serve also to introduce large quantities of water into the system, and are refreshing additions to richer foods, especially in hot weather, when their "crisp, cool succulence" is peculiarly acceptable. In order to be thus juicy and crisp, lettuces and other salads, such as cucumbers, must not be gathered when wilted and drooping after a hot day; too often this is the case, or else subsequent partial drying causes toughness. To obviate this defect, the root of lettuce or celery, &c., when dug up, should be trimmed under water, so as not to expose the cut stem or leaf-stalks to the air. The plants will then, if left in the water, imbibe more fluid very readily till their tissues are well filled. The stalk of the cucumber should be cut under water, and remain in it just in the same way. In addition to lettuce, celery, watercress, and cucumber, which are more fully described further on, the following salad plants may be here noted:

CRESS (*Lepidium sativum*) is a small cruciferous annual, probably a native of Persia. Its seeds may be grown very readily upon any moist surface, and are commonly sown with those of white mustard, to yield the familiar spring salad known as mustard and cress.

The RADISH (*Raphanus sativus*), like most cruciferous plants, has a pungent taste. When small and quickly grown, it is adapted for use in salads. It may be cooked with advantage.

ENDIVE (*Cichorium Endivia*) belongs to the *Compositæ*: it is a native of Northern China. It is much used in salads, but its leaves, even when blanched, are rather bitter.

SUCCORY or CHICORY (*Cichorium Intybus*) is a wild English plant, near the endive. Its leaves, when blanched, are used as salad.

BORAGE, is *Borago officinalis*; it is used in claret and cider cups chiefly. Its leaves have a taste resembling that of cucumber.

BURNET (*Poterium sanguisorba*) belongs to the *Rosaceæ*; its leaves, like those of borage, have much the taste of borage, and are used similarly.

SAMPHIRE (*Crithmum maritimum*) is an aromatic and saline umbelliferous plant, common on many sea shores and cliffs. Once it was much used in salads; now its leaves, gathered in May, are employed only in pickles.

SORREL (*Rumex scutatus*), a hardy perennial, native of Southern Europe, is much grown in France as a salad herb. The English species (*R. acetosa* and *R. acetosella*) are less juicy and more sour. All the kinds of sorrel contain oxalic acid and oxalates in abundance.

BEET-ROOT has been already described (p. 93).

A fair idea of the composition of the fresh and juicy vegetables commonly used as salads may be gathered from the following analysis. It is necessary to state, however, that the flavour of these plants, depending, as it generally does, upon traces of volatile oils too small to be weighed, is not explained by the figures representing the chief components of these vegetables.

CELERY.

French, *Céleri*. German, *Sellerie*. Italian, *Sedano*.
(*Apium graveolens*.)

Case 56. Celery is a native biennial umbellifer, common in sandy marshes. The wild plant has a very strong and disagreeable taste and smell; the cultivated varieties are tender, mild, and succulent, when earthed up and supplied with abundance of water. The blanched leaf-stalks of celery are eaten uncooked, as a salad herb, and are also introduced into soups; they may also be stewed in the same manner as onions or sea-kale. The fruits of celery contain more than the other parts of the plant of the peculiar essential oil to which its characteristic odour and flavour are due. The quantity of this oil in celery as eaten is too minute to be represented in the analysis.

Celery, it will be seen, contains some sugar. Freshly-cut celery has the following composition :—

	In 100 parts.		In 1 lb. oz.	gr.
Water - - - - - - -	93·3	...	14	406
Albumen - - - - - - -	1·2	...	0	84
Mucilage and starch - - - -	1·6	...	0	112
Sugar - - - - - - -	2·2	...	0	154
Cellulose - - - - - - -	0·9	...	0	63
Mineral matter - - - - -	0·8	...	0	56

For 1 part of flesh-formers in celery there are about 3 parts of heat-givers, reckoned as starch.

Lettuce.

French, *Laitue.* German, *Lattich.* Italian, *Lattuga.*
(*Lactuca sativa.*)

Case 56. The cultivated lettuce may have originated from *Lactuca scariola*, a wild form common in Europe.

The lettuce is the most generally used of all the vegetables which are eaten in the uncooked state. The varieties grown may be included in the cos or upright lettuce, and the cabbage or spreading lettuce.

Lettuces contain but little nutriment of any kind, except mineral salts, especially nitre. This and other soluble salts are removed from vegetables which require cooking by the water in which they are boiled. A small quantity of a sleep-producing substance, called *lactucarin*, is found in the stem of the lettuce, particularly when the plant is flowering.

Lettuces are a refreshing addition to more solid food.

The lettuce contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	96·0	...	15	157
Albumen	0·7	...	0	49
Starch, sugar, and gum	1·0	...	0	112
Leaf-green and fat	0·2	...	0	14
Cellulose	0·5	...	0	35
Mineral matter	1·0	...	0	70

The quantity of heat-givers and flesh-formers in the lettuce is insignificant.

Watercress.

French, *Cresson d'eau.* German, *Wasserkresse.* Italian, *Crescione.*
(*Nasturtium officinale.*)

Case 56. The watercress is a native cruciferous plant, which grows freely in wet places, especially in shallow streams. It is one of the most popular and most wholesome of all salad plants. It is generally assumed to owe its pungent taste and medicinal value to the presence of an essential oil, containing, like that of mustard, a considerable quantity of sulphur. But it has been shown that the chief constituent of the essential oil of watercress, though rich in nitrogen, contains no sulphur; there is, however, much sulphur, in one form or another, in this plant. Watercress is also remarkable for the quantity of mineral matter which is found in it.

The younger shoots of the watercress should be selected; they have a pleasant acidulous yet warm taste. Great care should be taken that they are perfectly clean and free from adhering animal matters.

Watercress contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	93·1	...	14	392
Albuminoids	1·7	...	0	119
Starch, gum, &c.	2·7	...	0	189
Leaf-green and fat	0·5	...	0	35
Cellulose and lignose	0·7	...	0	49
Mineral matter	1·3	...	0	91

The dietetic value of the watercress cannot be judged of by the proportion or amount of flesh-formers and heat-givers present, as it depends mainly upon the mineral matters, aromatic oil, and other minor ingredients.

CUCUMBERS.

French, *Concombres.* German, *Gurken.* Italian, *Cocomeri.*
(*Cucumis sativus.*)

Case 56. The cucumber, like the melon, the vegetable marrow, and the pumpkin, is a tropical plant, belonging to the Gourd Order (*Cucurbitaceæ*).

These plants flourish best in a rich but open soil; they require much water. When the fruit of the cucumber is grown quickly under glass it is more juicy and digestible than when grown slowly in the open air.

Young cucumbers are pickled in vinegar, and are known as gherkins.

The rind of the cucumber fruit is indigestible. The fruit itself contains little else besides water, some grape sugar, and a trace of volatile flavouring matter.

Peeled cucumbers contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	96·2	...	15	171
Albumen	0·2	...	0	14
Sugar (glucose)	2·0	...	0	140
Pectose and gum	0·7	...	0	49
Cellulose	0·5	...	0	35
Mineral matter	0·4	...	0	28

§ 5.—SACCHARINE AND OILY FRUITS.

Many of the vegetable products in this section are esteemed rather for their pleasant or refreshing taste than for any nutritive value which they may be assumed to possess. But though this is the case in our country, the statement is not true generally. The banana and the fig, among fruits rich in sugar, and the coco-nut, among those which abound in oil, are of vital import_ ance as substantive articles of diet to the populations of many countries, where the fruits we have just named may be grown easily and abundantly. But, of course, there are some fruits which could never prove of much service as food, owing to the large quantities of water and small quantities of flesh-forming matter which characterise the more juicy and succulent sorts. Yet such fruits are especially valuable on account of their potash salts, the citrate, malate, and tartrate. When fish or meat which has been preserved with common salt, the chloride of *sodium*, forms the chief article of diet, the blood loses much of its *potash* compounds, and becomes unhealthy, unless the loss be made up. Now, fresh vegetables and fruits, notably the lemon and the lime, effect this, for the reason above stated. But fruits have a nutritive value, if a small one; and besides that, their flavour and juiciness may serve to stimulate a weak appetite, to give variety and lightness to an otherwise solid diet, and to contribute, in a palatable and refreshing form, much of the water required for the daily needs in digestion and assimilation.

In the analyses of fruits which are here given, we have not pretended to enter into all those differences, often very minute, which distinguish fruits from one another. Sometimes the scent and flavour of a fruit altogether defy the powers of chemical analysis; sometimes the same odorous substance is detected in two products of decidedly different fragrance. And then so much of the character of fruits depends upon their texture—a quality that cannot be analysed—that we must rest content with a rather imperfect account of the chief nutrients and characteristic compounds present. It should be added, that many fruits contain when ripe *pectin*, the jelly-like substance into which the pectose of unripe fruits is changed; that most fruits, especially those which are soft and watery, rapidly suffer decay and fermentation; that the substances to which fruits owe their colour are insignificant in amount, and of no known dietetic importance; and that the changes which succulent fruits undergo, and the frequent presence of much acid or acid-salt in them, renders them liable to cause, especially when unripe or over-ripe, diarrhœa and other derangements of the digestive tract. Irritation, and even fatal inflammation of the intestine, have resulted from the indigestible skins of certain fruits, as plums.

Before describing the oily fruits, most of which are commonly spoken of as *nuts*, a few examples of characteristic and important fruits containing sugar will be given. The apple and pear may take precedence; and then we may consider other fruits which are natives of this country, or ripen in our climate. Foreign fruits will afterwards be noticed, especially those which—like oranges, grapes, and figs—are imported in large quantities into Great Britain. No strict arrangement, either botanical or chemical, will be followed.

Apples.

French, *Pommes*. German, *Äpfel*. Italian, *Mele*.
(*Pyrus Malus.*)

Case 57. The apple—like the pear, the quince, and the medlar—belongs to the Rose Order. The numerous varieties of cultivated apples have sprung from the wild apple or crab, a native of Great Britain. The apple is one of the hardiest of trees, but the fruit requires a considerable degree of summer heat to bring it to perfection. In the southern hemisphere, as in New

Zealand and Australia, it ripens well; yet good English apples have not been excelled in flavour and firmness.

The fermented liquor called cider is made from the expressed juice of apples. This fruit is also extensively used in pies, puddings, sauces, and confectionery. Dried or pressed apples are known as Normandy pippins, Norfolk biffins, &c.

The apple is an agreeable fruit; it is made very wholesome by baking or boiling.

Apples contain a small quantity of a fragrant essential oil, not represented in the following analysis :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	83·0	...	13	122
Albumen	0·4	...	0	28
Sugar	6·8	...	1	39
Malic acid	1·0	...	0	70
Pectose, pectin, and gum	5·2	...	0	364
Cellulose	3·2	...	0	224
Mineral matter	0·4	...	0	28

For 1 part of flesh-formers in apples there are 20 parts of heat-givers, reckoned as starch.

Pears.

French, *Poires.* German, *Birnen.* Italian, *Pere.*
(*Pyrus communis.*)

Case 57, where is also a sample of artificial "Essence of Pears."

The pear, like the apple, the quince, and the medlar, belongs to a section of the Rose Order, called *Pomaceæ.* The wild pear-tree is a native of England; it is the origin of the many improved kinds now in cultivation.

Some pears are hard and tasteless when gathered, requiring to be stored several months before they become fit for eating. Other varieties ripen early, and very soon afterwards begin to decay.

Some pears are adapted for baking, others for stewing. From some kinds the strong fermented liquor known as perry is made.

An artificial "Essence of Jargonelle Pears" is much used for flavouring "pear-drops," and other sweetmeats; it is a solution in spirit of amyl acetate. It is thought that the flavour of pears is partly due to this substance.

Pears contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	84·0	...	13	203
Albumen	0·3	...	0	21
Sugar	7·0	...	1	52
Malic acid	0·1	...	0	7
Pectose and gum	4·6	...	0	322
Cellulose	3·7	...	0	259
Mineral matter	0·3	...	0	21

The QUINCE (*Cydonia vulgaris*) is a native of Southern Europe. Its strongly-flavoured fruits are sometimes added to apple-pies and puddings; they make an excellent marmalade, and also a very agreeable jelly. Quince seeds are rich in mucilage.

The MEDLAR (*Cydonia germanica*) is a common European plant. Its fruit is not eatable until it has undergone a singular natural change, which is not in reality a process of decay, though it may appear to be so.

Some other fruits of the *Pomaceæ*, a division of the Rose Order, are eaten.

GOOSEBERRIES.

French, *Groseilles*. German, *Stachelbeeren*. Italian, *Uve spine*.
(*Ribes Grossularia.*)

Case 57. The gooseberry grows wild in Great Britain and in many parts of Northern Europe. It belongs to the same order of plants as the red currant and the black currant. Numerous varieties of the gooseberry have arisen in cultivation. The fruits of these sorts do not differ much in chemical composition, although unlike in size, colour, and flavour.

In the North of England this fruit is extensively cultivated, and has been brought to a great degree of perfection. It is a wholesome fruit, especially when cooked; it makes a good preserve and a tolerable wine. Large quantities of gooseberries are bottled for winter use.

The gooseberry contains from 6 to 8 per cent. of sugar, together with about 1½ per cent. of citric and malic acids.

Gooseberries contain, as an average—

	In 100 parts.		In 1 lb. oz.	gr.
Water	86·0	...	13	332
Albumen	0·4	...	0	28
Sugar	7·0	...	1	52
Citric acid	1·5	...	0	105
Pectose and gum	1·9	...	0	133
Cellulose	2·7	...	0	189
Mineral matter	0·5	...	0	35

For 1 part of flesh-formers in ripe gooseberries there are about 20 parts of heat-givers, reckoned as starch. The quantity of flesh-formers in 1 lb. of gooseberries is insignificant.

The Black Currant is *Ribes nigrum*, while the Red and White Currant both belong to another species, *R. rubrum*. Cultivation has greatly improved the quality and increased the size of these fruits. Many varieties of red currant are grown. In composition these fruits do not differ much from the gooseberry. They are not nearly related to the small dry fruits called currants, which are produced by a small vine.

The Strawberry, though containing more water than the gooseberry or the currant, has a richer fragrance and flavour. The cultivated varieties have arisen from several species of *Fragraria*, but mainly from the wild *F. vesca*, the common strawberry of our English woods.

The Raspberry (*Rubus idæus*) is a native of Britain. Several varieties of the cultivated plant are grown, the fruits being either red or pale amber. From the raspberry, as well as from the gooseberry and currant, jam, jelly, and wine of good quality are made. Strawberries are often preserved with sugar, but this fruit is perhaps better appreciated as a dessert fruit.

The BLACKBERRY (*Rubus fruticosus*) and the DEWBERRY (*R. cæsius*) are wild fruits which would repay cultivation. The flavour of some of the wild sorts is decidedly superior to that of others, and these may be made to yield a good preserve and a full-flavoured wine.

The BARBERRY (*Berberis vulgaris*) is a native of Britain. Its bright red fruit has an acid taste, but makes a pleasant preserve.

The BEARBERRY (*Arctostaphylos uva-ursi*) is a British plant belonging to the Heath Order. Its red berries are eaten by grouse.

The BILBERRY (*Vaccinium myrtillis*) and WHORTLEBERRY (*V. uliginosum*) are common in many woods. Their fruits may be made into a preserve.

The CRANBERRY is nearly related to the bilberry. The fruits of several species are used in the form of jams and in tarts. Large quantities of cranberries are imported from Russia and North America.

The ELDERBERRY is the fruit of *Sambucus nigra*, a native tree. A richly-flavoured wine is made from elderberries.

GRAPES.

French, *Raisins*. German, *Weintrauben*. Italian, *Uve*.
(*Vitis vinifera.*)

Case 58. The vine was very probably originally a native of Western Asia and the region south of the Caspian. It is profitably grown between 30° and 40° north latitude.

By long-continued cultivation of the original plant in different soils and climates, numerous varieties of the vine have arisen. Most of these kinds are grown for wine-making in France, Germany, Southern Europe, the Cape, Australia, &c. Some varieties yield fruits, which are simply dried. These are known as Valentia, muscatel, and sultana raisins—the last, from Turkey, have no seeds. Raisins are rich in sugar. The dried currants of the shops are merely very small raisins from a variety of the vine grown in the Ionian Isles; they are indigestible.

Fresh ripe grapes contain much sugar, sometimes nearly 20 per cent. The acid of grapes is chiefly tartaric, part of which is combined with potash.

Fresh grapes, of average quality, contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	80·0	...	12	350
Albumen	0·7	...	0	49
Sugar (glucose)	13·0	...	2	35
Tartaric acid	0·8	...	0	56
Pectose and gum	3·1	...	0	217
Cellulose	2·0	...	0	140
Mineral matter	0·4	...	0	28

For 1 part of flesh-formers in grapes there are about 20 parts of heat-givers, reckoned as starch. Grapes are twice as nutritious as gooseberries.*

Plums, &c.

The cherry, the plum, the apricot, and the peach are the chief "stone-fruits." They all belong to the same section (*Drupaceæ*) of the Rose Order, and are characterised by the presence of a hard seed with the fleshy pericarp. This seed contains an edible kernel, generally rich in oil, and having an aromatic somewhat bitter taste.

The cherry is *Prunus Cerasus.* This fruit is generally richer in sugar than many other fruits which ripen in this country, often containing 10 per cent. and sometimes more. One variety rather less sweet than the morello, is specially used in preparing the liqueur cherry brandy.

Many kinds of plums, as damsons, prunes, French plums,

* In Cases 14, 15, and 37 will be found bunches of currants from Cephalonia, with raisins, muscatels, sultanas, and currants from Patras, Cephalonia, Zante, Gulf of Salonica, Vostizza, Spain, Naples, Persia. Turkey, and South Australia; also illustration of French modes of cultivating the grape-vine.

greengages, are now extensively grown here or on the Continent. There is less sugar in plums generally than in cherries, but they contain a very large amount of pectose and pectin, the chief substances to which the gelatinizing character of these fruits is due. In the greengage, for instance, Fresenius found 1½ per cent. of sugar only, but not less than 10½ per cent. of pectous substances, or vegetable jelly.

The peach is here described more at length, as an example of this class of fruits, which, it must be noted, are generally less wholesome than most of those already considered in these pages.

Peaches.

French, *Pêches.* German, *Pfirsiche.* Italian, *Pesche.*
(*Amygdalus persica.*)

Case 59. The peach and the nectarine are produced by varieties of the same tree. It belongs to the almond group of the Rose Order.

The peach is now grown in many temperate climates. American peaches are said to be inferior to the English in richness of flavour; they are imported into this country dried, and also in tins.

The kernels of peach-stones yield an oil identical with that of bitter almonds; they are used in flavouring liqueurs. There is not much nutritive matter in the peach, but it is an agreeable and refreshing fruit. The quantity of sugar it contains is but small, yet the acid present is masked by much vegetable jelly, included in the analysis below under "pectose and gum." The skin of the peach is indigestible.

Peaches contain, after removal of the stones—

	In 100 parts.		In 1 lb. oz.	gr.
Water	85·0	...	13	363
Albumen	0·5	...	0	35
Sugar	1·8	...	0	126
Malic acid	0·7	...	0	49
Pectose and gum	8·0	...	1	122
Cellulose	3·4	...	0	238
Mineral matter	0·6	...	0	42

Apricots (the fruit of *Prunus armeniaca*) closely resemble peaches and nectarines in composition, but generally contain rather more sugar.

Rhubarb.

(*Rheum rhaponticum.*)

Case 59. Although used as a fruit, it is scarcely necessary to say that rhubarb is the stalk or petiole of the leaf. The plant furnishing this agreeable and succulent food is a hardy perennial, from the Volga river, and has been grown in this country since 1573. There are several varieties of *Rheum rhaponticum* in cultivation, and it is possible that *R. undulatum* may also be amongst the different kinds of rhubarb in use. The rhubarb belongs to the Buckwheat Order (*Polygonaceæ*).

The agreeable taste and odour of rhubarb are not brought out till the leaf-stalks are cooked. But when the expressed juice of these is allowed to ferment, it yields, with proper treatment, a delicious wine. The chief nutrient in rhubarb is the sugar (glucose), which amounts to about 2 parts in 100 of the fresh stalks. Its sour taste is due to oxalic acid, or rather to the acid oxalate of potash; oxalate of lime is also present. There are some conditions of the human body (the oxalic-acid diathesis) in which it is probably wiser to avoid eating rhubarb and other plants, as sorrel, in which oxalic compounds predominate.

The composition of the freshly-cut leaf-stalks of a red variety of rhubarb which had been grown in the open air, and were in good condition for use, is here shown :—

Composition of Rhubarb.

	In 100 parts.		In 1 lb. oz.	gr.
Water	95·1	...	15	94
Albumen	0·9	...	0	63
Sugar (glucose) and gum	2·1	...	0	147
Oxalic acid	0·3	...	0	21
Cellulose	1·1	...	0	77
Mineral matter	0·5	...	0	35

As 1 lb. of rhubarb contains less than 1 oz. of solid matter, and as even of this solid matter more than one quarter is not nutritive, it is obvious that the food value of this vegetable is very small. It is, indeed, esteemed mainly for its pleasant flavour, which is due to a trace of some volatile matter, too small to be identified, along with a little grape sugar and the acidulous compound already mentioned.

Figs and dates next claim attention. They are imported in a partially dried condition, and consequently are far more nutritious, weight for weight, than any of the fresh fruits we have been considering.

Figs.

French, *Figues*. German, *Feigen*. Italian, *Fichi*.
(*Ficus carica.*)

Case 59. The Fig Order includes several important trees, such as the mulberry and the banyan: one kind of fig-tree (*F. elastica*) yields much of the india-rubber of commerce. The sycamore fig (*F. sycomorus*) is a small fruit, common in Egypt, from another species.

The edible fig is a native of the Eastern Aral, the Caucasus, Syria, Persia, Asia Minor, and perhaps of South-Eastern Europe and Northern Africa; it has been long grown in the regions of the Mediterranean. The fig is cultivated in warm and sheltered situations in the south of England.

Large quantities of dried and pressed figs are imported into England. They contain much sugar, and but little water. The numerous so-called seeds in the fig are indigestible, and sometimes have an irritant action.

Dried Turkey figs contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	17·5	...	2	350
Albumen	6·1	...	0	427
Sugar (glucose)	57·5	...	9	88
Starch	3·0	...	0	210
Pectose and gum	5·4	...	0	378
Fat	0·9	...	0	63
Cellulose	7·3	...	1	83
Mineral matter	2·3	...	0	161

For 1 part of flesh-formers in dried figs there are quite 10 parts of heat-givers, reckoned as starch.

One pound of dried figs might produce at the most nearly 1 oz. of the dry nitrogenous substance of muscle or flesh.

Mulberries are the fruit of a beautiful tree (*Morus nigra*) belonging to the Fig Order, of Western Asia, extensively grown in Europe. Mulberries contain more acid than most dessert fruits, but possess a very characteristic flavour.

Dates.

French, *Dattes*. German, *Datteln*. Italian, *Datteri*.
(*Phœnix dactylifera*.)

Case 59. Dates are the fruit of a palm. The tree has been introduced into Southern Europe, but it is a native of North Africa. The cultivation of the date-palm is of great antiquity.

The fruits of this palm grow in clusters, weighing 20 lb. or more; they form an important food in Egypt and Arabia. Dates pounded and pressed into a kind of cake are much used by the inhabitants of Northern Africa, and by travellers through the Sahara Desert.

Dates contain more than half their weight of sugar, but there is a fair amount of flesh-formers present as well.

Dates, without the stone, contain—

	In 100 parts.	In 1 lb. oz.	gr.
Water	20·8	3	143
Albumen	6·6	1	25
Sugar	54·0	8	280
Pectose and gum	12·3	1	424
Fat	0·2	0	14
Cellulose	5·5	0	385
Mineral matter	1·6	0	112

For 1 part of flesh-formers in dates there are 10 parts of heat-givers, reckoned as starch.

One pound of dates might produce about 1 oz. of the dry nitrogenous substance of muscle or flesh.

Bananas.

(*Musa sapientum.*)

Case 60. The banana is the fruit of a handsome plant, grown almost everywhere in the tropics; it is a most important article of food in many hot countries. Bananas have been cultivated in India and China from very remote ages. Another species or variety of this plant (*M. paradisiaca*) yields the plantain, a fruit almost identical with the banana.

The banana is a nutritious food, having less water and more nitrogenous matter than is commonly found in fresh fruits. It contains, when ripe, much sugar, but very little starch.

The banana is a very productive plant. Its fruit grows in clusters of 100 to 200; a bunch of them will often weigh 50 lb. They are imported, to some extent, into this country, as a dessert fruit.

Fresh-peeled bananas contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	73·9	...	11	361
Albumen	4·8	...	0	336
Sugar and pectose	19·7	...	3	66
Fat	0·6	...	0	42
Cellulose	0·2	...	0	14
Mineral matter	0·8	...	0	56

For 1 part of flesh-formers in fresh-peeled bananas there are 4 parts of heat-givers, reckoned as starch.

One pound of bananas might produce, at the most, ¾ oz. of the dry nitrogenous substance of muscle or flesh.

Our next fruit is scarcely used at all in this country, except as food for cattle and horses; but it is of interest as a legume containing much sugar.

Carob Beans.

(*Ceratonia siliqua.*)

Case 60. Carob beans or locust beans, called also algaroba and St. John's bread, are really entire pods, not merely beans or seeds.

They are the fruit of a leguminous tree, a native of South Europe and the Levant.

Carob pods contain a soft pulp, rich in sugar; they are by no means deficient in flesh-formers. They are used chiefly for feeding cattle in England, but in some of the countries bordering on the Mediterranean they are employed also as human food. They contain a small quantity of a peculiar volatile acid, known as butyric acid—this gives them a rather rancid smell. Carob pods attract moisture from the air, and are liable to become mouldy on keeping.

Imported carob pods, as met with in the London market, contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	14·6	...	2	147
Albumen	7·1	...	1	60
Sugar	51·8	...	8	126
Pectose and gum	16·1	...	2	252
Fat	1·1	...	0	77
Cellulose and lignose	6·4	...	1	10
Mineral matter	2·9	...	0	203

For 1 part of flesh-formers in carob pods there are 8½ parts of heat-givers, reckoned as starch. One pound of carob pods cannot produce much over 1 oz. of the dry nitrogenous substance of muscle or flesh.

Oranges.

French, *Oranges.* German, *Apfelsinen.* Italian, *Melarancie.*
(*Citrus Aurantium.*)

Case 60. The tree which yields this delicious and wholesome fruit is a native of India, but it has been long grown in Southern Europe. Many varieties exist, as the mandarin orange, with an easily detached and very fragrant rind; the Malta blood orange, with red flesh; and the bergamot, which yields an essential oil much used in perfumery. The bitter or Seville orange (*Citrus*

Bigaradia); the lime (*C. Limetta*); the citron (*C. medica*); the lemon (*C. Limonum*); the shaddock, pomaloe, or forbidden fruit (*C. decumana*); and the cumquat (*C. japonica*), are all species of the same genus, and are all characterised by the presence of similar fragrant essential oils in the peel or rind, and by varying quantities of citric acid, citrate of potash, and sugar in their fleshy pulp. Besides the flavours they impart to other foods, many of the fruits we have named are of direct alimentary and medicinal value. The orange and its various products, in the form of orange marmalade (into which Seville oranges are generally introduced), orange wine, and candied orange-peel are the best known. This fruit is imported into England in vast quantities from Malta, the Mediterranean coasts, Lisbon, and the Azores—very fine fruit being brought from the island of St. Michael. The orange can, however, be enjoyed in perfection only when taken perfectly ripe from the tree. The imported fruits are always gathered in an unripe state. The orange-tree yields another essential oil besides that in the fruit—the oil of neroli being obtained from orange-flowers. The tree is evergreen, and its rich, green, glossy leaves, and masses of golden fruit, form a beautiful feature in the landscape of many parts of Italy.

An orange of good quality should not lose more than one-fifth its weight by the removal of the peel. The peeled fruit contains about 86 per cent. of water, 8 to 10 per cent. of sugar, and small quantities of citric acid, citrate of potash, albumen, cellulose, &c.

We shall have to recur to the subject of the Orange Order when discussing the "flavourers," in the Fourth Part of this book, on Food Adjuncts.

The pomegranate (*Punica Granata*), the prickly pear (*Opuntia vulgaris*), the jak fruit of Ceylon (*Artocarpus integrifolia*), the bread-fruit of the Moluccas and other islands (*Artocarpus incisa*), the tamarind, the mangosteen, and many other fruits, which we have no space to describe, are of considerable importance in different parts of the world—some of these fruits forming the chief sustenance of large populations. Among them, mention should be made of the pine-apple (*Bromelia Ananas*), which of late years, through the large importations of these fruits from the West Indian Islands, has become familiar and accessible to every one. Originally of Brazilian origin, this plant has rapidly spread in many tropical countries. It has been grown in England for nearly 200 years.

Nuts.

Cases 61 & 62. The chestnut is so rich in starch, and contains so little oil or fat, that it might have been included amongst the bread-stuffs. It is the produce of *Castanea vesca*, the sweet or Spanish chestnut tree, a native of Western Asia. Large quantities are imported from Spain and Italy, where, as in Southern Europe generally, it forms an important article of food. Its meal is made into cakes, or the nuts are boiled or roasted.

In the oily seeds or nuts which are now to be described, we have food-products of very great value. They contain little or no starch, but much nitrogenous or albuminoid matter, together with, in many cases, 50 per cent. of fixed oil or fat. They are rather rich food, and somewhat difficult of digestion, unless ground into meal, or cooked, or mixed with lighter kinds of food. The oil in some nuts is very liable to become rancid and unwholesome. We select for description the walnut, the filbert, the almond, and two or three well-known kinds.

Walnuts.

French, *Noix*. German, *Wallnüsse*. Italian, *Noci*.
(*Juglans regia*.)

Case 63. The walnut-tree is a native of the Himalayas, Persia, and the southern provinces of the Caucasus. It was introduced into Greece and Italy some centuries before the Christian era. The walnut is now grown throughout temperate Europe.

Unripe walnut fruits, when the shell is still soft, make an excellent pickle; a delicate sweetmeat is prepared by boiling them in sirup.

Walnuts contain a sweet oil much used in Southern Europe for food, and, under the name of nut-oil, for painting. The marc of walnut-kernels, or walnut-cake, is a good cattle food.

Walnuts in the shell yield one-third their weight (about 36 per cent.) of peeled kernels, which are the crumpled cotyledons, or seed-leaves. These when quite fresh contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	44·5	...	7	53
Albumen	12·5	...	2	0
Mucilage, &c.	8·9	...	1	185
Oil	31·6	...	5	24
Cellulose	0·8	...	0	56
Mineral matter	1·7	...	0	119

For 1 part of flesh-formers in walnut-kernels there are about 6¾ parts of heat-givers, reckoned as starch.

One pound of walnuts cannot produce more than 2 oz. of the dry nitrogenous substance of muscle or flesh.

Case 63. The HAZEL-NUT, the FILBERT, and the COBNUT are produced by *Corylus avellana*, and the cultivated varieties of this native tree. The best hazel-nuts come from Spain, and are known as Barcelona nuts. Cobnuts and filberts are largely grown in Kent. Fine filberts, freshly gathered and ripe, contain rather more than half their weight of edible kernel. This, if analysed before drying, just as it is taken from the shell, gives the following results:—

COMPOSITION OF FILBERT KERNELS.

	In 100 parts.		In 1 lb. oz.	gr.
Water	48·0	...	7	297
Albumen, &c.	8·4	...	1	151
Oil	28·5	...	4	245
Mucilage, starch, &c.	11·1	...	1	340
Cellulose	2·5	...	0	175
Mineral matter	1·5	...	0	105

For 1 part of flesh-formers there are here about 10 parts of heat-givers, reckoned as starch.

Cases 61 & 63. Another well-known oily nut is the SWEET ALMOND, the produce of a small Mediterranean tree (*Amygdalus communis*), belonging to a section of the Rose Order. The so-called Jordan almonds come from Malaga.* The almond does not ripen properly in this country. The brown coat of the almond kernel is indigestible, and should be removed by pouring boiling water on the kernels and peeling them. Almonds correspond in general character to filbert kernels, but are much drier when imported than when gathered. The bitter almond is produced by a mere variety of the same tree, but it contains a peculiar ferment called emulsin, which is capable of changing a nitrogenous matter, present in the bitter almond and the sweet, into prussic acid, the essential oil of bitter almonds, and glucose. This change occurs when bitter almond meal is mixed with water and gently warmed.

Case 46. The GROUND-NUT, or pea-nut (*Arachis hypogæa*), though an oily seed, really belongs to the leguminous plants, and has been already described in the section on pulse. In addition to 50 per cent. of oil it contains about the same amount of nitrogenous matter (24·5 per cent.) which usually occurs in beans and peas.

COMPOSITION OF GROUND-NUTS (shelled).

	In 100 parts.		In 1 lb. oz.	gr.
Water	7·5	...	1	87
Casein, &c.	24·5	...	3	403
Oil	50·0	...	8	0
Mucilage, &c.	11·7	...	1	382
Cellulose and lignose	4·5	...	0	315
Mineral matter	1·8	...	0	126

For 1 part of flesh-formers in these seeds there are 5 parts of heat-givers, reckoned as starch.

Case 63. The PISTACHIO-NUT (*Pistacia vera*) is the produce of a small Mediterranean tree. The fruit resembles a small almond,

* In Case 61 are shown fifty varieties of almonds cultivated in France.

but has a bright green kernel, which owes its colour to chlorophyll, or leaf-green. The kernels possess a taste not unlike that of the sweet almond; they are much used in French confectionery. The following analysis represents the

COMPOSITION OF PISTACHIO-KERNELS.

	In 100 parts.		In 1 lb. oz.	gr.
Water	7·4	...	1	80
Albuminoids	22·7	...	3	272
Oil	51·1	...	8	77
Mucilage, &c.	13·0	...	2	35
Cellulose	2·5	...	0	175
Mineral matter	3·3	...	0	231

For 1 part of flesh-formers in pistachio-kernels there are 6 parts of heat-givers, reckoned as starch.

One pound of Pistachio-kernels might produce at the utmost 3¾ oz. of the dry nitrogenous substance of muscle or flesh.

Case 64. The OLIVE (*Olea europæa*) contains most of its oil outside the seed, in the green fleshy pericarp, which is sometimes eaten, the whole fruit being preserved in brine.

Case 64. The HICKORY-NUT is produced by a North American tree (*Carya alba*), which belongs to the *Juglandaceæ*. It resembles a small walnut. Another species of the same genus, *C. olivæformis*, yields a similar nut, the pecan or picary nut.

Case 64. The nut of the *Cocos nucifera*, commonly called cocoa-nut, but which we shall here term the coco-nut (to distinguish it from cacao), is a very characteristic fruit, rich in oil.

COCO-NUT.

French, *Coco*. German, *Cocosnuss*. Italian, *Cocco*.
(*Cocos nucifera.*)

The lofty and most useful tree which yields the coco-nut is a palm, now largely cultivated in many tropical islands, and on many tropical coasts. A single tree will bear from 80 to 100 fruits.

The outer husk of the coco-nut affords a strong fibre called "coir," from which mats, brushes, and cordage are made. The shell of the nut is formed into bottles and drinking-cups, and gives, when properly burnt, a very valuable charcoal. The spirit called "arrack" is distilled from the fermented juice, or "toddy," of the flowering branch of the coco-nut palm, while the milk or liquid part of the kernel is, when fresh, a nourishing and pleasant beverage.

The solid white kernel of the coco-nut is rich in oil, which is expressed and used for many purposes. The solid kernel weighs, when fresh, about 1 lb., and has the following composition :—

Case 64.	In 100 parts.		In 1 lb.	
			oz.	gr.
Water	46·6	...	7	200
Albumen, &c.	5·5	...	0	385
Oil	35·9	...	5	325
Sugar, &c.	8·1	...	1	130
Cellulose	2·9	...	0	203
Mineral matter	1·0	...	0	70

For 1 part of flesh-formers in this kernel there are about 15 parts of heat-givers, reckoned as starch.

One pound of coco-nut kernel could form, at the utmost, about 7/8 oz. of the dry nitrogenous substance of muscle or flesh.

Dika Bread.

(*Irvingia Barteri.*)

Case 64. The food known as dika bread is made from the fruit of a tree belonging to the Quassia Order. This tree grows in profusion on the west coast of Africa, from Sierra Leone to the Gaboon: although not related to the mango-tree of India it is called the wild mango.

The fruit from which dika bread is made is about the size of a swan's egg. It contains a large white almond-shaped kernel.

The bruised kernels, warmed and pressed, form the so-called dika bread, which is largely consumed by the natives of the Gaboon, who use it, when scraped or grated, in stews.

Dika bread contains three-fourths of its weight of a solid fat. Its taste is said to resemble that of a mixture of roasted cocoa and roasted flour.

Dika bread contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	5·0	...	0	350
Albumen	9·5	...	1	227
Starch, &c.	7·2	...	1	66
Fat	73·0	...	11	298
Cellulose	3·0	...	0	210
Mineral matter	2·3	...	0	161

For 1 part of flesh-formers in dika bread there are 18 parts of heat-givers, reckoned as starch; but it must be remembered that 100 parts of this food contain heat-givers equal to at least 170 parts of starch.

One pound of dika bread might produce 1½ oz. of the dry nitrogenous substance of muscle or flesh.

Cases 61 and 62. The names of a few other nuts remarkable for their richness in oil are given below:—

Brazil-nuts, seeds of *Bertholletia excelsa.*

Sapucaia-nuts, seeds of *Lecythis zabucaijo,* and other species.

Double Coco-nuts, *Loidicea seychellarum.*

Palm-nut, *Elais guinensis.*

Candle-nut, seeds of *Aleurites triloba.*

PART III.—ANIMAL FOODS.

In the various parts of animals, and in the products of animal origin which are used as food for man, there are present many kinds of nutrients identical, or practically identical, with those found in vegetables. In both kingdoms albuminoids, oil or fat, and phosphates and potash salts abound. But, on the other hand, neither starch nor cellulose occurs in animal foods, while sugar is generally absent, or else exists in mere traces, with the solitary exception of milk. Yet there are some substances which are distinctive of animal tissues, not occurring at all in plants. Such are the ossein of bones, the cartilagin of cartilages, and the similar nitrogenous compounds of connective tissue and skin. Add to these the hæmoglobin of the blood, and some of the rarer and less thoroughly understood constituents of the brain and bile, and we have the chief distinctive compounds of animal structures. It will be seen further on that animal foods are usually richer in nitrogenous matters and in fat than vegetable foods; and also, that on the average, they contain a smaller percentage of water, when the comparison is made with materials in the fresh state.

§ 1.—Milk and Dairy Produce.

As the natural food of the young of the mammalia, it is found that *milk* may be regarded as a model food. It furnishes all the nutrients required by the growing immature animal; and it furnishes these nutrients in due proportion.

Cows' milk is nearly opaque under ordinary conditions of light; it has a faint tinge of straw-yellow, which becomes more marked when the animal has abundance of green food. Milk has a soft, slightly sweet taste, it has also a faint animal odour when warm and fresh. When milk is allowed to stand some time the first change which occurs is the rising of the cream, owing to the lower specific gravity of the globules of milk-fat, which at first are scattered uniformly through the milk. These minute globules—easily seen under the microscope—are the main cause of the white opacity of milk; but there are also many still more minute globules of casein, the chief nitrogenous nutrient of milk. The amount of cream which rises depends upon many conditions. The first of these is the richness of the milk in the milk-fat; other conditions are: temperature—a low temperature being favourable to the separation of the cream —a considerable bulk of liquid, a wide vessel, and complete freedom from agitation, are also favourable conditions. The chief losses which milk suffers when skimmed are the removal of most of the fat, and about one-sixth of the casein.

The next change which milk suffers on keeping is that of turning sour. This occurs specially in hot weather, and first affects milk which has not been kept in clean vessels and in pure air. The souring of milk, however brought about, is marked by the presence of an acid—*lactic acid*, which is formed from the peculiar sugar of milk known as *lactose*. It may be retarded by the addition of a little carbonate of soda, or, as has been recently discovered, by a small quantity of boracic acid. As casein is separated from solutions by lactic acid, as well as by nearly all other acids, milk which has turned ceases to be of uniform appearance and opacity. Curds separate—these curds consisting of casein, but entangling also, as the substance becomes insoluble, much of the milk-fat and of the phosphates. This separation of curds is aided by heat. The liquor in which they float—the serum of milk, or whey—contains about one-fourth of the nitrogenous matter of the milk, all its sugar, and some of its mineral matter.

Case 65. The chief constituents of milk—whether cows' milk, human milk, goats' milk, asses' milk, or the secretion of other mammals—are casein, lactose, or sugar of milk, milk-fat, and phosphates. The nature and variations in composition of cows' milk are the most important part of the chemical study of this subject. Cows' milk, from a herd of healthy animals properly fed, presents a remarkable uniformity of composition. But the total amount of nutrients in it will vary within certain rather narrow limits with the following circumstances. Morning milk will often be poorer in total solids than evening milk; much watery food, as brewers' grains, &c., will impoverish the milk; a small daily supply of oil-cake will add about 1 per cent. to the total solids of milk; milk from cows pastured upon poor and overstocked land will be poor in quality and reduced in quantity; milk drawn last from the udder—the "strippings"—will be richest, especially in cream, and consequently in milk-fat or butter. The following may be taken as the average composition of cows' milk:—

	In 100 parts.		In 1 pint. oz.	gr.
Water	86·3	...	17	330
Casein and other albuminoids	4·1	...	0	370
Milk-fat	3·7	...	0	333
Lactose, or milk-sugar	5·1	...	1	22
Mineral matter	0·8	...	0	72

Thus the total solids of milk amount to 13·7 per cent.; the solids, other than fat, being 10 per cent. It is very rare to find genuine and healthy milk showing a percentage lower than 9 of solids not fat, but some instances have been recorded where these constituents were found to be as low as 8¼ per cent.; but in these cases the food of the cows must have been deficient in solid nutrients, or very watery. The ratio of flesh-formers to heat-givers, reckoned as starch, in average cows' milk is as 1 to 3⅓.

One pint of cows' milk weighs about 1 lb. 4¾ oz.: if one pound of milk be digested and oxidized in the body, it is capable of yielding a force equal to 390 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform is 78 tons raised 1 ft. high. One pound of milk can produce at the most about ¾ oz. of the dry nitrogenous substance of muscle or flesh.

So far cows' milk only has been considered. Now we may introduce the milk of other animals, comparing the composition of the most important kinds.

Case 65. *Human Milk.*—The milk of woman is less rich in solids generally, and in milk-fat and casein specially, than cows' milk. The latter requires the addition to each pint of about 10 oz. of warm water, and of about 1½ oz. of sugar (preferably milk-sugar), in order that it may approach human milk in composition. The following figures show the average composition of human milk:—

	In 100 parts.		In 1 pint. oz.	gr.
Water - - - - - - - -	89·0	...	18	146
Casein and other albuminoids - -	1·6	...	0	144
Milk-fat - - - - - - -	2·3	...	0	207
Lactose, or milk-sugar - - - -	6·9	...	1	184
Mineral matter - - - - - -	0·2	...	0	18

The average specific gravity of human milk is 1031. The ratio of flesh-formers to heat-givers, reckoned as starch, is as 1 to 7.

Asses' milk, goats' milk, &c.—The average composition of the milk of several other animals is shown in the following table:—

CONSTITUENTS OF MILKS (in 100 parts).

	Ass.		Mare.		Goat.		Sheep.		Pig.
Water - -	88·7	...	89·8	...	86·4	...	83·8	...	84·8
Casein, &c. -	2·4	...	2·1	...	4·8	...	5·8	...	4·3
Milk-fat - -	1·5	...	1·6	...	4·2	...	4·8	...	5·0
Milk-sugar -	7·1	...	6·1	...	4·1	...	4·8	...	5·1
Mineral matter	0·3	...	0·4	...	0·5	...	0·8	...	0·8

In Sweden, Norway, and Denmark sheep's milk is used; in Switzerland, much goats' milk; in Tartary, mares' milk; camels' milk amongst the Arabs, and reindeer's milk in Lapland. In many of these countries milk, from one source or another, forms a very important part of the food, not only of children, but of adults, and a much greater quantity is consumed than is the case with the labouring classes in the British Isles. There are many parts of the rural districts of England where milk is seldom seen, not being used generally even with tea. It is consumed more extensively in Ireland than in England, in proportion to the population.

In Tartary, mares' milk is allowed to ferment, whereby alcohol and carbonic acid gas are formed from some of the sugar present; the casein separates at the same time in curds. Such fermented milk is called *koumiss*, and is found to be a wholesome and generally nutritious food. It is said to possess even some special value in consumption. An imitation of it is prepared in London from sweetened cows' milk.

Cream.

The cream which rises from cows' milk when the liquid is cooled and at rest, is not constant in amount or composition. If water be added to milk the cream rises more quickly, but is not increased in absolute amount. The cream usually measures 12 per cent., or ranges within 10 and 15 in average Case 65. samples of milk—the milk being placed in tubes half-an-inch in diameter, where it remains twenty hours before the degrees occupied by the cream are read off. Some notion of the average composition of cream may be gathered from the following analysis, but the range of variation is great, the water alone varying between 45 and 65.

CONSTITUENTS OF CREAM.

	In 100 parts.
Water	55·0
Casein	6·0
Milk-fat	36·3
Milk-sugar	2·5
Mineral matter	0·2

SKIM MILK.

When the cream which has risen on milk is removed, the liquid which remains is poorer in milk-fat and in total solids, but its percentage of milk-sugar is increased. It is a light and digestible food, but the ratio between its flesh-forming and heat-giving nutrients is different from that of fresh milk, the heat-givers being much lower. Its composition will vary much according to the extent to which the cream has risen and been removed. The following is an analysis of skim milk :—

COMPOSITION OF SKIM MILK.

	In 100 parts.
Water	89·0
Casein	4·3
Milk-fat	0·4
Milk-sugar	5·5
Mineral matter	0·8

PRESERVED AND CONDENSED MILK.

Case 65. Although there are several ways of treating milk so that it may be preserved sweet and wholesome for some time, or reproduced for use very easily and simply, yet there is but one preparation of this kind which is extensively used. This is called *condensed* milk; but in reality the milk has not only been condensed by the removal of a large proportion of its original water, but it has received a considerable addition of cane-sugar, to preserve it. Thus it happens that this condensed milk, or preserved milk, cannot take the place of milk as a model food, the proportion of heat-givers to flesh-formers being too high. Preserved milk is generally prepared by evaporating milk, after the addition of cane-sugar, till it acquires a thick consistence. The pale straw-coloured sirup is poured into tins, which are then closed from the air by soldering. During evaporation some of the fatty matter is dissipated along with the vapour of water. The milk presents these results on analysis:—

COMPOSITION OF PRESERVED MILK.

	In 100 parts.
Water	24·0
Casein	15·2
Milk-fat	11·5
Milk-sugar	17·7
Cane-sugar	27·6
Mineral matter	2·0

For 1 part of flesh-formers in this preserved milk there are 6 parts of heat-givers, reckoned as starch.

ADULTERATION OF MILK.

Case 66. The removal of cream and the addition of water are the only ways in which milk is commonly impoverished. The removal of cream shows itself in the thinner and less opaque appearance of the milk; the addition of water produces the same effect. As milk-fat, the chief part of cream, is lighter than water, its partial removal from the milk makes the specific gravity of the remaining milk *greater*: by the subsequent addition of water the specific gravity may be *lowered* down to that of the original milk. Thus it is clear that the specific gravity of milk, taken alone, is valueless as a test of its quality. The indications of the "gravity lactometer" should be combined with the use of a set of graduated tubes in which to ascertain the number of measures of cream which rise from 100 measures of milk in 24 hours. And it is also advisable to ascertain the opacity of the sample by means of the lactoscope. Chemical analysis, of course, affords a more complete proof of the sophistication of milk. The total solids, and also the solids not fat, should be ascertained. A hundred grains of milk should leave, when carefully dried up, from 12 to 14 grains of solid substance, including milk-fat, casein, milk-sugar, salts, &c.; and the solids other than fat ought to amount to 9 or 10 grains.

It has been argued that the removal of cream from, and the addition of water to milk, are not adulterations injurious to health. As, however, these operations lower the feeding value of the milk considerably, and also seriously alter the relation between the heat-givers and flesh-formers of this model food, the above position cannot be maintained. It must also be borne in mind that there are many children whose daily allowance of milk, supposing it to be of good quality, barely suffices to sustain life: when this milk has been lowered by one-fourth or one-third of its original feeding value, it is not difficult to foretell the results.

The statements that chalk, brains, gypsum, &c., are used to thicken milk are almost entirely devoid of foundation.

Milk has sometimes been the means of spreading disease, either through its direct contamination with the specific poison of disease during the milking of the cows, or by means of the water used in rinsing the vessels employed, or in diluting the milk. The milk itself is sometimes unwholesome from the outset, owing to the unhealthy condition of the cow.

BUTTER.

French, *Beurre.* German, *Butter.* Italian, *Burro.*

Although butter consists chiefly of milk-fat, yet it contains by no means inconsiderable quantities of the other constituents of milk. It may be obtained from cream most readily, but also by the direct churning of milk. Butter made from sweet cream has a more pleasant taste and keeps good longer than that made from sour cream: this difference is caused mainly by the presence of much casein or curd in the butter from sour cream.

Much butter is now made in factories, in the United States of America, in Sweden, and elsewhere. By scrupulous attention to the purity and healthiness of the milk received, to the absolute cleanliness of the vessels used, and to the temperature and other conditions essential for a successful result, an excellent quality of butter is uniformly produced. The exact temperature, both in the rising of the cream and during the churning process, is always maintained; ice and currents of warm water being used as required. The taint, or unpleasant and peculiar taste which so much butter possesses, can be avoided when all necessary precautions are taken to prevent the access of any kind of odorous vapours to the milk or cream. Nothing is so strongly absorptive of odours or volatile flavours as butter. It absorbs and retains the vapours from cheese, from meat, and especially from every kind of decaying vegetable or animal matter. If improper or strongly-flavoured food has been given to the cows, it is in the butter made from the milk that the taste of that food will be most clearly perceived.

The best temperature for churning lies between 57° and 61° Fah.: 60° is a fair degree of heat. Sometimes cream is heated to a much higher temperature first—say 180° Fah.—and then cooled down to 60° Fah. before being churned. Butter thus made keeps well. It is generally considered that 1 lb. of butter can be made from 23 pints of milk.

Butter always has some salt added to it: this salt must be quite pure. If it be not free from magnesium compounds, it will give a bitter taste to the butter. Even fresh butter has some salt in it—from ½ to 2 parts in the 100. Salt butter ought not to contain as much as 8 per cent., but more has been found in inferior samples. If butter is to be kept some time or exported, it receives, besides salt (2 to 5 per cent.), a small addition of sugar—not, however, more than 8 oz. to the hundredweight.

The purity and goodness of butter can be ascertained by means of the microscope, chemical analysis, and certain special tests of melting points and specific gravity. But these tests cannot be applied except by experienced analysts. Still it is easy to learn a good deal about some of the adulterations practised on butter, by simply melting a portion of it in a glass tube plunged in hot water. After a time the water, the curd or casein, and the true butter or milk-fat, separate into layers. The water remains lowest: on its surface, and mingled with a portion of the melted fat, lies the curd; while the remainder of the fat constitutes a layer resembling oil, and remaining at the top. Now, as there should not be more than 8 to 13 per cent. of water in good butter, the watery layer should not exceed in volume one-eighth of the whole butter. Nor should the casein, or curd, be very conspicuous. Water has, however, been found to the extent of 30 per cent. or more in some samples of butter, while salt often occurs also in great excess. Unfortunately, also, imitations of butter are now made on a large scale, and may be used to adulterate butter without being easily recognised. If they are sold under the names of "butterine" and "oleo-margarine," purchasers know that they are not buying butter, though they may be purchasing a wholesome and cheap substitute for it. But these purified fats (bone-fat, horse-fat, &c.) are sometimes imported into England as Brittany or Normandy butter, and are also used for the fraudulent sophistication of genuine butter. The flavour of the true product is given to them by working them up with butter-milk, and it is difficult to recognise their origin.

Case 67. We cannot give an exact analysis of fresh butter which shall fully represent its components; but we may take the following figures as showing the average proportions of its most important constituents when of good quality :—

	In 100 parts.		In 1 lb. oz.	gr.
Water - - - - - - - -	10·0	...	1	262
Casein - - - - - - - -	1·0	...	0	70
Milk-fat - - - - - - - -	87·7	...	14	14
Milk-sugar - - - - - - -	0·3	...	0	21
Common salt - - - - - - -	1·0	...	0	70

It is scarcely necessary to say that butter contains too small a quantity of flesh-forming material for it to be reckoned in comparison with its high amount of heat-giving substance. If we change the latter into the corresponding amount of starch, it will be found that 1 lb. of butter corresponds to $2^1/_{10}$ lb. of starch.

Cheese.

French, *Fromage.* German, *Käse.* Italian, *Formaggio.*

The manufacture of cheese depends upon the peculiar property possessed by casein of being curdled by acids. On the addition of an acid to milk, the casein present, which constitutes three-fourths of the nitrogenous matter present, is separated from the liquid, which is straightway resolved into a mixture of irregular masses of separated casein, in which most of the globules of milk-fat are entangled, with a slightly cloudy liquid called *whey*, which holds the milk-sugar in solution, as well as some nitrogenous matter in the form of albumen and lacto-protein. This separation of milk into curds and whey is the first step in the preparation of cheese. It is usually made to occur, not through the use of an ordinary acid, but by means of *rennet.* Rennet is prepared from the fourth stomach of the calf, by first cleansing the stomach and the curd contained therein, and then leaving some brine in contact with its lining membrane for a few days. The salt liquid will thus acquire very active properties, so that a small quantity will curdle a large bulk of milk. Before adding the rennet, the milk is warmed to a temperature which varies according to the quality of cheese to be made. Generally, however, in cheese factories, where the regulations as to temperature are carefully carried out, the milk is heated to 84° Fah., then the rennet is added, and after the curd has been once cut, the heat is raised to 98°; at this stage the complete souring of the mass takes place. The subsequent treatment of the curd, and the pressing and ripening of the shaped cheeses, cannot be described here. In the cheese factories which are so numerous in the United States, and which are being established in England also, the whole process of cheese manufacture is carried out very quickly and uniformly. In this country factory cheese is of more uniformly good quality, and fetches a higher price, than the produce of the ordinary dairies of the several districts in which both kinds of cheese are made and can be compared. Some idea of the quantity of cheese made in factories in the United States may be gathered from the statement that the exports of this cheese from New York amounted in 1874 to nearly 97,000,000 lb., most of this coming to England. There are no less than 500 cheese factories in the State of New York.

There are three chief kinds of cheese :

Whole-milk cheese,
Skim-milk cheese,
Cream cheese,

but these sorts pass by insensible gradations from one to the other. So-called whole-milk cheeses are often produced in dairies where some small quantity of butter is also made, and where some cream is abstracted from the the milk. If evening milk be skimmed, and then mixed with the morning milk, half-skim cheese will be the product. The skimming of milk, too, may be carried out so completely as to leave very little milk-fat for the cheese, or else it may be done so imperfectly as to affect very slightly the richness of the product. Cream cheese, also, is very variable in composition, according to the quantity of cream which is added to the milk used for its production. Neufchâtel and some other soft kinds of cream cheese are very rich in milk-fat. Stilton cheese contains a smaller proportion of this constituent, but still is much richer than Cheddar cheese, which generally represents the average composition of a whole-milk cheese made from rich milk. Cheshire, and single and double Gloucester cheese show a slight reduction in the proportion of their milk-fat.

American cheese is generally lower still in its proportion of this ingredient, while Dutch cheese is a good illustration of a true skim-milk cheese. It may be stated generally that cream cheese contains less water and casein and more fat than whole-milk or skim-milk cheese; that whole-milk cheeses are made up of about equal proportions of milk-fat, casein, and water; and that skim-milk cheeses contain less fat but more water than either of the other sorts. But it must be recollected that these observations apply to those cheeses which are eaten in a ripened and hardened condition; for in many newly-made cream cheeses the water may amount to $^3/_5$ths or more of the whole weight of the cheese.

Case 67. The chief constituents of a fair sample of double Gloucester cheese are shown in the following analysis :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	34·3	...	5	214
Casein	29·2	...	4	294
Milk-fat	29·6	...	4	322
Milk-sugar	2·0	...	0	140
Phosphates	3·1	...	0	217
Common salt	1·8	...	0	126

For 1 part of flesh-formers in the above kind of cheese there are little more than 2½ parts of heat-givers, reckoned as starch.

One pound of this cheese could form nearly 5 oz. of the dry nitrogenous substance of muscle or flesh.

Cheese is naturally of a pale yellow or straw colour. The darker yellow and orange hues which it often shows are due to the colouring matter known as Arnatto or Annatto. This dye is obtained from the pulp in which the seeds of *Bixa Orellana*, a small South American tree, are embedded. Arnatto is too often adulterated, sometimes with injurious substances. It is introduced into the heated milk, before the addition of rennet, in making cheese. Butter also is often coloured by it; and it has been found in milk and cream. It is to be regretted that popular prejudice still demands a high colour in cheese, as the entire abandonment of the use of annatto is very desirable; its employment introduces impurities into the cheese, and does not improve the flavour in any way.

The digestibility of cheese varies with its texture, its age, and its composition. Generally speaking, it cannot be said to be easily attacked by the gastric and intestinal secretions. But a moist, crumbly cheese, fairly rich in fat, is more rapidly and completely digested than the drier and more nitrogenous skim-milk kinds. By various modes of preparation, such as grating and admixture with starchy matters, cheese may be made more useful and available for food. It should be eaten along with bread, rice, or other kinds of food rich in heat-giving nutrients, in which cheese is deficient. It requires some time before persons unaccustomed to eat cheese as a substantive article of the daily diet can derive full advantage from its nutritive properties. The presence of much bone-forming material in cheese is worthy of remark.

Some kinds of cheese, especially those which contain most milk-fat, and are not of a very close texture, acquire a strong odour and flavour by keeping. Both the casein and the milk-fat are then partly decomposed, the former yielding ammonia and ammonium sulphide, and the latter giving rise to butyric, caproic, and other acids. The blue mould, or mildew, which makes its appearance in old and very ripe cheeses, such as Stilton, is a vegetable fungoid growth. Cheeses are also liable to the attacks of minute animals. The common cheese-mite is *Acarus domesticus*; the cheese-fly, *Piophilus casei*, deposits its eggs in the cheese, where they reach the larval stage, becoming the cheese-maggots known as "jumpers." It is scarcely necessary to state that all these forms of animal and vegetable existence cause a considerable consumption of the food-substance of the cheese on which they live, lowering its nutritive value. Usually, however, the decayed cheeses to which these remarks apply are consumed in small quantities as food-adjuncts merely, on account of their rich flavour, or supposed power of aiding in the digestion of other articles of food.*

§ 2.—Eggs.

French, *Œufs.* German, *Eier.* Italian, *Uova.*

Eggs of course contain all the necessary constituents of food. Those of different kinds of birds, especially of the common hen, are largely consumed by man.

A bird's egg consists of several parts, which may be briefly comprised under the three terms of *shell*, *white*, and *yolk*. The shell consists mainly of earthy or mineral matter; when free from moisture it contains in 100 parts about 91 parts of carbonate of lime, 6 of phosphate of lime, and 3 of nitrogenous organic matter. Inside the shell there is a delicate membrane, which forms a kind of sac for the white of the egg. This part consists of a thick, ropy liquid, nearly transparent, and of a very pale straw tint, or almost colourless, when fresh, but becoming quite white, opaque, and nearly solid when sufficiently heated. These changes are due to the coagulation of the substance called albumen, which is contained in a soluble state in the unchanged white of the egg, but becomes insoluble on being boiled. The dissolved albumen occurs in large, thin, membranous cells in the white. Within the white lies the yolk, enclosed in a thin membrane, and tethered by two cords (*chalazæ*) to the membranes of the white. The yolk is yellow, and nearly opaque.

Case 68. In a very large hen's egg, weighing 1,000 grains (rather over 2¼ oz.), the shell and membranes will weigh about 100 gr., the white about 610 gr., and the yolk about 290 gr. The average weight of a hen's egg, shell and contents, is about 1¾ oz. It becomes rather lighter by being boiled, losing a little water.

* Some specimens of different kinds of cheese, &c., will be found in Case 67.

The white of a hen's egg has about the following composition :—

	In 100 parts.
Water	84·8
Albumen	12·0
Fat, sugar, extractives, and membranes	2·0
Mineral matter	1·2

The yolk of a hen's egg shows a much greater degree of richness than the white. It contains—

	In 100 parts.
Water	51·5
Casein and albumen	15·0
Oil and fat	30·0
Pigment, extractives, &c.	2·1
Mineral matter	1·4

The mineral matter of the contents of hens' eggs, though small in quantity, is rich in quality, consisting, as it does, mainly of phosphates of lime, potash, soda, magnesia, and iron.

The mixed whites and yolks of hens' eggs (the shells being excluded) contain—

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	71·7	11	207
Albumen and casein	14·0	2	105
Oil and fat	11·0	1	332
Membranes and extractives	2·0	0	140
Mineral matter	1·3	0	91

Eggs are very nutritious articles of food. They contain about as much flesh-forming and heat-giving substances as an equal weight of butchers' meat. For 1 part of flesh-formers present in them there are nearly 2 parts of heat-givers, reckoned as starch. One pound of the mixed yolks and whites can produce at the most a little more than 2 oz. of the dry nitrogenous substance of muscle or flesh.

One pound of hard-boiled eggs, if completely oxidized, could set free a force equal to 1,415 tons raised 1 ft. high. The greatest amount of work outside the body which it could enable a man to perform is 283 tons raised 1 ft. high. The remainder of the stored-up force in this amount of food will be in part unexpended, but much of it will be used in keeping up the heat and internal activity of the body, and in the repair of its tissues.

One pound of white of egg can set free force equal to no more than 357 tons raised 1 ft. high, and can enable a man to perform external work equal to only 71 tons raised 1 ft. high, whilst 1 lb. of yolk of egg can set free force equal to 2,051 tons raised 1 ft. high, and could enable a man to perform external work equal to the raising of 410 tons 1 ft. high.

The number of eggs imported into Great Britain is enormous. During the first quarter of 1876 it was something like 17¼ millions. It has been calculated that 18 eggs would contain an amount of flesh-forming substance and of other nutrients sufficient for the various needs of life in an adult man for one day. It would be necessary, in order to provide the same amount of albumen from such a fruit as the pear to consume no less than 70 lb. It would be difficult to find a more striking illustration than this of the concentrated character, so far as nitrogenous or flesh-forming substance is concerned, of the egg.

§ 3.—BUTCHERS' MEAT.

The variations in composition between different joints from the same animal are considerable. Add to this the fact that there are numerous additional differences, due to peculiarities of individual animals, to race, to age, and to the modes and materials of feeding, and we shall find it easy to account for the great discrepancies between different analyses of the same kind of meat. The variations in the amount of *fat* are the most conspicuous, and influence, of course, the proportions of other meat-components greatly. A piece of meat may contain but 5 per cent. of fat, when it will be found to possess 70 per cent., or perhaps 75 per cent. of water. But should 50 per cent. of fat be present (a fat mutton or pork chop may contain more) then the water may not be higher than 38—the rule being, the more fat the less water. If, then, nitrogenous or flesh-forming material be wanted, the leanest meat will furnish this, along with a considerably greater proportion of saline or mineral matter than is found in fat meat. Where heat-givers and force-producers are in demand, as in cold countries, and during fairly hard work, then the fatter meats and bacon are at once more suitable and more economical.

There are some signs by which the good quality of butchers' meat may be generally judged. Amongst these, in the case of mutton and beef, we may name a rich, bright, and uniform colour, and a firmness of texture, quite free from flabbiness, though moderately soft and elastic. Damp and clammy meat, with a tendency to exude moisture is generally unwholesome. Very young meat, from animals forced to a large size in a very short time, is neither agreeable in taste, nor easily digested. The rapid rearing and fattening of animals, though profitable to the farmer, produces a poor and inferior quality of meat. The flesh, or true muscular fibre, is not properly developed, while the connective and other gelatinous tissues are present in superabundant proportion.

Meat is tender, if properly cooked, *before* the *rigor mortis* has set in, but it must be kept some days *after* that rigidity of the muscles has occurred if it be required to possess this valuable quality. Still, it is better for meat to be somewhat tough rather than unwholesome owing to the commencement of putrefaction, which so readily occurs in hot weather.

A word should be said here concerning measly and braxy meat.* The former condition, when well marked, is easily

* For a model of a piece of measly pork, see Case 71.

detected by the eye. It is caused by the presence of parasitic animals—species of *Trichina* and *Cysticercus*. It is believed that these embryonic forms of animals, in part belonging to the genus *Tænia* (tapeworms, &c.), are destroyed by the heat of boiling or roasting meat. Care should be taken to avoid imperfectly cooked pork, or ham, or sausages; as well as any vegetables, as salad plants, which have not been thoroughly washed. Flesh-meat which is measly is also peculiarly liable to decomposition, and becomes objectionable on that score. The same may be said of braxy meat—the flesh of unhealthy or diseased animals which have been slaughtered in order to anticipate their imminent death, and the consequent total loss of their flesh as human food. Moreover, braxy meat may contain the specific poisons of various diseases, as well as the medicinal agents administered to the sick animal.

The various processes of cooking meat influence its composition and digestibility differently. Roasting before an open fire is far preferable to baking. If meat be boiled, it should be plunged in boiling water for a few minutes, and then such an amount of cold water added as will suffice to lower the heat of the water to about 170° Fah., which temperature should not be much exceeded during the whole time of cooking. Meat loses considerably both in digestibility and flavour when twice cooked. Salt meat is less nutritious and wholesome than fresh, except in the case of bacon and ham. The liquor in which mutton has been boiled contains valuable mineral and organic matters which ought not to be wasted. The liquor in which salted beef has been boiled is not available for food, except to a small extent, owing to the immense quantity of common salt which it contains. This salt in excess has an indirect injurious action on the human system, as explained on p. 24. The chemistry of those changes which occur during the processes of cooking cannot be dwelt upon here. But those changes are mainly the following: the removal of much water in the form of vapour and as gravy, the latter containing the soluble organic and inorganic matters of the joint. Much gelatin, too, is found in the gravy, this substance being produced from those tissues of the meat which are not true muscular fibre, and which are rendered soluble by a moist heat. Much fat is melted out of the adipose tissue, and certain slightly carbonised matters, or dark-coloured substances, are formed out of the carbonaceous and nitrogenous constituents of the meat. To these dark-coloured materials, which are but little understood, the aroma, or flavour and odour, of a roasted joint are greatly due. They may be compared to the similar products found in the crust of bread, and in baked pastry and puddings. The general tendency of the process of roasting meat is to render it more soluble, digestible, and nutritious.

We now come to the question of the composition of the different kinds of meat in general use as food. Our information on this subject being still imperfect, it will probably be best to give somewhat minute details about a single kind of butchers' meat which we have lately submitted to special examination, and then to present a more general view of the composition of the other kinds of flesh-meat.

Case 69. A mutton-chop shall be the subject of our illustration. It contained, when quite fresh, a proportion of bone amounting to 8 per cent.—perhaps a rather lower proportion than usual. When submitted to careful analysis, it gave the following results when the flesh and fat were taken together in the fresh state for analysis :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	44·1	...	7	24
Albumen	1·7	...	0	119
Fibrin (true muscle)	5·9	...	0	413
Ossein-like substances	1·2	...	0	84
Fat	42·0	...	6	315
Organic extractives	1·8	...	0	126
Mineral matters	1·0	...	0	70
Other substances	2·3	...	0	161

The bone of this mutton-chop was analysed, and gave the following results :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	32·2	...	5	66
Ossein	18·7	...	2	434
Fat	9·0	...	1	193
Phosphate of lime	34·1	...	5	200
Carbonate of lime, &c.	6·0	...	0	420

A recently-published analysis of a mutton-chop described as "lean" showed very different results to those we have given above. "The more lean, the more water;" and consequently the number representing the percentage of water was 75·5; the fat was set down as 8·6; the albuminoids as 10·5; the ossein-like substances as 1·9; and the mineral matter as 3·5.

To show the influence of cooking upon a mutton-chop, we may cite two analyses, in one of which (*a*) the gravy and dripping were carefully preserved and analysed with the lean cooked meat of the chop; while in the other case (*b*) they were excluded:

	In 100 parts. *a*		*b*
Water	54·0	...	51·6
Nitrogenous matter	27·6	...	36·6
Fat	15·4	...	9·4
Mineral matter	3·0	...	1·2
Other substances	—	...	1·2

The useful lessons to be drawn from the above analyses will be best studied by a reference to the composition and properties of the several nutrients, as described in the First Part of the present Handbook; it would require too much space to enlarge upon these matters here.

Cases 69 & 70. Before giving some analyses of other kinds of meat, it would be well to remind our readers of what was said on p. 148 about the great variation in composition which different animals and parts of animals present. Thus, the following figures must not be looked upon as representing a series of standards. They have been drawn up from the numerous analyses* (of the carcasses of various animals) which have been carried out by Messrs. Lawes and Gilbert. We quote them from the former "Inventory of the Food Collection."

THE COMPOSITION OF 1 LB. OF

	Beef.		Mutton.		Pork.		Veal.		Lamb.
	oz. gr.		oz. gr.		oz. gr.		oz. gr.		oz. gr.
Water - -	8 0	...	7 16	...	6 69	...	10 0	...	8 44
Albuminoids -	1 122	...	0 385	...	0 315	...	1 199	...	0 360
Ossein-like substances	1 62	...	1 52	...	0 385	...	1 82	...	0 400
Fat - - -	4 340	...	6 176	...	8 0	...	2 281	...	5 263
Mineral matter -	0 350	...	0 245	...	0 105	...	0 312	...	0 244

According to Frankland, 1 lb. of the lean of beef, if digested and oxidized in the body, might produce an amount of force equal to 885 tons raised 1 ft. high. The greatest amount of external work which it could enable a man to perform is 177 tons raised 1 ft. high. One pound of lean mutton-chop can produce at the utmost rather less than 2 oz. of the dry nitrogenous substance of muscle or flesh, that is, assuming the analysis by Mène given on p. 152 to be a fair representation of this article of food.

The following further data relate to other meats, &c., as force-producers, the higher figures representing the total amount of force capable of being set free by the digestion and oxidation within the body of those animal foods, and the lower numbers representing the force available for external work—both in tons raised 1 ft. high, or "foot-tons :"—

	Foot-tons.		
1 lb. of beef fat - - - -	5,626	...	1,125
1 lb. of lean of veal - - -	726	...	145
1 lb. of boiled ham - - -	1,041	...	208

* A series of photographs of French breeds of oxen, sheep, and pigs will be found in the Collection; also a series of stuffed and mounted heads of some of the chief breeds of British oxen. A head of the eland, a large kind of antelope, is also shown. This African animal has been successfully bred in England. Its flesh is tender and of excellent flavour.

This seems the proper place to introduce a word or two concerning some of the internal parts of animals (or *viscera*) which are consumed as food. These often require careful cleansing and thorough cooking, and are more likely to be diseased than the muscular flesh. In most cases they are of very close texture, and they do not always contain the same kinds of nutritive nitrogenous matters as are present in ordinary meat.

Calves' Liver, according to Payen's analysis, contains the following proportions of its constituents :—

	In 100 parts.
Water - - - - - - - -	72·3
Nitrogenous matter - - - - - -	20·1
Fat, &c. - - - - - - - -	6·1
Mineral matter - - - - - -	1·5

Here the ratio of flesh-formers to heat-givers, reckoned as starch, is as 1 to 7-10ths—a proportion which shows the propriety of the use of fatty or starchy food with liver, as illustrated in the familiar dish of "liver and bacon."

Case 70. Tripe is the cleansed paunch or first portion of the ruminant stomach of the ox. The exact nutritive character of tripe is not known. It generally contains much fat. A sample as sold by the butcher, but freed from the lumps of fat present, showed the following composition :—

	In 100 parts.		In 1 lb. oz.	gr.
Water - - - - - - - -	79·5	...	12	216
Nitrogenous matter - - - - - -	10·0	...	1	262
Fat - - - - - - - - - -	10·0	...	1	262
Mineral matter - - - - - - -	0·5	...	0	35

These numbers show a high percentage of water and a low percentage of mineral matter, due to the cleansing and boiling in water which tripe undergoes before it is sold.

Sweet-bread should be the thymus gland of the ox: the pancreas goes under the same name. Among other viscera or internal organs of animals which are eaten are the heart and the kidneys. Both of these organs are of very dense and firm texture and cannot be regarded as of easy digestibility. They are highly nitrogenous articles of food, but the heart generally contains some fat.

Case 71. Reference has already been made to the composition of bone. Blood, especially pigs' blood, is sometimes used as food in the form of black-pudding. It requires a considerable admixture of starchy and oily matter to afford a complete nourishment: it contains about 78 per cent. of water, the remainder being chiefly nitrogenous matter with some mineral salts.

Case 71. Bullocks' tongues, horses' tongues, rein-deer tongues, and sheeps' tongues are commonly used as food, and are nutritious and digestible. Some of these kinds are dried and imported in that condition: these require long soaking in cold water before being cooked.

§ 4.—Poultry and Game.

One of the chief characteristics of the flesh of fowls, notably those which are wild, is the almost entire absence of fat. When much fat is present the flavour of the meat is often less delicate, and its digestibility, especially when roasted, decidedly difficult. It does not seem that game, even when "high," and therefore to some extent decomposed, is really unwholesome when properly cooked. A very large number of birds furnish food to man, in different quarters of the globe. The flesh of those birds which feed on grain or other vegetable products is less strongly flavoured than that of carnivorous birds. A mere list of names of the most important kinds of poultry and game would not be very useful, in the absence of details concerning their relative values as food, and the chemical composition

For specimens of birds used as food, see Cases 72 to 77.

of their flesh. But we give here an analysis of the flesh of the common fowl as representing this kind of animal food :—

	In 1 lb.	
	oz.	gr.
Water - - - - - - -	12	107
Albuminoids - - - - - -	2	104
Ossein-like substances - - -	1	52
Fat - - - - - - - -	traces	
Mineral matter - - - - - -	0	174

About thirty different species of birds are commonly used as food in Great Britain.*

Case 78. The flesh of the hare and the rabbit approaches somewhat nearly in texture and composition to that of poultry.

We may now introduce a strange example of the out-of-the-way products of animal origin which have been used as food for man. That the eggs of birds and the flesh of birds should be so used is familiar enough to us, but that their nests should be regarded as suitable for eating, and even as a great delicacy, is certainly somewhat surprising. Such, however, is the case; and we may therefore here give a brief account of—

* For the place in the animal kingdom of the edible birds, see the diagrams, above the Cases.

Stuffed and mounted specimens of the common pheasant, a native of Asia Minor; of the ringed-pheasant, a native of China; of the parti-coloured pheasant, a native of Japan; and of varieties and hybrids of the above, are shown in Case 72. All the above have been introduced or successfully bred in this country.

Case 73 contains specimens of the capercailzie, grouse, and ptarmigan.

Case 74 contains a collection of specimens of native Australian waterfowl such as are commonly sold in the markets of Melbourne, South Australia.

Case 75 contains specimens of some of the game-birds of Nova Scotia—wood-grouse, prairie-grouse, ptarmigan, and American woodcock.

Eggs of various breeds of domestic poultry are shown in Case 68; also eggs of the swan, pheasant, pea-fowl, partridge, plover, redshank, snipe, pigeon, turtle-dove, heron, moorhen, guillemot, emu, and ostrich.

Edible Birds' Nests.

Case 77. Edible birds' nests may certainly rank amongst the curiosities of food. They are considered great delicacies in China, where they form part of all ceremonious feasts, being dissolved in soups. They reach China from the Southern Archipelago, chiefly from Java, Borneo, Celebes, and the Sulu Islands. It has been estimated that no less than 8,400,000 of these nests are annually imported into Canton. The finest and whitest kind sells for as much as £5 or £6 the lb., but it requires about fifty nests to make up one pound. In reality these singular structures are rather the brackets upon which the birds afterwards build their nests than the nests themselves. The bird—a kind of swift known as the salangan (*Collocalia esculenta*)—builds both in marine and inland caverns, first forming, mainly with its saliva, a number of loops, which it subsequently works up into the shell-shaped support for its nest. The nest itself is made of grass, leaves, and seaweed, but the edible bracket or support consists almost exclusively of the salivary secretion of the bird. It is a mistake to suppose it to be made of seaweed, which the salangan neither eats as food nor uses in the building of these brackets, though the nests are often made of it. The salangan builds and breeds four times in the year. The brackets are removed three times, the best being obtained in July and August.*

Reptiles.

Case 79. In this country the reptiles used as food are few in number. Their flesh is regarded as a luxury. It is, however, wholesome and digestible. The green turtle of the West Indies, and of some parts of the South American coast, is the best known

* Specimens of these nest-brackets, cleaned and in their natural state, and of the salangan swift, are shown in Case 77.

and most highly appreciated of the reptiles used as food. These animals sometimes weigh as much as 700 lb. They are imported alive into this country. Their flesh is the basis of turtle-soup. Sun-dried turtle, cut into convenient pieces for culinary purposes, are now received in this country from the West Indies and other places. They are an excellent substitute for live turtle. The land tortoise, which is common on the Mediterranean coasts, is eaten by the inhabitants of Italy and the Levant. A small fresh-water turtle, the terapin, is eaten in America, and is imported into this country.

A large frog (*Rana esculenta*) is eaten in many parts of Europe. The hind legs are selected as the best part to be consumed. Various other reptiles are eaten in different countries—the iguana in Guayaquil, the tegu or tequixin in Brazil, the axolotl in Mexico, and the green lizard in Rome.

§ 5.—Fish, &c.

Cases 80 to 87. The kinds of fish commonly available for food in England are numerous. The muscular flesh of the same fish differs in different parts of the animal and in different seasons of the year. Those fish which are least oily and fat are the most wholesome; but their highly nitrogenous character demands the abundant use of starchy foods, in order that a due proportion of heat-givers may be consumed along with the flesh-formers they contain. A dry, woolly, or tough texture in the muscular fibre of fish is an indication of indigestibility. Thorough cleansing and thorough cooking of fish is essential to its wholesomeness. Lemon juice is one of the best sauces that can be used with fish: some of the compound sauces in vogue are of very doubtful composition and purity. The least oily fish are whiting. They are the most easily digested, especially when boiled. Flounders, soles, plaice, and several other kinds, are nearly equally available for the invalid. Eels, salmon, herrings, and even mackerel, are far more oily and less digestible.*

The published chemical analyses of fish are very discordant. This arises in great part from the condition of the fish varying at different times of the season. An analysis of a mackerel in good condition gave—

	In 100 parts.	In 1 lb. oz.	gr.
Water	68·7	10	434
Nitrogenous matter	13·5	2	70
Oil or fat	12·5	2	0
Common salt	2·2	0	154
Phosphates, potash-salts, and other mineral matter	3·1	0	217

In the nitrogenous matter named above is included a substance known as creatine; it abounds in skate and cod.

Cases 80 & 81. We quote (under all necessary reserve) the following figures from the former "Inventory of the Food Collection":—

COMPOSITION OF 1 LB. OF

	Salmon. oz.	gr.	Mackerel. oz.	gr.	Sole. oz.	gr.	Conger-eel. oz.	gr.	Pike. oz.	gr.	Herring. oz.	gr.
Water	12	143	10	374	13	374	11	208	12	281	12	406
Nitrogenous matters	2	43	3	387	1	350	3	233	3	23	1	270
Fat	0	301	1	56	0	14	0	350	0	42	1	60
Mineral matter	0	387	0	57	0	136	0	84	0	91	0	145

* Mounted specimens of the common sorts of fish brought to the London markets are shown in Case 82. A painted plaster-cast of a full-grown salmon, a mounted specimen of a male salmon (Case 82A), and a set of earthenware troughs, to illustrate the method of artificially hatching out the ova of salmon and other fish, are exhibited.

Specimens of dried fish of various kinds may be seen in Cases 83 to 87. Amongst these is a collection of edible fishes from Victoria, Australia; and many sorts of dried fish, &c., from the French colonies of St. Pierre, Tahiti, and Cochin-China. These latter specimens include capelins, herrings, cods' tongues, shrimps, prawns, trepangs, &c. Specimens of the Bummeloh fish of the Chinese Seas and Indian Ocean are also shown. These fish, known in Bengal as "Bombay ducks," are of delicate flavour when fresh, but by drying and salting acquire a very strong smell and taste.

Diagrams presenting a tabular view of the families and orders of fishes are shown in the collection.

According to Frankland's experiments, the following figures represent the force, expressed in foot-tons, which could be liberated by the digestion and oxidation in the body of 1 lb. of whiting and mackerel :

	Total work.	External work
Whiting - - - - - - - -	491	... 98
Mackerel - - - - - - - -	1,000	... 200

The consumption of fish in London is very large ; the chief market is Billingsgate.

Fish are preserved for subsequent use in several ways—by drying, by smoking, by salting, and by the use of oil. The removal of moisture or the exclusion of air is the chief condition of success. Most kinds of dried and salted fish are rendered more palatable and wholesome by being soaked for some hours in cold water. The fish which are most easily preserved are those of firm texture, or of moderate size, and particularly those which are naturally rich in oil or fat. Herrings, anchovies, pilchards or sardines, and salmon, are familiar examples. The dried bummeloh fish, known in India as "Bombay ducks," are highly esteemed. Caviare, the roe of the sturgeon, is generally consumed in a decomposed state, and then cannot be considered wholesome. Fresh caviare is a very different article, and does not demand an acquired taste for its appreciation.

For specimens of dried fish, &c., see Case 87.

Case 88. Oysters and other molluscs may be briefly noticed here. Oysters are most digestible when eaten raw, much of the nitrogenous matter they contain being rendered tough and insoluble by heating. Oysters are often improved in flavour and wholesomeness by being kept for a day in a shallow dish with some weak brine, a little oatmeal being given to them. Oysters contain about 14 per cent. of flesh-formers and 80 of water. Mussels are more frequently found in an unwholesome condition than oysters.

On the continent of Europe there is one kind of snail which is often eaten as food. It is common in some parts of southern France, and is also found rather abundantly in many of the southern parts of England. It is called the Roman or apple snail (*Helix pomatia*). When properly cleansed and properly cooked it is a nutritious article of food. It can be collected only for a short period during the summer, but then is found in large numbers in some districts in Gloucestershire, Kent, and Surrey. It occurs abundantly on the site of many Roman stations in England, and is believed to have been introduced by the Romans.

Cases 89 to 91. Lobsters and crabs are not very easy of digestion. The latter should be cleansed with the greatest care before being eaten. These crustacea are very coarse feeders, and it is probably for this reason that they so frequently disagree even with healthy persons. Other crustacea commonly eaten in Great Britain are the fresh-water cray-fish, the shrimp, and the prawn.*

§ 6.—Bacon and Preserved Meats.

By salting, or by the exclusion of air, many animal products used as food may be preserved for a long time free from decomposition. It is not to be supposed that no changes in composition occur, but the decay to which meat of all kinds is so prone does not take place. In most cases the digestibility of the meat is not improved but rather diminished, at all events by salting, though this is probably not equally true of "tinning," and is not the case when the process of freezing is employed. We will first describe the salting process, as applied to pork, giving this instance as an illustrative example; afterwards we will notice other methods of preserving meat.

* Specimens of many different crabs, lobsters, and other crustacea, are shown in Cases 89 to 92.

Bacon.

French, *Lard.* German, *Speck.* Italian, *Lardo.*

When *cured*, or preserved by salting and drying, and generally by the process of smoking in addition, pork becomes bacon.

The preparation of bacon is now carried on very extensively and systematically in factories specially constructed and fitted up for the purpose. The following sketch may give some notion of the plan commonly adopted.

After being fasted 24 hours, the pig is taken to the slaughter-house and killed. It is then hung up by the hind legs, singed by means of gas, scraped, opened, cleansed by powerful jets of water, and dressed. When the carcass has become cool and firm, which is generally the case after about 12 hours, it is ready for boning or cutting up. This is done by placing the pig on a strong table and cutting off the head close to the ears. The fore feet are then removed, and the hind feet so as to leave a shank to the ham. The carcass is then divided straight along the back and the shoulder blade taken out. The sides are now ready for salting. Each side is laid singly on the floor of a cool cellar, and dressed with a mixture of saltpetre (nitrate of potash) and salt, 4 ounces of saltpetre being used for each side, together with a quantity of salt corresponding to the size of the side. Brine is also forced into the flesh by means of a force-pump and jet. The next day the sides are piled one above the other, and remain so for four days, when they are turned over and sprinkled with more salt. Thus they remain for 12 days, when they are washed and dried. The next day they are taken to the "smoking-house," where they hang for three days, being continuously smoked during that time with the fumes of burning oak sawdust; thus they acquire the desired colour and flavour. The sides, when cold, are ready for market. Cured bacon sometimes become rancid or *resty* through exposure to air: this may be avoided by keeping it in dry bran. Another injury to which bacon is subject arises from the attacks of a small fly, the larvæ of which are known as jumpers.

For domestic use pork may be cured as follows:—Stir some salt with hot water till no more of the substance is dissolved: this forms the brine or pickling liquor. Then mix, for a pig of moderate size, one pound of brown sugar and half-a-pound of nitre; rub this mixture well into the meat, which is then to be put into the pickle, remaining there two days. After this take it out and rub the pieces with salt alone. Return it to the pickle. It will be ready for use, after drying and smoking, in six or eight weeks. It is scarcely necessary to say that bacon varies greatly in composition. It always contains less water and more mineral matter than the pork from which it has been prepared, while the fat in it is more digestible. Highly smoked and dried bacon sometimes retains but 12 or 14 per cent. of moisture; but a fair sample of streaky bacon, such as would be selected for the breakfast table, would be nearly represented, both as to moisture and its other chief constituents, by the following numbers:

Case 93.

	In 100 parts.		In 1 lb. oz.	gr.
Water	22·3	...	3	248
Nitrogenous matter	8·1	...	1	130
Fat	65·2	...	10	189
Salt	3·8	...	0	256
Phosphates, &c.	0·6	...	0	42

For one part of flesh-formers in the bacon examined there are nearly 20 parts of heat-givers, reckoned as starch, the 65·2 per cent. of fat being equivalent to nearly 160 parts of starch: and it must be further noted that the whole of the 8·1 per cent. of nitrogenous matter shown in the analysis cannot be reckoned as true albuminoids or flesh-forming nutrients, but, being in part, related to gelatin, is of less value. On this account we must reckon the amount of dry muscular substance producible from 1 lb. of bacon as under 1 oz.

The unsalted trimmings and offal of a bacon factory are utilised in the form of sausages, the minced materials being mixed with bread, fat, and condiments, and then preserved in the previously prepared small intestine of the pig. The surplus fat is melted, strained, and poured into cleaned pig-bladders; it is known as lard.

Considerable quantities, both of bacon and of lard, are imported into this country from British colonies and from foreign countries. In 1875 the imports of bacon and hams amounted to 131,495 tons; the imports of lard to 26,967 tons; and the imports of salted pork to 11,639 tons. During the first three months of 1876 the imports of bacon and hams showed an increased value of £400,000 over the corresponding period of 1875.

Preserved Meats.

Case 94 and 95. There are several plans of preserving meat and animal food products generally. Simple drying is one of the most effective of these, but the flavour and other qualities of the meat are not improved thereby in most instances; still this plan is available for some substances, and has long been in use. Drying in wood-smoke has the further advantage of preserving the substance, to some extent, from further change even should it become moist. This effect is due to the creasote or carbolic acid which is present in the smoke. It has even been found that a piece of fresh meat which has been dipped in a watery solution of carbolic acid will dry up without becoming offensive in odour or taste.

Salt, sugar, and many substances of a saline nature may be used to preserve meat from decomposition. They act by reducing the proportion of water present, and by preventing the development of those lower forms of vegetable and animal life which accompany and aid, if they do not originate, decay. But the most important methods of preserving animal products depend upon the exclusion of the air. This result may be achieved in several ways, which do not appear at first sight to have much in common. In all of them, however, the objects in view are the removal of the air originally present in the food, and the prevention of any subsequent entrance of air. To accomplish these ends numerous plans have been devised. For the air may be excluded or removed by a high temperature or by a low one, or by the introduction of a substance like oil or fat, which mechanically excludes the air. Of the later method, sardines and pilchards preserved in oil, and then closed or hermetically sealed in tin cases, afford an illustration. Of the former method, the Australian meats are good examples. The meat, freed from bone, is placed in the tins, which are usually surrounded by a boiling solution of chloride of calcium, capable of being heated several degrees above the boiling point of water. The air in the meat is expelled by the heat, and finally by the rush of steam. When, by experience, this expulsion of air is judged to be complete, the tins are quickly soldered up and will then keep sound a great length of time. It should be stated that the tins often receive an addition of gravy, or, rather, of jelly, with a little salt, and occasionally some condiment or spice. Other processes for preserving meat have not proved equally available. Such processes are briefly noted here. The joints to be preserved have been coated with collodion, with solid paraffin, or with a mixture of gelatin and treacle, or gelatin and glycerin. Solutions of the sulphites of lime, magnesia, or soda, which absorb oxygen readily, have been employed. The sulphite of lime in powder, sometimes sold as a "meat preserver," has been successfully used for preventing meat from becoming tainted in hot weather, and in removing any taint which may have been acquired. Powdered charcoal, if freshly burnt, has the same properties. But the previously described method of enclosing meat in sealed vessels—generally of tinned iron, but sometimes of glass—is undoubtedly the most generally applicable of all meat-preserving processes. The same method is used, also, for the preservation of nearly every kind of moist vegetable and animal products used as food, but prone to decay under ordinary conditions. The tinned Australian meats are gradually becoming more appreciated in England. They are moderate in price, agreeable in flavour, and perfectly wholesome. They generally have one defect, it is true, that of having been over-cooked. But during the last year or two several improvements have been devised in the process of tinning meats, by which the considerable heat and length of time necessary to secure complete expulsion of the air, before the tins in which the meat is contained can be sealed up by soldering, have been reduced. It has been found that a little sulphite of soda enclosed in the tins may be used to absorb the last traces of oxygen—that constituent of the air which causes decay. And even gases, such as carbonic acid, carbonic oxide, and sulphurous acid have been introduced into the vessels containing preserved foods, for the same purpose. Then, too, methods of injecting antiseptic gases or solutions into the carcasses of animals used for food have been experimented with. Further progress will doubtless be made during the next few years in these directions; much, for instance, may be expected from the application of cold and of condensed gases in the preservation of provisions. We also regard the processes of drying and smoking as worthy of more extended use in connection with the preservation of butchers' meat.

From Australia we already receive smoked and dried legs of mutton of excellent quality.

Cases 94 and 95. The importation of tinned Australian meats has assumed very considerable proportions since its origination ten years ago. During the last few years the annual value of these Australian tinned meats has often exceeded £500,000 sterling. It may be well to state that the prejudice against these tinned meats has been partly of the usual unreasonable sort, which revolts against all novelties in food; and has partly arisen from ignorance as to suitable modes of cooking these meats

They may be properly used in Irish stews, in soups, and in many other ways, provided they be duly flavoured with condiments and are not re-cooked further than is necessary to heat them where they are not preferred cold. One caution about the tinned meats is necessary. Sometimes—though rarely—they have been found to contain a little lead in solution in the gravy; sometimes a large number of small globules of soft solder, containing much lead, at the bottom of the tin. This caution applies to all tinned provisions, vegetable as well as animal. They should be carefully examined for metallic globules, which may prove injurious if swallowed with these foods.

Meat Extract and Fibrin.

Case 93. When raw meat is thoroughly extracted with cold water, a liquid is obtained which contains creatine and a number of other crystallised nitrogenous matters, together with such mineral salts as the phosphate, sulphate, and chloride of potassium. So long as the extract remains at a low temperature, it will also retain in solution some at least of the soluble albumen of the meat. If the liquor be now boiled down, the albumen will curdle and separate, while the filtered liquor, if further concentrated, will become a nearly solid brown mass, rich in the permanently-soluble constituents of muscular flesh. Such a preparation does not contain more than a very small proportion of the true nutrients of meat, but is little more than a food-adjunct. Thus it is, that Liebig's Extract of Meat cannot be regarded as a food, though its use as a flavourer and as a medicine is not unimportant; it also furnishes some of the minor food constituents. An extract of meat prepared with boiling water contains gelatin. The fibrin of meat which is used in the preparation of these extracts is valuable when dried and powdered, or made into fibrin biscuits, &c., as a rich flesh-forming nutritive material.

PART IV.—OF FOOD-ADJUNCTS.

It is impossible to draw a sharp line of distinction between true nutrients and food-adjuncts. There is scarcely a single article of food which does not possess some constituents which give it flavour, perfume, or colour, but which yet cannot be considered as doing any actual work in the body. But these adjuncts, in the forms of flavouring and colouring matters, &c., make our food agreeable, stimulate a flagging appetite, aid indirectly in the digestion of the nutrients, and help to render palatable food which would otherwise be wasted. More than this: some of the food-adjuncts actually furnish—along with their characteristic flavouring, stimulating, or narcotic constituents—real nutrients. Cocoa and beer are examples in point. And it has been thought that the active principles of certain food-adjuncts have some power of economising the true nutrients by arresting the rapid changes of tissue, &c., which go on in the body. In general terms we may affirm, that if injurious or even dangerous consequences may follow upon the excessive use of the true nutrients of the body, much more will this be the case with the food-adjuncts.

The order in which we shall consider the several groups of food-adjuncts has been already indicated (p. 9). The first group contains alcohol as its most characteristic ingredient.

§ 1.—Beer, Wine, and Spirits.

The food-adjunct which is present in all fermented liquors, and in the different kinds of distilled spirits prepared therefrom, is a liquid known as alcohol and as spirits of wine. This liquid burns readily when a flame is applied to it, but it is very doubtful whether it is ever completely burnt or oxydised in the human body. Contrary to the general impression, it now appears that alcohol in any form lowers the temperature of the body. To many constitutions it is decidedly injurious, even when consumed in very moderate quantities and in the weakest or most dilute liquors. Its use throughout the day is nearly always fraught with danger. It is probable that it is best taken, not as a stimulant before work, but as a restorative after work, and as an accompaniment to the substantial meal of the day. Much, too, depends upon the form in which the alcohol is taken. Light wines, perfectly natural and not fortified with spirit, and pure beer or ale, are probably the most desirable liquors for general use. The worst kinds are distilled spirits, not only because of their strength, but because of the absence of those other constituents which modify the effect of alcohol in other beverages. But there is another bad quality in most spirits—that is the presence of a liquid called fusel oil. The exact physiological action on the human organism of fusel oil is not ascertained, but there is good reason to believe this liquid (in reality itself a kind of alcohol) to be more active than ordinary alcohol. We shall recur to this subject in the paragraph on distilled spirits. Here, however, a few further words about ordinary alcohol may not be out of place. The term "absolute alcohol" is used to designate pure spirits of wine wholly unmixed with water. It is chemically pure alcohol, the hydrate of ethyl, a liquid boiling at 173° Fah., and having the specific gravity 794 (water being 1000). Proof spirit is a mixture containing 49¼ per cent. of its weight of absolute alcohol: its specific gravity is 920.

BEER.

French, *Bière.* German, *Bier.* Italian, *Birra.*

Case 96. The most commonly used of all fermented liquors in England is beer, under which term we include ale and porter. These liquors are prepared from malted grain by simple fermentation, without concentration, dilution, or distillation of the fermented liquor.

The three materials employed in the manufacture of beer are malt, hops, and water.

The malt is made of sprouted or germinated grain, usually barley or rye. To prepare malt the grain is first placed in the "cistern," where it remains 50 hours, absorbing a large quantity of water and swelling considerably. It is then shifted into what is called the "couch," where, according to excise regulations, it remains 20 hours, and where the duty is taken by gauge. After this it is removed to the "floors," where the process of growth soon makes itself evident by the appearance of the slender rootlet of the seed. Barley in this stage of its conversion into malt is shown in specimen 3; while 4 shows the grain when it is six days old, the sprout, or *acrospire*, as it is called, being now much longer. The next specimen (No. 5) is of the grain when 10 days old, and No. 6 shows the grain when the sprouting has gone on to the full extent desired. Most maltsters and brewers dry the grain when it is from 10 to 12 days old, but occasionally 14 days elapse before the process of malting is considered sufficiently complete. These variations depend partly upon the quality of grain employed, partly upon the temperature during malting, and partly upon the special purpose for which the malt is intended. When the germinated grain is considered sufficiently grown, further sprouting is stopped by drying it in the malt-kiln. The heat used causes other changes, and is different according to the kind of beer for which the malt is to be used. Some idea of the temperatures may be gathered from this list:—No. 7, pale malt, for the palest ales, at about 100° Fah. No. 8, amber malt, for other ales, at about 120° Fah. No. 9, brown malt, for porter, at about

160° Fah. No. 10, black malt, for colouring, at 380° or 400° Fah. When malt has been finished by drying, it differs a good deal from the original unmalted grain. Instead of 15 per cent. of water, it contains only five; but the chief change which it has undergone is the conversion of some of its starch into a kind of gum called dextrin, and into a species of sugar. It is found that screened malt contains, moreover, a substance capable of changing both dextrin and soluble starch into sugar. We say "screened" malt because the malt after kiln-drying is always sifted, to remove the rootlets or acrospires, which, under the name of malt dust or malt coombs (No. 11), form a very valuable food for cattle, containing, as they do, about one quarter their weight of flesh-formers. The substance in malted grain which has the power of changing starch into dextrin and sugar is sometimes spoken of as *diastase* or *maltin*—it is a nitrogenous substance belonging to the albuminoid group. When malt is used for brewing it is first crushed (see specimen No. 12) and then infused in water, by which its soluble constituents are dissolved out, "wort" being produced, and brewers' grains are left (see No. 13). The wort is usually fermented at temperatures ranging between 60° and 90° Fah. During the fermentation sugar changes into alcohol, which remains in the liquor, and carbonic acid gas, which partly remains, giving briskness and frothiness to the beer, and partly escapes.

Hops are added to the wort to give an agreeable bitter taste and keeping quality to the beer. Hops are the cones or strobiles of the hop (*Humulus Lupulus*), called *houblon* by the French, and *Hopfen* in German. They were condemned in Henry VI.'s reign as an "unwholesome and wicked weed." In mediæval times other plants were used for the same purpose, as ground ivy (*Nepeta Glechoma*), sweet gale (*Myrica Gale*), and sage (*Salvia officinalis*). Hops contain about 4 per cent. of the astringent substance tannin, 1½ per cent. of a fragrant essential oil, and much resin. These substances are chiefly found in the yellow glandular secretion of the hop cones, called *lupulin*. Over

60,000 acres are devoted to the culture of this plant in England, chiefly in Kent, Sussex, and Worcestershire, while increasing quantities are yearly imported from Bavaria, Wurtemberg and Belgium. Specimens of hops from different localities are shown in the case (Nos. 14, 15, 16, 17, 18, 19). The exhausted or spent hops (No. 20) are useful as manure.

Of the water used in brewing beer little need be said. It should of course be free from all injurious impurities, and especially from any organic matters undergoing change. But it must be noted that there is one mineral substance which exercises a decidedly beneficial effect upon beer, both during the progress of the brewing and on the finished product—this is sulphate of lime or gypsum. When the water available for brewing is deficient in this compound, it is introduced by allowing the water to pass over or through blocks of this mineral, or by stirring in the sulphate of lime in fine powder or crystals.

To make three barrels of ale (108 gallons), the quantities of the several materials required will be somewhat as follows:—

> 1 quarter of MALT;
> 8 pounds of HOPS; and
> 5 barrels of WATER—the barrel being 36 gallons.

In brewing, one barrel of water—that is, 36 gallons—is lost by evaporation, and 14 gallons in the fermentation and racking; 18 gallons are absorbed by the grains, and 4 gallons by the hops.

The process of brewing is begun by crushing the malt, and then pouring hot water (180° Fah.) upon it, with constant stirring. This *mashing* yields the liquor called *sweet wort*, which is then boiled with hops, and afterwards rapidly cooled. The liquor is now fermented by the aid of *yeast* from a previous brewing. The fermentation is stopped before it is complete by separating the yeast and drawing the beer off into casks. The fining of beer may take place naturally, or it may be effected by means of isinglass dissolved in tartaric acid, in sour beer, or in weak sulphuric acid. There are many other fining materials which may be used.

The finished beer holds in solution a large number of substances, but the quantities of these substances present are not large—this fermented liquor always containing between 80 and 90 per cent. of water. The following is a list of the chief compounds known to occur in beer :—

1. ALCOHOL, or spirits of wine, from 8 to 3 per cent.
2. DEXTRIN, about 4·5 per cent.
3. ALBUMINOIDS, about 0·5 per cent.
4. SUGAR, about 0·5 per cent.
5. ACETIC, LACTIC, and SUCCINIC ACIDS, about 0·3 per cent.
6. CARBONIC ACID GAS, about 0·15 per cent.
7. MINERAL MATTER, about 0·3 per cent.

In the following analyses only some of the above constituents are separately entered, the items 2, 3, and 4 above being, for instance, set down as "extractive matter," a term which includes also several substances not named above (glycerine, caramel, hop-extract, &c.).

An imperial pint of the beers named contains—

Beers.	Water.		Alcohol.		Acetic acid.	Extractive matter.		Mineral matter.
	oz.	gr.	oz.	gr.	gr.	oz.	gr.	gr.
London Stout -	18	342	1	74	22	1	25	22
London Porter -	18	412	1	10	16	1	3	18
Pale Ale - -	18	409	1	12	17	0	372	10
Strong Ale - -	17	399	2	18	21	2	42	30

A few words may not be out of place here as to the introduction of other materials (besides those already named) into beer.

But it should be at once stated that many of the substances supposed to be used for the purpose of adulterating beer and malt liquors are rarely so employed, and that some of these substances have never been so used. Thus, the rumour that strychnine (from the seeds of *Strychnos nux-vomica*) had been extensively used to give bitterness to beer was entirely devoid of foundation. There is also reason to think that the employment of "Cocculus Indicus"—the fruits of *Anamirta Cocculus*—in brewing has been very limited and exceptional: other bitter vegetable products have however been detected in some samples of ale. Caramel, or burnt sugar, liquorice, and salts of iron have been found in porter. A very common adulteration is salt—the object of this addition being not so much to develop the flavour and preserve the liquor, as to produce a craving for more drink in the frequenters of the beer-shop. Much artificial sugar (glucose) is also used in brewing, for the purpose of strengthening the wort. The use of gypsum, of which we have before spoken, can hardly be regarded as an adulteration.

Beer which is sour or hard, or that which is thick and muddy, is not wholesome. The decided sourness of some beers is due to the alteration of a good deal of the spirit, which by exposure to air acquires oxygen, becoming changed into vinegar or acetic acid. The cloudiness of beer is often due to a second fermentation.

WINE.

French, *Vin*. German, *Wein*. Italian, *Vino*.

When the sugary juice of any fruit is left to itself for a time, at a moderately warm temperature, the change known as fermentation occurs. This fermentation is generally brought about by the growth of a low form of vegetable life, an organised ferment. It consists of a splitting up of the sugar present in the liquid (or at least of a large part of it) into alcohol, which remains in the liquid, and carbonic acid gas, which escapes more or less completely.

Case 96. Although the fermented juice of all fruits may be regarded as wine, yet the term is generally limited to the alcoholic liquor prepared from the grape. But we have in England at least two familiar native wines—perry, or pear wine, and cider, or apple wine. Other so-called British wines are usually made-up or compound liquors, into which a large quantity of cane or beet sugar has been introduced. They cannot be regarded as true wines, nor are they generally wholesome.

By a reference to the analysis of grapes (p. 118) it will be seen that the chief ingredient in their juice is glucose, a kind of sugar. There is also some albuminoid matter and a little tartaric acid, chiefly in combination with potash; other minor ingredients also exist in grape-juice. The seeds of the grape contain the astringent substance, tannin, with some bitter principles, while in the skins not only does colouring matter exist, but also some flavouring matters and tannin. From these facts it will be clearly seen that very different qualities of wine may be made from the same quality of grape, according to the method of operating upon the fruit. The colour, the bouquet or volatile flavour, the astringency, &c., of a wine may thus be varied according to the admission or exclusion of the characteristic ingredients of the skins and stones of the grapes.

Case 97. The main difference between grape juice and grape wine is the substitution of the sugar in the former by the alcohol which is characteristic of the latter. But other changes occur in the fermentation and ripening of wines. Much of the acid tartrate of potash is deposited from the liquid on being kept, this deposit being called argol. Argol consists chiefly of the above-named tartrate, but with it a little colouring matter and some tartrate of lime are always found. In the stronger but natural white wines small floating crystals of cream of tartar often occur; they are nearly pure acid tartrate of potash. A small quantity of free acetic acid is found in wines. When they become sour it is this acid to which the sourness is due; it is formed by the oxidation of some of the alcohol present, a change which occurs more readily in weak natural wines than in those which contain much alcohol. Another important characteristic of wines is the presence, in small quantity, of certain compounds called ethers. They are usually fragrant oily liquids, of which traces are present in all wines. These ethers are compounds formed by the union of the ordinary alcohol or spirit of wine with some of the acids which are contained in the fermented liquor—at least this is usually the case. Much, then, of the flavour and perfume of a wine is due to these ethers, some of which existed, ready-formed, in the grape itself, while others were slowly formed on keeping the fermented liquor. Different varieties of grape yield differently-flavoured wines, but the alcoholic strength of a wine depends mainly upon the proportion of sugar in the grapes and in the degree of completion to which the process of fermentation is carried. The same kind of grape gives a very different wine as to flavour and alcoholic strength in accordance with the climate in which it is grown, the season, and the soil.

The quantity of true or absolute alcohol in natural wines varies from 7 per cent. in some hocks, clarets, and other light wines, to 13 per cent. in many Greek and Hungarian vintages. When the quantity of absolute alcohol exceeds 13 or 13½ per cent. it may usually be considered that the wine has received an addition of distilled spirit, or has been fortified. Wines of delicate flavour will not bear fortifying, the alcohol added being usually derived from the fermentation of artificially-prepared grape sugar, and containing the coarsely-flavoured alcohols known as fusel oil. A fortified wine may contain a good deal of sugar, for the addition of spirit to a fermenting liquid checks, more or less completely, the further change of the sugar.

Wines under 26° of proof spirit pay on importation a duty of 1*s.* a gallon; those over 26° and under 42° pay 2*s.* 6*d.* Large and increasing quantities of natural wines now come into this country. Even of Spanish wines so imported about half are of natural strength, while the average of all Spanish wines does not show much over 28 per cent. of proof spirit—rather less than 14 per cent. of absolute alcohol.

Case 97. The following table shows the quantities of alcohol, of fixed acids—calculated as tartaric acid—of acetic acid, of sugar, of ethers, and of mineral matter or ash, contained in fair average samples of eight different kinds of wines commonly consumed in Europe. One imperial pint of each of the following wines contains about—

Name of Wine.	Alcohol (absolute).	Tartaric and other fixed acids.	Acetic acid.	Sugar.	Ethers.	Mineral matter.
	oz. gr.	gr.	gr.	oz. gr.	gr.	gr.
Hock - -	1 219	39	18	none	4	16
Claret - -	1 306	31	18	0 9	6	18
Champagne -	1 343	20	10	1 120	5	20
Burgundy - -	2 18	24	17	0 10	6	18
Carlowitz - -	2 35	36	19	none	5	16
Sherry - -	3 147	24	12	0 236	4	38
Madeira - -	3 218	26	18	0 175	5	33
Port - - -	3 218	23	12	0 359	6	20

The different wines made in this country from rhubarb stalks, gooseberries, currants, cowslips, elderberries, oranges, &c., contain oxalic, malic, and other acids, besides the tartaric acid which is the chief acid of the grape. Now these acids are not thrown out of the liquor after fermentation, as is the case to a great extent with the wine from grapes. Thus sugar has to be added to mask the acidity of these liquors, and in consequence they are not so wholesome as the natural imported wines. But it must not be supposed that grapes are entirely free from all acids save tartaric, or that the analyses above given represent every constituent of the wines we have included in the table.*

* Specimens of grapes, &c., will be found in Case 58. A model vineyard is labelled 101. Samples of British wines are shown in Case 98.

The ethers of wine previously alluded to include a number of compounds not yet completely analysed or understood. Some of them, however, have been examined pretty fully, and even exactly imitated by chemical means. Œnanthate, butyrate, and acetate of ethyl are the names given to some of the best known of these ethers. These ethers enter into the composition of the artificial "oil of cognac" and various flavouring essences.

Cider, the fermented juice of apples, contains from 2¾ to 4½ per cent. of absolute alcohol, together with some malic acid, gum, mineral matter, &c. The quantity of sugar present varies with the less or more complete fermentation of the apple-juice.

Perry, made from pears, closely resembles cider in flavour and composition.

Distilled Spirits.

When any kind of fermented liquor is warmed, the vapour which first comes off contains much of the spirit or alcohol present. If the vapour be collected and cooled it assumes the form of a liquid, which originally received the name of spirits of wine. The operation is known as distillation, and the product is called distilled spirits. As the heat is continued the distilled liquid becomes weaker and weaker, containing more water and less alcohol. The cause of the differences in flavour between distilled spirits from different sources lies not in the alcohol, but in the traces of ethers or essential oils which accompany this alcohol—which are volatile, like alcohol, and which are easily dissolved by it. The flavours of distilled spirits originate in the substances which by their fermentation have given rise to the alcoholic liquors which have been distilled. But it is usual, in many cases, to add flavouring matters of many kinds to distilled spirits. Indeed, from the same batch of spirits obtained by the distillation of a fermented solution of grape sugar or malt sugar, either gin, or whisky, or brandy may be prepared. The spirit used must be pure—at least it must have no very pronounced flavour of its own—if it has to be used as the basis of several distinct kinds of ardent spirits. It must tell no tales of its origin —of the starch, old rags, paper, or woody fibre, from which, by the action of sulphuric acid, it has been derived. It must in fact deserve the name often given to it of *silent* spirit.

Case 99. The following are the chief varieties of distilled spirits in common use :—

Gin, which is obtained, or should be obtained, from the distillation of fermented grain, is flavoured with the essential oil of juniper berries, and other aromatic substances. Many recipes for the preparation of this liquor are in use by the distillers, but the general plan is to introduce into the still the essential oil (which is often turpentine), the aromatic seeds and fruits, the creasote, and other materials of strong taste which are in vogue, and to distil the spirit once or more from this complex mixture. The less residue there is left when a pint of gin is boiled down till nothing more can be driven off at the heat of boiling water the more likely it is to be wholesome. Another test for the quality of this and all other distilled spirits is the following: Get a straight glass tube, about three feet long, about half an inch wide, open at both ends, and perfectly clean and dry. Hold it upright, and pour the spirit to be tested down it, so that the inner surface of the tube is thoroughly wetted. Then move the tube to and fro till the ordinary alcohol has become vaporised. There will remain behind most of the odorous substances present in the original spirit. Thus the fusel oil, so abundant in the spirit distilled from fermented beet-root sugar or potato-starch sugar, will remain in the tube, and may be detected by its powerful and choking smell. This fusel oil contains what are called the higher alcohols of the same series as that to which ordinary alcohol belongs. Amongst these we may name butyl, propyl, and amyl alcohol. On keeping a spirit which contains these alcohols they will often be found to diminish in quantity, giving rise to compound ethers like acetate of butyl and amyl. These ethers are more agreeable in taste and smell, and probably less objectionable, from a physiological point of view, than the fusel oil from which they originate.

Gin is sold at very varying strengths, so far as alcohol is concerned—a common strength being 17 under proof. It is often lowered still further by the addition of water. The water used is too often itself unwholesome and charged with impurities. Nothing but carefully prepared and filtered distilled water should be used—this is the case in the best distilleries. But the distillers are not to blame in most cases for the bad quality of the gin sold in public-houses. The retailers, not infrequently, having lowered the alcoholic strength of the liquor by means of water, restore the fiery character of the spirit by means of natural and artificial preparations of a heating character.

A sample of London gin was found to be 22 under proof, and contained 11⅓ gr. of solid matter per pint.

Cordial gin is flavoured with additional spices and essential oils, as cinnamon, cloves, &c. Gin containing sugar is sold as sweetened gin.

The words "gin" and "geneva" are believed to be derived from the French word *genièvre*, juniper.

Brandy, when genuine, is the spirit distilled from wine. Imitations are sold under the name of British brandy. Cognac and other genuine French brandies are flavoured with prunes or dried plums, and always contain some sugar. Caramel, or burnt sugar, and many other substances are used to colour and flavour the spirit from potatoes, &c., which receives the name of brandy in England. True brandy contains some œnanthic and acetic ether from the wine; the imitation brandy is flavoured with the so-called essence of cognac, an artificial mixture of certain chemically-prepared ethers.

A good sample of true cognac, of pale colour, was found to contain 136 gr. of solid dissolved substances per imperial pint, 74 gr. being sugar. It was of proof strength, but is usually sold at 15 under proof. A fair sample of dark brown "British brandy" was found to contain 61½ gr. of solid fixed matter per pint, 18¼ gr. being sugar. Its strength was 17 under proof.

True brandy improves in flavour by being kept.

Whisky, when genuine, is distilled from fermented grain. It has a smoky taste, owing to the presence of traces of creasote, &c., from wood or peat smoke. By the addition of artificial flavourers, any distilled or silent spirit may be made into whisky. A good sample of Scotch whisky, two years old, was 10 over proof (but it is often sold at 10 under proof). The same sample was found to contain 6 gr. of solid matter per pint, 3 gr. of this being sugar. Whisky is sometimes put into sherry casks. If it becomes thick it should be filtered through paper-pulp filters; too often it is fined by chemical preparations, such as the following: First, a little carbonate of soda in solution is thoroughly mixed with the liquor, and then a corresponding quantity of Epsom salts is added. The precipitate of carbonate of magnesia which then forms carries down with it any floating particles. But salts of several kinds, and other impurities, are thus introduced into the spirit.

A sample of so-called Scotch whisky supplied by a large London firm was found to be rather impure so far as fixed matter is concerned. The total residue from one pint amounted to 50 gr., 42 of which were sugar.

Rum is made from the molasses, or dark uncrystallisable liquid sugar, which is obtained in the preparation of solid sugar from cane juice. The skimmings from the vats in which the cane juice is clarified and boiled down are used in the same way. White rum is the pure distilled spirit, but ordinary Jamaica rum has been coloured with caramel.

A genuine sample of rum from the West Indies was found to contain 36½ gr. of solid residue per pint, 18 gr. being sugar, and 1½ gr. being mineral matter. The chief natural flavouring material of rum is butyric ether, but this spirit sometimes receives in addition the flavour of the pineapple.

Case 99. Besides gin, brandy, whisky, and rum, there are many kinds of spirits from sources other than those already named, and possessed of different flavours, artificial or natural. Amongst these we may name the following, premising that all the products are obtained by the distillation of a fermented solution of sugar—that sugar being naturally present in the original fruit, root, &c., or else produced by a change of starch into sugar. Distilled spirits are obtained from oranges, cashew-nuts, apricots, Jerusalem artichokes, sugar-millet, potatoes, flowering branch and sap of many palms (arrack), cider, cider lees, maize, honey, refuse of starch manufacture, &c. &c. A Japanese spirit, called "saki," is distilled from rice.

The peculiar and often disagreeable odour and taste of distilled spirits may be removed by careful and repeated distillation, and by very thorough filtration through animal charcoal. Some chemical substances are also found to be useful in aiding the separation of the fusel oil and other substances upon which the odour and flavour of different distilled spirits depend.*

Liqueurs.

Case 99. When a considerable quantity of sugar is added to a flavoured spirit, a *cordial* or *liqueur* is the product. The flavouring materials used in liqueurs are named in the next section of the present part of this volume: they are very numerous, and include natural products, as fruits, seeds, bark, and roots, as well as the essential oils and separated aromatic principles of these parts of plants. Orange bitters contain the essential oil of orange-peel and the bitter substance which accompanies it. Noyau is

* In Case 100 there are numerous specimens of distilled spirits or alcohol from new or unusual sources. They have been rendered potable by filtration through charcoal, &c.

flavoured with the essential oil of bitter almonds, which is identical with that distilled from peach kernels, laurel leaves, &c. Chartreuse contains a peculiar kind of turpentine, with the essential oil of angelica. The names of other liqueurs sufficiently indicate the nature of the flavouring substances to which their taste and some other qualities are due. Absinthe is wormwood, and gives its name to a bitter liqueur much consumed in France. Tea, coffee, cocoa, and vanilla are also employed in the preparation of liqueurs or flavoured spirits.

Some notion of the amount of spirits annually consumed in Great Britain may be gained from the following figures, which represent the total Customs and Excise duties on spirits paid in the year ending 31st March, 1876 :—

England	£13,206,641
Scotland	4,041,419
Ireland	3,328,752
Total	£20,576,612

The total value of these distilled spirits amounted to £43,067,022. If to this figure we add £72,785,921 as the cost of the malt liquor consumed in one year, £13,112,029 for the foreign wines, and £1,000,000 for other alcoholic liquors, we arrive at a grand total of £130,000,000 or more as the annual value of the alcoholic beverages made in or imported into the United Kingdom. It is estimated that the above annual quantity of distilled spirits contains 21,000,000 gallons of absolute alcohol, the total quantity in all the beverages being at least 80,000,000 gallons. The number of gallons of spirits paying duty in the year 1875 was as follows :—

	Gallons.
British spirits	30,106,107
Colonial spirits	5,361,486
Foreign spirits	6,421,164
Total	41,886,757

The duty payable on imported spirits is 10*s.* 5*d.* per gallon. Most of the rum imported came from British Guiana and the British West Indies. From France 3,250,000 gallons of brandy were received, and from Holland a small quantity of Geneva.

§ 2.—Condiments, Spices, and Flavourers.

The taste of many vegetable products is so definite and so strong that they cannot be used as substantive articles of diet. These fruits and seeds, &c., are, however, very useful as means of imparting agreeable flavours to the simpler food materials, which thus become not only more palatable but more wholesome. Still, the condiments, spices, and flavourers must be used with moderation, or their action on the processes of digestion and assimilation may become injurious.

The chief active and efficient ingredients of this group of food-adjuncts are volatile—that is, they may generally be dissipated by a moderate heat. Most of them are known as essential oils, but some are solid crystalline bodies or resinous matters. We shall here first describe the chief condiments, then the spices, and afterwards the group to which the name of flavourers has been given.

Mustard.

French, *Moutarde.* German, *Senf.* Italian, *Mostarda.*

Case 102. *Black Mustard* is the seed of *Brassica nigra*, a plant found wild in most parts of Europe. It is cultivated in Elsass, Bohemia, Italy, Holland, and England. It flourishes in the rich alluvial soils of Lincolnshire and Yorkshire. It was in common use in the Middle Ages as a condiment. Black mustard seeds are but one-fifth the size of white mustard seeds: they contain one-third of their weight of a bland fixed oil, while the pungent essential oil is not produced till the ground seeds are wetted. This pungent oil contains both nitrogen and sulphur. The best flour of mustard contains nothing but black and white mustard seeds:

some manufacturers, however, produce an inferior material containing flour, turmeric, and capsicum. The seeds of another kind of mustard (*Brassica juncea*) are largely substituted for the true black mustard; no less than 790 tons of this kind having been imported from British India into the United Kingdom in 1872.

White Mustard, the seeds of *Brassica alba*, does not yield a pungent oil. Its cultivation is extending in England, as in Essex and Cambridgeshire.

Pepper.

French, *Poivre*. German, *Pfeffer*. Italian, *Pepe*.

Case 102. *Pepper* consists of the fruits (twenty to thirty of which grow on one flower-stalk) of *Piper nigrum*, a perennial climbing plant, a native of Travancore and Malabar, but introduced into Sumatra, Java, Siam, West Indies, &c. Pepper owes its pungency to about 2 per cent. of an essential oil: it contains also 2½ per cent. of piperin.

White Pepper is prepared from the above-named fruits when ripe by removing the dark pericarp or covering; it thus becomes less pungent.

Long Pepper consists of the unripe spike or fruit produced by two other species of *Piper*, namely: *P. longum*, a native of Malabar; and *P. officinarum*, a native of the Indian Archipelago.

Cayenne Pepper is prepared from the pods of one or more kinds of *Capsicum*. The small pods are called chillies, and are produced by *C. fastigiatum*, a plant which is wild in South India, and cultivated in tropical Africa and America. Chillies have been termed Spanish pepper, red pepper, and pod pepper. Another species of capsicum (*C. annuum*) yields the larger pods, generally called "capsicums" (the *poivrons* of the French); of these several varieties exist. This plant was grown in England by Gerarde in 1597: our supplies are derived chiefly from Zanzibar, Natal, &c. The capsicum belongs to the *Solanaceæ*, the Order which includes the potato, the tomato, and tobacco.

Horse-radish.

French, *Raifort.* German, *Meer Rettig.* Italian, *Rafano.*

Horse-radish is the root of a common European perennial plant (*Cochlearia Armoracia*); it has been used as a condiment in England from the 17th century. It yields a pungent essential oil, which seems to be the same as that from black mustard. The poisonous roots of aconite, *Aconitum Napellus*, sometimes called monk's-hood or wolf's-bane, have been mistaken for those of horse-radish.*

Parsley.

French, *Percil.* German, *Petrosilie.* Italian, *Prezzamolo.*

Parsley is *Apium Petroselinum*, a native umbellifer of Sardinia; the leaves of which are used not only as a garnish, but are eaten fresh or dried as a flavourer.

Mint.

French, *Menthe.* German, *Münze.* Italian, *Menta.*

Mint or Spearmint is *Mentha viridis*, a pleasant aromatic labiate herb, used in seasoning and for boiling with green peas.

Thyme.

French, *Thym.* German, *Thimian.* Italian, *Timo.*

Thyme is *Thymus vulgaris*, a small labiate shrub of South Europe, not a native of England. Its odour and taste are due to an essential oil known in trade as origanum oil. Wild English thyme (*Th. Serpyllum*) is a different plant.

Fennel is an umbelliferous plant, *Fœniculum vulgare*, found wild in the countries bordering on the Mediterranean: it has a perennial root stalk, while the Indian plant is an annual. The fruits of fennel (commonly called seeds), as well as the leaves, contain a peculiar aromatic essential oil, which is also found in

* Compare the specimens of the roots of these two plants as shown in the collection.

anise-seeds. Chopped fennel leaves are used in the melted butter eaten with mackerel: the fruits give flavour to certain cordials.

Marjoram (*Origanum vulgare*), Sweet Marjoram (*O. Majorana*), Sweet Basil (*Ocymum basilicum*), and Sage (*Salvia officinalis*), are all labiate plants, and are known as pot-herbs. Their aromatic leaves are used either fresh or dried for seasoning food.

Cumin is an umbelliferous plant (*Cuminum Cyminum*) which has been known from very early times. Its fruits contain an essential oil of very strong odour and taste: they are used in the preparation of some spirits and cordials, and form a constituent of curry-powder. Dutch cheese is sometimes flavoured with cumin.

Turmeric is the root-stock of *Curcuma longa.* It is used as a yellow dye as well as a condiment: it is one of the chief ingredients of curry-powder. Our supplies come mainly from Bengal and Pegu—the Cochin turmeric is from another species of Curcuma. The odour of turmeric is due to an essential oil, present to the extent of 1 per cent. *Curcumin* is the yellow colouring matter.

Chervil (*Anthriscus Cerefolium*) is an umbelliferous plant, the young leaves of which are used in France for flavouring soups and salads.

Dill is an umbelliferous plant (*Anethum graveolens*) resembling fennel. Its fruits are aromatic, but it is little used for culinary purposes in Europe.

Anise, or *Pimpinella Anisum*, is a native of Asia Minor, Egypt, &c.: it is cultivated in many parts of South Europe. The fruits contain about 2 per cent. of an essential oil, which is used in flavouring cordials.

Capers are the flower-buds, and sometimes the unripe fruits of *Capparis spinosa*, a wall plant of South Europe. Our supplies are chiefly from Italy and France. Capers are prepared and preserved by pickling them in vinegar. A common substitute for them is found in the unripe fruits of the garden nasturtium (*Tropæolum majus*): other substitutes are also in use on the Continent.

GARLIC is a native of Southern Europe and is closely related to the onion, but has a much stronger taste. Its bulb consists of ten or twelve parts called "cloves." It is *Allium sativum.* It is used in sauces.

SHALLOT, or Eschalote (*Allium ascolonicum*), is a native of Palestine. Its cloves are milder than those of onions: it is used in pickles, salads, and seasoning, and to flavour vinegar.

CHIVES (*Allium Schœnoprasum*) are a native of Britain. They form a favourite addition to soups in Scotland.

TARRAGON is *Artemisia Dracunculus*, one of the *Compositæ.* It is closely related to the well-known aromatic plants, common wormwood and southernwood; but, unlike them, its leaves are undivided. It is a native of Siberia, but is cultivated to some extent in France as an ingredient in salads and pickles, and for flavouring vinegar.

SAVORY is of two kinds: summer savory is *Satureja hortensis*, a most aromatic annual plant, a native of Southern Europe; the other is an evergreen, *S. montana.* They are used for sauces and seasoning, and admit of being dried.

SPICES.

Spices are usually added to articles of food containing sugar, while condiments are eaten with meat, and generally with any foods which contain common salt. But it is impossible to draw any very distinct line between condiments and spices. Amongst the latter we may include—

Case 103. GINGER is the rhizome or root-stock of *Zingiber officinale*, a reed-like plant now grown in most hot countries: it has been long known and esteemed. Most of our ginger comes from the East and West Indies, and has been scraped. Its odour is due to an essential oil, its hot taste to a peculiar resin.

Fresh or green ginger, consisting of the young shoots of the rhizome, forms, when boiled in syrup, an agreeable preserve.

CARDAMOMS are the aromatic fruits of many plants belonging to the Ginger Order. Common cardamoms are the produce of *Elettaria Cardamomum*, a reed-like perennial common in the moist mountain forests of Malabar: "Grains of Paradise" are the fruits of *Amomum Melegueta*, an allied plant of West Africa; they are used to give pungency to spirits, &c., also in veterinary medicine.

CINNAMON consists of the true bark or *liber* of a small evergreen tree of Ceylon, *Cinnamomum zeylanicum*: it was known in very ancient times as a spice. The crop is gathered about May and November, the two-year-old shoots being stripped and slightly fermented. Cinnamon contains a fragrant essential oil.

CASSIA is the bark of a Chinese species of *Cinnamomum*, while "Cassia buds" are the unripe fruits of the same tree.

SASSAFRAS is produced by *Sassafras officinale*, a tree of North America.

NUTMEGS are the seeds of *Myristica fragrans*, a handsome evergreen tree, wild in the Banda Isles, New Guinea, &c., and cultivated elsewhere with some success. The long nutmeg is the produce of *M. fatua*. The nutmeg contains about 6 per cent. of an aromatic and pungent essential oil.

MACE is a covering of the nutmeg, and is termed an *aril* in botany. It contains about 4½ per cent. of an aromatic oil.

CLOVES are the dried calyx and flower-buds of *Eugenia caryophyllata*, an evergreen tree belonging to the Myrtle Order. Our supplies come from Zanzibar and the West Indies. Cloves are used in flavouring cordials and apple tarts and puddings. They contain a pungent aromatic oil in considerable quantity.

ALLSPICE or Pimento is a small dry berry, the fruit of *Pimenta officinalis*, an evergreen tree of the Myrtle Order common in the West Indies. Pimento contains about 4 per cent. of an aromatic pungent oil much like that of cloves. Our supplies come wholly from Jamaica.

CARAWAY, or *Carum Carvi*, is a biennial umbelliferous plant something like a carrot. It is cultivated to some extent in Kent and Sussex; much is imported from Holland. An acre yields from four to eight hundredweight of the fruits. They contain an essential oil, and are used to flavour cakes, confectionery, biscuits, and cordials.

PEPPERMINT is a labiate plant (*Mentha Piperita*). It is grown in Surrey and Cambridgeshire, and is common, as a wild plant, in many parts of England. The whole plant, especially just before flowering, is rich in an essential oil of aromatic and even burning taste, which is used to flavour sweetmeats and cordials.

CORIANDER (*Coriandrum sativum*) is an umbelliferous plant of the south of Europe, and is cultivated largely in France. The fruits of this plant contain a small quantity of essential oil: they are used in flavouring cordials.

ANGELICA (*Archangelica officinalis*) is an umbelliferous plant common in most parts of Europe. Its roots, though of somewhat medicinal taste, are used as food in Norway and Lapland; the stems, boiled in sirup, yield a pleasant sweetmeat; the fruits are used in flavouring some cordials, as Chartreuse.

FLAVOURERS.

Some artificial and some natural products of strong taste and smell are included in this group of flavourers. In many instances flavourers are prepared by the distillation of seeds, fruits, &c., when the fragrant essential oil comes over and is condensed. Such essential oils dissolved in spirit of wine constitute the extracts or flavouring essences so much used in cookery. But the compound ethers, many of which may be prepared artificially, are now used for similar purposes. The following flavourers are in common use:—

Case 103. 1. *Essential Oil of Lemon*, and of other fruits of the genus *Citrus*, as the orange and the citron. These oils occur in the rind of the fruits, whence they may be removed not only by distillation but by pressure. The fresh peel of these fruits is used for flavouring, but it may be preserved by careful drying. It is also eaten after having been boiled in sirup as candied peel, and in several other forms.

Case 104. 2. *Oil of Bitter Almonds* is obtained—by means of maceration in water, and subsequent distillation—from the bitter almond, a variety of *Amygdalus communis*. The same essential oil may be got from peach and plum kernels and from laurel leaves. The crude oil, as obtained by distillation, always contains prussic acid in considerable quantity. This most poisonous substance ought always to be removed from the bitter-almond flavouring used in cookery. No preparation of bitter almonds, no essence of "ratafia" or peach-kernels, should be employed in the kitchen unless it is guaranteed to be free from prussic acid. Cakes, custards, and blancmange are flavoured with oil of bitter almonds. The odour and taste of this oil are approached in two artificial products—nitrobenzol and benzonitril. Nitrobenzol, which is incorrectly termed artificial oil of bitter almonds, and sometimes essence of mirbane, is obtained by acting upon benzol (a liquid constituent of coal-tar) with nitric acid. It is poisonous, and has a much less agreeable odour and taste than the true oil. Benzonitril is obtained by the distillation of hippuric acid, a substance contained in the urine of horses and oxen.

Case 104. 3. *Vanilla.*—The flavourer known under this name consists of the fruits of an orchid belonging to the genus *Vanilla*. The most highly-prized sort is obtained from *V. planifolia*, a plant indigenous to hot regions of Eastern Mexico. It was brought to Europe by the Spaniards.* Other species of vanilla are also used, but are thought to be of inferior quality. The pods of the various kinds of vanilla owe their rich and agreeable aroma to the presence of a white crystalline substance called vanillin. This substance is now made artificially from another natural product—coniferin, which is contained in the sapwood of pines. The

* Specimens of vanilla from the French colonies of Réunion (introduced there in 1817), Guadaloupe, and Guiana, are placed in Case 104.

artificial vanillin is not a mere imitation of the natural substance, but is absolutely identical with it. Vanilla is used to flavour cocoa, chocolate, ices, biscuits, creams, and even coffee and tea.

Case 104. 4. *Artificial Fruit Essences.*—Although there are few cases in which the exact nature of the delicate flavours of fruit has been ascertained, yet there can be little doubt that the discovery has been made in some instances. Even were this not so, still there are now known many artificial products, chiefly the so-called compound ethers, which resemble very closely indeed in taste and smell the natural flavours of certain fruits. One of the most extensively used of all these is the acetate of amyl, a compound ether which may be regarded as derived from vinegar and potato oil by the removal of the elements of water. The so-called essence of Jargonelle pears is a spirituous solution of the acetate of amyl: it is employed in flavouring confectionery, especially pear-drops. Unfortunately it is used too freely, and is seldom sufficiently pure for this purpose. Other compound ethers impart the flavour of other fruits to articles of confectionery, liqueurs, and foods. Apple oil is chiefly valerate of amyl, pineapple oil is butyrate of ethyl and butyrate of propyl, and grape or cognac oil is a mixture of several compound artificial ethers. Many other flavourers of similar character have been artificially prepared: they are much used by the makers of cheap confectionery.

There are some natural products used as spices, condiments, or flavourers, which we have not described; indeed, a volume would be required for the adequate treatment of this subject, for the details connected with these products are very numerous. Take one example. Saffron has long been used for colouring and flavouring confectionery, fancy biscuits, &c. The plant which yields it, the *Crocus sativus*, was grown in the reign of Edward III. The part used consists of the stigmas only of the flower, and the colouring substance they contain is so intense that one grain of the commercial saffron will colour yellow ten gallons of water. Our supplies of saffron now come chiefly from Spain and France, but the plant was once largely grown in England between Saffron Walden and Cambridge. To give similar details as to other flavourers would obviously occupy an amount of space much greater than the importance of the subject warrants: we cannot therefore further dwell upon these numerous minor flavourers. But we may name in passing that sauces should be included here, for they usually contain mixtures of several condiments dissolved in weak vinegar and other liquids, and that there are some materials of animal origin used in part for the same purposes.

Case 94. Of these latter the extract of meat invented by Liebig is the most important. It contains nitrogenous matters, such as creatine, with large quantities of potash salts—in fact, all the constituents of flesh which can be dissolved by hot water. Still, it is a stimulant and flavourer chiefly, and cannot be regarded as a substantive food.

§ 3.—Vinegar, Pickles, and Acids.

Case 108. There are several acids in most vegetable products. They exist partly in the form of salts, and partly in the free state. The most common and most important vegetable acids are these four: Citric Acid, Tartaric Acid, Malic Acid, and Oxalic Acid. To these must be added a fifth acid, the Acetic; which, however, is mainly produced artificially by the change or oxidation of alcohol or even of sugar, but which occurs also to a small extent in some fruits, especially when they are over-ripe or decaying.

All the acids probably act in the processes of digestion and nutrition in much the same way. They exert a solvent action upon many of the nutrients, but their own nutritive power is very small, for they cannot be consumed in sufficient quantity to give out any appreciable amount of heat or force. More than this, they are already highly oxidized products, and require but a small further addition of oxygen to be converted into the final products of oxidation—carbonic acid and water: this is especially the case with oxalic acid.

Case 108. CITRIC ACID and its salts—the citrates—are particularly abundant in the fruits of some plants of the orange tribe, more particularly in the lemon. From this fruit the crystallised citric acid of commerce is separated on a large scale. The expressed juice is boiled down, and imported into this country in a concentrated form. Citric acid is an acid of agreeable taste and quite wholesome, even when taken in rather large quantities. It is found in the free state in many unripe English fruits, as gooseberries; but it is also present in the form of citrates of potash, lime, and other bases.

Case 108. TARTARIC ACID is the characteristic acid of grapes. It occurs mainly in the form of the acid tartrate of potash. This substance is the main constituent of *argol*, the crust which is deposited from wine. When purified, argol yields tartar, or cream of tartar, which is identical with the acid tartrate of potash. Tartaric acid is a solid crystalline substance, which, like citric acid, is easily soluble in water. It is a less pleasant and wholesome acid than citric acid.

MALIC ACID is present in many fruits, especially in those of the Rose Order. It may be extracted from apples and pears.

OXALIC ACID, more particularly in the form of the acid-oxalate of potash, is present in the common sorrel (*Rumex acetosa*), in the wood sorrel (*Oxalis acetosella*), in the garden rhubarb (*Rheum rhaponticum*), and in many other plants. It is the least wholesome of all the acids we have named; indeed, it acts, even in moderate doses, as an irritant poison.

ACETIC ACID is best known in the form of vinegar, which is a weak mixture of real acetic acid and water, usually flavoured with burnt sugar, or malt extract, or some condimental herb, as tarragon or chillies. Four kinds or varieties of vinegar are commonly used in Europe. These are—1, Malt Vinegar; 2, Wine Vinegar; 3, Wood Vinegar; 4, Vinegar from starch, sugar, &c. The acid in all of these products is identical, but there are evident differences in flavour and odour between the different sorts. It is usual, however, by the addition of colouring matter and flavouring essences, to render the detection of the sources of the inferior vinegars very difficult. All the varieties of vinegar, save that obtained by means of the destructive distillation of wood, are formed by the oxidation of alcohol. This compound, however formed, whether by the direct fermentation of sugar or from starchy materials, may be readily oxidized, gaining one additional proportion of oxygen and losing two proportions of hydrogen. The oxidation of weak alcohol into acetic acid may be accomplished by simple exposure of the liquid to warm air, but the change is usually accompanied and greatly aided by the presence of a vegetable organism such as yeast and the so-called vinegar-plant.

Good vinegar contains 5 per cent. of real or glacial acetic acid. Sulphuric acid is sometimes found in it to a larger extent than allowed by law, which is 1 part in 1,000. A solution of chloride of barium produces a more or less dense white precipitate only in vinegar containing sulphuric acid.

Case 108. Vinegar is extensively used not only as a condiment in sauces and salads, but for the preparation of a great variety of pickles. The vegetables thus preserved in vinegar include the greater number of those which we have described in the second part of this volume. Among them we may name unripe walnuts, onions, cauliflowers, gherkins, French beans, red cabbage, capsicums, samphire, mushrooms, and small unripe maize-cobs. Care should be taken that pickles are free from copper, a poisonous metal which sometimes finds its way into the vinegar through the solvent action of that acid upon the vessels used in preparing pickles.

§ 4.—Tea, Coffee, and Cocoa.

The group of food-adjuncts which we are now about to study is distinguished from all the preceding groups by the presence of a peculiar class of active principles called alkaloids. These contain the element nitrogen, which is absent from nearly all the essential oils, from all the kinds of alcohol, and from all the acids which occur in articles of food. Many of these alkaloids act powerfully on the nervous system, generally as sedatives and narcotics. Some of them are not only medicinal, but, even in small doses, actually poisonous. But the action of tea, coffee, and of many other food-adjuncts which owe their properties mainly to the presence of certain alkaloids, is often greatly modified by the other constituents of these food-adjuncts. Tea, for instance, contains a fragrant essential oil which is stimulating; while the presence of tannin, an astringent substance, further modifies the general result produced by the theine contained in an infusion of tea.*

We will first examine into the chemistry of the ordinary beverages—tea, coffee, cocoa, &c., which closely resemble one another in the peculiarity of their active alkaloids; afterwards a few notes on tobacco and opium shall be given.

Tea.

French, *Thé.* German, *Thee.* Italian, *Tè.*
(*Thea sinensis.*)

Cases 109 to 113. The plant which yields the tea of commerce is a native of Bengal: it is a shrub nearly allied to the camellia. It has been long grown in China, and may indeed be indigenous to parts of that empire. Our supplies come mainly from China, but a good deal of tea is grown in British India and in Japan.

* A fine specimen of theine may be seen in the collection.

There are three varieties of the tea-plant, from each of which both green and black tea may be prepared. Black tea is made from leaves which have been allowed to ferment before drying; green tea from leaves which have been quickly dried. However, large quantities of tea are still artificially coloured or faced, though the practice is a very deceptive one, even where the colouring materials used are not injurious to health. Old leaves, damaged leaves, and exhausted or spent leaves may be so faced with black-lead, indigo, Prussian blue, French chalk, or turmeric, that a fictitious bloom is imparted to them; and the four last-named materials are used in imitating or enhancing the tint of green tea. Different qualities of strength and flavour in tea are due to the varieties of the plant, to the soil and climate, to the age of the leaves, and to the mode of curing and drying them. The younger leaves yield teas of the highest quality and the most delicate flavour. These kinds contain more soluble matters than the older leaves. Black tea contains less theine, essential oil, and tannin than green tea. Exhausted or spent leaves and leaves which have been accidentally damaged by water are often re-dried, gummed, and faced with colouring matters; such teas and those adulterated with mineral matters and the leaves of other plants, are known in China as *lie* tea. One good test of the genuineness of a sample of tea consists in crushing 100 grains, and boiling it with water till nothing more is thus extracted. When this liquor is boiled down to dryness, the residue of fixed soluble matters thus separated should weigh about 35 grains, certainly not less than 26, for in the latter event the sample consists of or contains damaged, spent, or old leaves.*

* Dried specimens of varieties of the tea-plants cultivated in Assam, with numerous samples of prepared teas from Brazil, China, East Indies, Java, Formosa, Trinidad, Victoria (Australia), are shown in Cases 109 to 113. Samples of broken tea, consolidated by hydraulic pressure, are also shown, together with similar preparations of tea and coffee, to which milk and sugar have been added.

Good average black tea, as imported, may be fairly represented by the following figures :—

	In 100 parts.		In 1 lb. oz.	gr.
Water - - - - - - - -	8·0	...	1	122
Theine - - - - - - - -	2·5	...	0	175
Tannin - - - - - - - -	14·0	...	2	105
Essential oil - - - - - - -	0·4	...	0	28
Minor extractives - - - - - -	15·0	...	2	175
Insoluble organic matter - - - - -	54·4	...	8	308
Mineral matter - - - - - - -	5·7	...	0	399

Although the infusion of tea has little actual nutritive value, it increases respiratory action and excites the brain to greater activity. The stimulating effects of tea upon the nervous system are due to the essential oil and the theine: the tannin is an astringent. It has been estimated that half the human race now use tea either habitually or occasionally.

COFFEE.

French, *Café.* German, *Kaffee.* Italian, *Caffè.*
(*Coffea Arabica.*)

The shrub or small tree which yields the seed coffee is a native of Abyssinia. This plant belongs to the Rubiaceæ, an extensive order, including the Peruvian bark, ipecacuanha, and madder plants. Coffee is now grown throughout the tropics. Our principal supplies* come from Ceylon, but Java, the West Indies, Brazil, and Central America produce large quantities.

* Specimens of raw coffee berries, and branches of the coffee tree, are shown in Cases 114 and 115, together with samples of roasted coffee, coffee essence, and substitutes for and adulterants of genuine coffee. The specimens of coffee berries come from the following countries: Yemen (Mocha); Colombo, and other parts of Ceylon; Neilgherry Hills, Bombay; Cape Verde Islands, St. Thomas, Madeira, Costa Rica, Madras, Mozambique, Angola, Bahia, Venezuela, Java, Sandwich Islands; and the French Colonies of Réunion, Martinique, Guiana, Guadaloupe, Gaboon, Senegal, Tahiti, Pondicherry, and Mayotte.

It appears that more than one distinct species of coffee plant yields the berries met with in commerce, and that the *Coffea liberica* is superior to the ordinary kind or variety. Originally the coffee plant was introduced into Arabia in the fifteenth century, while it was not till the year 1652 that the first coffee-shop was opened in London.

The fruit of the coffee tree, which presents a superficial resemblance to a red cherry, contains two seeds. The soft pulp and the parchment-like covering of the seed having been removed, the imported coffee "beans," as they are now called, are roasted. Thus moisture is driven off and a fragrant oil produced, to a mere trace of which the strong aroma of roasted coffee is due.

Many cheap vegetable matters, as acorns and chicory and parsnip roots, are used, when roasted, to adulterate ground coffee.

Case 114. Roasted coffee generally contains—

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	5·0	0	350
Albuminoids	15·0	2	175
Theine (Caffeine)	0·6	0	42
Tannin	4·0	0	280
Minor extractives	34·4	5	220
Cellulose	38·4	6	63
Mineral matter	4·6	0	322

Coffee owes its stimulant effect on the circulatory and nervous systems to the theine and aromatic oil present. In order that coffee may be enjoyed in perfection, not only must it be free from admixture with the cheap and miserable adulterants commonly stated to improve its taste, but it must be freshly roasted to the right extent, freshly ground, and so made into a beverage that its soluble constituents are extracted without its aroma being dissipated.

Cocoa.

(*Theobroma Cacao.*)

The chocolate tree occurs both wild and cultivated in the northern parts of South America, and also in Central America, as far north as Mexico. It is grown chiefly in Brazil, Guiana, and Trinidad. There are four species of *Theobroma* known.

A single fruit of this tree contains many seeds closely packed in a little pulp. The cleaned cocoa seeds, after drying, roasting, and winnowing from their husks, are broken into coarse fragments known as *nibs*. These, after long boiling in water and removal of the floating cocoa-butter, yield a light beverage, milder in its action upon the respiratory and nervous system than tea or coffee.

Case 116. Good cocoa-nibs contain—

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	5·0	...	0	350
Albuminoids	17·0	...	2	315
Fat	51·0	...	8	70
Theobromine	1·5	...	0	105
Cacao-red	3·0	...	0	210
Gum, &c.	10·9	...	1	326
Cellulose and lignose	8·0	...	1	122
Mineral matter	3·6	...	0	252

Theobromine is the active principle of cocoa; the taste and aroma of cocoa are due mainly to an essential oil and to tannin. For general use cocoa is a milder and less stimulating beverage than tea or coffee.

Prepared Cocoa.

Most of the cocoa consumed in Europe is prepared for use by admixture with other substances, or by removing part of the fat or "cocoa-butter." Cocoa-nibs, if simply ground, would yield a rich but heavy food, not a beverage. It may, indeed, be shown that 100 parts of cocoa-nibs contain heat-givers equivalent to 132 parts of starch, while the flesh-formers present amount to no less than 17 parts—the ratio of the latter to the former being thus as 1 to 8. One pound of cocoa-nibs might in fact produce as much as 2¾ oz. of the dry nitrogenous substance of muscle.

The chief forms of prepared cocoa are—

Case 116. *Soluble Cocoa.* Mixtures of ground cocoa, with starch, &c., are called soluble cocoa. With boiling water a thick mucilage is produced, in which the finely-ground cocoa remains suspended—it does not dissolve.

Chocolate is cocoa ground up with sugar and flavoured with *vanilla,* sometimes with bitter almonds as well, or with cinnamon and other spices; it generally contains some starch or flour.

Flake and Rock Cocoa are made from the whole seed, nib and husk being ground together to a paste.

Pressed Cocoa (such as Van Houten's) is prepared from cocoa-nibs—a small proportion of the cocoa-butter having been previously expressed so as to leave about 33 per cent.

Maté, or Paraguay Tea.

(*Ilex paraguayensis.*)

Case 113. In Paraguay, North Corrientes, Chaco, and South Brazil, the leaves of a small tree are used just in the same way that tea is employed in China, India, and Japan. The infusion of these leaves contains tannin, an aromatic oil, and some theine. Indeed, it is a singular and most instructive fact that the chief characteristic constituent of tea, coffee, maté, guarana-bread, and the African kola nuts, is identical—the alkaloid theine or caffeine. Even cocoa contains a very nearly-related substance—theobromine. Naturally, all these plants have come into general use amongst the inhabitants of the countries where they flourish; and now it is ascertained that their chief physiological properties depend upon the presence of a substance which is identical in five of them, and closely allied in the sixth.

Maté is prepared by drying, and then gently roasting the leaves, still attached to their stems and branches: the whole tree being often cut down for this purpose. When the drying and roasting have rendered the leaf brittle, and developed the aromatic oil which gives the peculiar flavour and odour to maté, then the branches are removed to large rough mortars, which are merely pits dug in the ground, where it is beaten and bruised till the leaves are reduced to fragments. The maté, after sorting, is next placed in fresh bullock-skins, well rammed, and placed in the sun to dry.

The composition of maté is somewhat variable. Several sorts are known in the South American markets: *caa-cuys*, the head of the leaf; *caa-miri*, the leaf torn from its mid-rib and veins without roasting; and *caa-guaza*, or *yerva de palos* of the Spaniards, which contains the whole leaf with leaf-stalks and small branches roasted. In consequence of these different qualities, and the crude mode of preparation in general use, it is found that the quantity of mineral matter in maté is twice as great in some samples as in others. The average amount of tannin may be set down as 16 per cent., while the theine is present to the extent of about 1·3 per cent.

Maté does not yield a wholesome beverage fit for habitual use. It acts upon the nervous system mainly, but it affects the digestive tract also, and often injuriously. The habitual use of hot, strong infusions of maté is very prejudicial to the general health, although the occasional employment of this food-adjunct after great fatigue is refreshing and restorative. But confirmed maté-drinkers, like opium-eaters, prefer to give up their food rather than their daily allowance of maté.

Maté is prepared for drinking by pouring boiling water upon a teaspoonful of the powdered leaves in a cup or calabash, adding a little sugar, and sucking up the infusion through a small tube or "bombilla."

GUARANA-BREAD is another substitute for tea. It is used extensively in Brazil and other parts of South America. It is prepared from the seeds of a small climbing plant (*Paullinia sorbilis*). The seeds are roasted, ground, mixed with a little water, and pressed into sausage-like forms. Pieces broken from one of these rolls have merely to be infused in cold water to form a refreshing and grateful beverage, said also to be a valuable remedy in sick-headache. It contains no less than 5 per cent. of theine.

Case 124. COCA, the leaves of *Erythroxylon Coca*, may perhaps be appropriately named in this section. This plant, which is used as a stimulant in Peru, contains an alkaloid called cocaine. It is believed to possess the power of sustaining strength and endurance during unusual bodily exertion. This plant, the coca, is perfectly distinct from the *Cocos nucifera* and the *Theobroma Cacao.*

Case 113. Under the designation of "tea substitutes" we may group many vegetable products which are, or have been, used in different parts of the world. With the exception of the kola-nut of Central Africa, none of these minor tea-substitutes are known to contain the same alkaloid as tea, coffee, and maté. We name a few of the different plants yielding such herb teas.*

Swiss tea, from several Alpine plants;
Bosjes and Boer tea (*Cliffortia ilicifolia* and *Cyclopia vogelii*);
Hottentot tea (*Helichrysum serpyllifolium*);
Mountain tea (*Gaultheria procumbens*);
Lime tea (flowers and leaves of *Tilia europæa*);
Labrador tea (*Ledum palustre* and *L. latifolium*);
Kola tea (nuts of *Cola acuminata*);
Appalachian tea (*Prinos glaber*);
Corossal tea (*Anona muricata*);
Sumatra tea (leaves of *Coffea arabica*).

§ 5.—TOBACCO AND OPIUM.

Amongst the food-adjuncts we give the last and lowest place

* Samples of the teas here named and of many other kinds are shown in Case 113. The specimens include New Jersey tea, Heidelberg tea, Siderita tea from Greece, Faham tea of Mauritius, and many substances used as tea in the French colonies of Réunion, Guiana, Guadaloupe, Gaboon, Martinique, and St. Pierre.

to tobacco and opium. If there be difficulty in fixing the exact position which we should assign to tea or to spices, such difficulty is more decided still in the case of tobacco. But although we cannot regard tobacco as a true food, we should remember that there are many circumstances under which really nutritious substances cease to be nutritious. The work done by the various nutrients which we have considered is not always the same, for it varies with the quantities consumed, and the modes in which they are used. Thus a nutrient taken in excess may become, in part, at least, a food-adjunct; while a food-adjunct may become a medicine or even a poison. Water itself affords a good illustration of some of these points. A due daily supply of it is necessary as a nutrient; but a considerable excess of it will act medicinally, and it becomes hurtful and in some sense poisonous when still larger quantities are consumed. And we see that while all the true nutrients are equally necessary to the human body, provided that they are given in due proportion and quantity, the food-adjuncts have very variable values. Alcoholic liquors afford a characteristic instance of this fact. Taken in limited quantity, they may justly be regarded as belonging to that section of the food-adjuncts which perhaps best deserves the name of accessory-food. But it is too easy to pass this limit, and to change the office performed by alcohol into that of a poison. Tobacco and opium must be ranked either as medicines or poisons. Tobacco is the less baneful of the two, but its excessive use is followed by a disordered state of the nervous system, and may lead to dangerous and even fatal diseases.

TOBACCO.

French, *Tabac.* German, *Tabak.* Italian, *Tabaccho.*
(*Nicotiana Tabacum*, and other species.)

This plant furnishes the most generally used of all the narcotics. A native of America, it was introduced thence into many other parts of the world, and has been cultivated in Europe for more than three centuries. Sir Walter Raleigh much promoted its use in England. In the year 1872 nearly 20,400 tons of unmanufactured tobacco were imported into this country, half of this quantity being from the United States of America. The duty paid on the tobacco for home consumption amounted to £6,694,000 in the above-named year.

It appears that there are several species of plants which yield the tobacco of commerce, although they are all included in the genus *Nicotiana*. The most abundant sort is furnished by *N. Tabacum; N. rustica* is said to yield the East Indian tobacco, as well as Latakia and Turkish; while *N. persica* is the tobacco of Shiraz. Other species are *N. quadrivalvis, N. multivalvis*, and *N. repanda*. But the distinctions between these plants, and the several sorts of prepared tobaccos which they are assumed to furnish, are not yet accurately known.

Case 117. The composition of dried tobacco leaves varies greatly with the conditions of their growth, as well as with the sort of plant grown. The mineral matter is considerable (13 to 28 per cent.) and includes much nitre, the presence of which gives to the dry leaf its peculiar property of slowly smouldering away with slight deflagrations, like amadou or tinder. The most important principle or constituent of tobacco is, however, the *nicotine*, a nitrogenous substance of the group of the alkaloids. This nicotine has a very powerful action upon the nervous system, being a narcotic, like the morphine, narcotine, &c., found in opium. Some of the more delicate tobaccos of Havannah contain less than 2 per cent. of nicotine; the stronger tobaccos, as Virginian shag, contain 6 per cent. As much as 10 per cent. has been found in some samples grown in Europe. When the tobacco is burnt in the operation of smoking, the nicotine is in great part destroyed, other volatile alkaloids (picoline, &c.) being produced from it. These are contained in the smoke, are liquid, like nicotine, and are also poisonous. The average amount of water in commercial tobacco is 13 per cent.

The preparation of tobacco leaves for use by drying, fermentation, and other processes, alters very much their natural character and flavour. Sometimes various "liquors" and "spices" or "pickles" are used in this treatment of the leaves, different flavours being developed thereby. Snuff is prepared chiefly from the stalks and ribs of the tobacco leaf.*

OPIUM.

Case 124. Opium is the dried latex or milky juice of the opium-poppy (*Papaver somniferum*). It is procured by making cuts in her unripe capsule, and collecting the juice which exudes. The half-dried juice is moulded into small masses, and then finally covered with leaves of different plants, or with thin protective coverings of other materials, such as mica. The opium-poppy is extensively grown in Egypt, Asia Minor, Persia, Algeria, and the East Indies. The large Chinese demand for opium is supplied mainly from British India; in the European market the best opium (known as Turkey or Smyrna opium) is the produce of Asia Minor.

Opium contains a large number of different alkaloids or active principles, fifteen of these having been already described. The most important of these constituents is morphine, to which alkaloid most of the characteristic properties of opium are due. The quantities of morphine present in different samples of opium differ much: Smyrna opium sometimes contains as much as 14 and sometimes less than 7 per cent. Most of the alkaloids of opium are poisonous: thebaine is the most virulent.

Opium is very valuable as a medicine, acting in small doses

* Samples of tobacco in the raw and manufactured state, including snuff, cigars, cigarettes, negrohead, cavendish, &c., are shown in Cases 117 to 122. The samples are from the following countries: Brazil, Corsica, France, French Colonies, Germany, Greece, Havannah, Hungary, East Indies, Java, Kurdistan, New South Wales, Queensland, Sweden, Shiraz, Victoria, and United States of America.

as a sedative and anôdyne, alleviating pains, and producing a quiet sleep. When smoked, as in China and many other parts of the world, it is generally consumed with tobacco or some other leaf in a pipe.* Indeed, many of the Chinese tobaccos contain opium. It produces a peculiar soothing effect, but the habitual use of opium is most hurtful to mind as well as body. After all it is doubtful whether opium should find a place in a food-collection. The same observation applies also to hemp.

* Chinese opium, opium-pipes, and prepared tobaccos are shown in Case 139 (see National Foods).

PART V.—OF DIET AND DIETARIES.

THE work and offices performed by human food have been already discussed in the First Part of this hand-book. What we propose to describe in the few pages which remain at our disposal is the nature of various actual dietaries. But we will first look at the relative values of different constituents and articles of food before we pass on to consider how these food-materials are actually employed in the daily rations of individuals, of groups of persons engaged in similar occupations, and of nations.

§ 1.—FOOD-EQUIVALENTS.

As several different kinds of compound nutrients are necessary to sustain life and activity, to calculate the amount of carbon and the amount of nitrogen, &c., in a day's ration will not alone suffice to show the dietetic value of that ration. We must first of all be sure that the carbon and the nitrogen are present in such forms as are practically available for nutrition. This being the case, we may assume that about 75 per cent. of the fat present in a dietary is carbon; 42 per cent. of the other heat-givers, and 53 per cent. of the flesh-formers, also consisting of the same element. If we take the hydrogen of all these nutrients into account, and calculate it into its equivalent quantity (so far as heat-giving power is concerned) of carbon, we shall find that all the above figures must be increased. It will not lead us into serious error if we assume that hydrogen is equivalent to thrice its weight of carbon. Thus we may calculate the weight of carbon or its equivalent in any given daily allowance of food of which the composition is known. As the nitrogenous nutrients contain on an average nearly 16 per cent. of nitrogen, the quantity of this element present in a day's ration may also be ascertained without difficulty. Now, an adult man weighing 154 lb. will require—under ordinary conditions of living, and if performing a fair amount of work and taking moderate exercise—something like the following amounts per diem :—

Of carbon - - - -	4,900 grains.
Of nitrogen - - - -	300 ,,

These, at least, are round numbers easily remembered and useful for our present purpose—the calculation of food-equivalents; that is, the weights of different kinds of food which can furnish in an available form the above amounts of carbon and of nitrogen.

Case 125. The following table shows approximately the quantities of various vegetable and animal products which would be capable of furnishing the supply of *carbon* requisite for one day :—

	lb.	oz.
1. Bacon - - - - - - - - - -	1	0
2. Scotch oatmeal - - - - - - -	1	9
3. Ripe dry peas - - - - - - -	1	10
4. Cleaned rice - - - - - - -	1	11
5. Gloucester cheese - - - - - - -	1	11
6. Wheaten flour - - - - - - -	1	13
7. Wheaten bread - - - - - - -	2	8
8. Eggs, mixed yolks and whites - - - -	5	3
9. Potatoes - - - - - - - -	6	6
10. Lean of beef - - - - - - -	6	6
11. Cows' milk - - - - - - - -	8	11
12. White turnips - - - - - - -	20	0

The necessary *nitrogen* for one day would be furnished by—

		lb.	oz.
1.	Gloucester cheese	0	15
2.	Ripe dry peas	1	3
3.	Scotch oatmeal	1	10
4.	Eggs, mixed yolks and whites	2	0
5.	Lean of beef	2	1
6.	Wheaten flour	2	8
7.	Bacon	3	4
8.	Cleaned rice	3	7
9.	Wheaten bread	3	13
10.	Cows' milk	6	8
11.	Potatoes	24	0
12.	White turnips	54	4

A glance at the preceding table will show that no one article of food taken alone can furnish the exact quantities, *both* of nitrogen and of carbon requisite for the day's nourishment; cows' milk, however, occupies nearly the same position in both sections of the table. Potatoes, on the other hand, are so deficient in available nitrogen that nearly four times the weight of these tubers necessary to furnish the requisite quantity of carbon must be eaten in order that the former element may be taken in sufficient amount. To bring out the full meaning of the preceding table it should be studied in connection with the two tables which we now proceed to give.

The *quantities* of different articles of food requisite for a day's ration, so far as the important elements, nitrogen and carbon, are respectively concerned, having been now discussed, we may proceed to consider the relative amounts of work producible from 1 lb. of different important articles of food. The following table contains the results furnished by some of Dr. Frankland's experiments :—

Name of food.	Tons raised 1 ft. high.	Name of food.	Tons raised 1 ft. high.
Beef fat	5,649	Oatmeal	2,439
Butter	4,507	Arrowroot starch	2,427
Cheshire cheese	2,704	Wheaten flour	2,383

Name of food.	Tons raised 1 ft. high.	Name of food.	Tons raised 1 ft. high.
Pea meal	2,341	Lean of veal	726
Ground rice	2,330	Guinness's stout	665
Gelatin	2,270	Potatoes	618
Cane sugar	2,077	Whiting	491
Yolk of egg	2,051	Bass's ale	480
Grape sugar	2,033	Apples	400
Hard-boiled egg	1,415	Milk	390
Bread crumb	1,333	White of egg	357
Lean of boiled ham	1,041	Carrots	322
Mackerel	1,000	Cabbage	261
Lean of beef	885		

We may here remind the reader that the greatest amount of work outside the body which the oxidation within the body of 1 lb. of each of the above substances could enable a man to perform, would be about one-fifth of the amounts mentioned in the above list.

The relative cost of the several quantities of the above substances which would contain the same energy, and so be capable of performing the same amount of work, is given in the following

TABLE OF THE WEIGHT AND COST OF VARIOUS ARTICLES OF FOOD REQUIRED TO BE OXIDIZED IN THE BODY, IN ORDER TO RAISE 140 LB. TO THE HEIGHT OF 10,000 FEET :—

Name of food.	Weight in lb.	Price per lb. s. d.	Cost. s. d.
Ground rice	1·341	0 2	0 2¾
Bread	2·345	0 1½	0 3½
Oatmeal	1·281	0 2¾	0 3½
Flour	1·311	0 2¾	0 3¾
Pea meal	1·335	0 3¼	0 4½
Potatoes	5·068	0 1	0 5¼
Beef fat	0·555	0 10	0 5½
Commercial grape sugar	1·537	0 3½	0 5½
Cod-liver oil	0·553	1 2	0 7¾
Cane sugar	1·505	0 4	0 8½
Cocoa-nibs	0·735	1 0	0 8¾
Cheshire cheese	1·156	0 10	0 11½
Apples	7·815	0 1½	0 11¾
Cabbages	12·020	0 1	1 0¼
Butter	0·693	1 6	1 0½

Name of food.	Weight in lb.	Price per lb. s. d.	Cost. s. d.
Carrots - - - -	9·685	0 1½	1 2½
Hard-boiled eggs - -	2·209	0 6½	1 2½
Milk - - - -	8·021	0 5 per quart	1 3½
Arrowroot - - -	1·287	1 0	1 3½
Mackerel - - - -	3·124	0 8	2 1
Guinness's stout - -	6¾ bottles	0 6 per bottle	3 4½
Lean beef- - - -	3·532	1 0	3 6½
Lean veal- - - -	4·300	1 0	4 3½
White of egg - - -	8·745	0 6	4 4½
Bass's pale ale - - -	9 bottles	0 6 ,,	4 6
Lean ham, boiled - -	3·001	1 6	4 6
Whiting - - - -	6·369	1 4	9 4
Isinglass - - - -	1·377	16 0	22 0½

The above table does not take the element nitrogen into account; and thus many articles of food which appear the most economical, are quite unequal to the task of supplying the whole needs of the body. Beef-fat, for instance, is destitute of nitrogen, or nearly so, while on the other hand pea-meal contains too large a proportion to be utilised completely were this article of food to be consumed alone. But a reference to preceding pages of this volume, especially to the data given under the analyses of the several foods as to the ratio of flesh-formers to heat-givers, will enable the reader to obtain the necessary information for the complete comprehension of this table; he will then be in a position so to adjust the proportion of the several articles of food to one another as to construct useful dietaries in which there will be no marked excess of carbon over nitrogen, or of nitrogen over carbon—that is, no marked excess beyond the quantities respectively required of each element.

In the above table the force-producing value of the fermented liquors named is exaggerated, for the alcohol they contain is very imperfectly utilised in the body.

§ 2.—Public Dietaries.

The experience of governments and local authorities in the supply of food to persons depending upon dietaries furnished at the public cost, has led to very conclusive results as to the nature and amount of nutrients requisite for varying amounts of work and for various conditions of bodily health. The dietaries of the army and navy, as well as of hospitals, prisons, and workhouses, will generally be found to correspond with the amount and character of the work demanded from the persons concerned. In the former "Inventory of the Food Collection" the following figures are given as representing the nitrogenous, or flesh-forming nutrients, and the carbon in the daily diet of soldiers, sailors, pensioners, and other persons subsisting on public or ascertainable dietaries.

Case 126. 1. The English soldier requires, both in this country and in India, about 5 oz. of flesh-formers in his daily food; he must receive likewise 10 oz. of carbon.

2. The English sailor receives 5 oz. of flesh-formers and 10 oz. of carbon.

3. The English sailor, in his salt-meat dietary, receives nearly 6 oz. of flesh-formers daily, and 12 oz. of carbon. These larger amounts may be necessary owing to the less digestible nature of his food.

4. The Dutch soldier, *in war*, receives daily 5 oz. of flesh-formers with 10½ oz. of carbon.

5. The Dutch soldier, *in peace*, or in garrison, has a lower diet, containing only 3½ oz. of flesh-formers and 10 oz. of carbon. With this diet he is below fighting condition.

6. The French soldier, although his diet is made up with articles of food very different from those eaten by the English soldier, receives nearly the same amount of flesh-formers—4¾ oz., with 12 oz. of carbon. The French soldier is thus always kept in fighting condition.

7. The Royal Engineers, when occupied in the South Kensington Museum, were found to eat an amount of food containing $4\frac{6}{10}$ oz. of flesh-formers, and 13 oz. of carbon daily.

When the sailor or soldier retires from active work he naturally requires less amounts of flesh-forming and heat-giving nutrients in his food. It is found, however, that the carbon actually consumed is but little lower under these circumstances. Paupers in workhouses, of whom but little labour is expected, require less flesh-formers and carbon than active soldiers and sailors and artisans. Boys 10 years of age, at school, receive about half the flesh-formers required by active men, and about three-fourths the quantity of carbon. Ladies in luxurious repose consume about the same amount as young schoolboys. It must always be remembered that flesh-formers can be, and constantly are, used in the human body as force-producers; but, on the other hand, the heat-givers or force-producers (starch, sugar, and fat) cannot be applied to the formation of flesh. The dietaries of some of the classes of persons named in this paragraph are illustrated below:

Case 127. 8. Greenwich pensioners receive $3\frac{1}{2}$ oz. of flesh-formers and 10 oz. of carbon in their daily rations.

9. The Chelsea pensioners have 4 oz. of flesh-formers and $9\frac{3}{4}$ oz. of carbon.

10. The old men of Gillespie's Hospital, Edinburgh, have 3 oz. of flesh-formers and 10 oz. of carbon daily.

11. Paupers in our workhouses receive, on the average, $3\frac{1}{4}$ oz. of flesh-formers and $8\frac{1}{4}$ oz. of carbon only.

12. The boys of Christ's Hospital in London receive $2\frac{1}{2}$ oz. of flesh-formers and 7 oz. of carbon daily.

It will be instructive to give the details of a few other dietaries in a somewhat different and more extended form. In the table which follows, we show the amounts of flesh-formers and of the two chief groups of heat-givers in eight dietaries of widely different characters. No great degree of accuracy is attainable in such tables, but the figures we have adopted will be found near enough to the truth for our present purpose. It may be repeated here that it requires about 4 oz. 150 gr. of albuminoids to furnish 300 gr. of nitrogen.

Cases 128 and 129. The daily rations of Public Dietaries will contain about the following quantities of—

Diet.	Albuminoids.		Fat.		Starch, Sugar, &c.		Mineral matter.	
	oz.	gr.	oz.	gr.	oz.	gr.	oz.	gr.
Prisoners' Punishmen (=1 lb. bread)	1	130	0	112	8	70	0	162
Prisoners for seven days (=1 lb. bread and ¼ lb. oatmeal)	1	350	0	210	10	312	0	262
Subsistence or famine	2	145	0	368	11	302	0	280
Prisoners' light labour	3	222	1	138	16	318	1	25
Prisoners' hard labour	4	36	1	244	18	353	1	145
Healthy adults with moderate exercise	4	94	1	174	11	302	0	312
Hard-working artisans	5	35	2	400	22	96	0	408
Navvies, blacksmiths, and others working very hard	5	280	2	150	20	180	0	420

The above numbers illustrate the necessity for largely-increased quantities of nitrogenous compounds or flesh-formers when really heavy work has to be done. Practical experience points unmistakably to this conclusion, but it is not yet clearly ascertained in what way these greater quantities and higher proportions of nitrogenous matter are utilised in the body. As the albuminoids may perform many functions, we are at a loss to know upon which of these functions there is the most decisive call during hard bodily labour. The notion that the nitrogenous constituents of muscle are extensively consumed during hard work is inexact; but it is probable that the non-nitrogenous heat-givers and force-producers cannot do their work fully unless there be a commensurate increase in the amount of flesh-formers which accompany them. Muscles which have to be exercised or used much increase, requiring for that increase additional supplies of flesh-formers over and above those used for other purposes in the nutrition of the body.

We have not space to discuss the dietaries of children and invalids, and of athletes in training, although these subjects are important and interesting particularly through the light which they derive from chemical and physiological investigations. Attempts have been made to prepare foods suitable for infants from the common bread-stuffs by converting much of their starch into dextrin and glucose. This has been done by heat or by the Case 96. action of malt. Still, there is often a deficiency of flesh-formers in such substitutes for mothers' milk. In the dietaries considered suitable for invalids, attempts have been made to devise food-preparations from which certain nutrients are Case 39. wholly excluded. For diabetic patients gluten bread and biscuits, bran biscuits, as well as cakes made with sweet almonds and eggs, have been prepared. In such preparations both starch and sugar are partially or wholly excluded. Fluid Case 77. extract of meat is another article which is capable of being used in conjunction with the above vegetable preparations so as to complete the dietary of a day. This extract must not be confused with Liebig's Extract, which is a stimulant and restorative, not a nutrient or substantive food. The fluid extract of meat contains all the constituents of lean meat in a soluble condition: indeed, an artificial process of digestion has been already accomplished before the material is consumed as food.

§ 3.—National Foods.

It must not be imagined that the vegetable or animal products which are used as the staple articles of food in different countries are in all instances perfectly adapted to the needs of the inhabitants. Some at least of the national foods and dietaries are too bulky, and thus lead to an excessive distension of the stomach and abdominal viscera. Such a result may ensue, if twice, thrice, or four times as much as is necessary of the other nutrients has to be eaten in order to provide the requisite quantity of flesh-formers. But we may often trace several elements at work in the construction of national dietaries. Besides the local peculiarities of the vegetable and animal foods which are most abundant and attainable, we have the influence of those instinctive appetites for particular articles of food, which certainly exist however difficult of explanation they may be. Religious or superstitious usages are also most important factors in the result in many instances, although they will not always serve to explain the abstention from certain perfectly wholesome and nutritious foods, or the consumption of absolutely noxious or useless materials like clay. But this aspect of the subject before us, though interesting as a study, could not be discussed without entering into very voluminous details as to the curiosities of food. We may, however, give a few illustrative examples of national foods, citing those which are in common use in India, China, Japan, and Siam.

Cases 130 to 132. *Indian Foods.* These include cereal grains, pulse, salep, arrowroot, fungi, oils, sugar, coffee, condiments, spices, and narcotics.

Cases 133 to 139. *Chinese Foods.* These include wines and spirits, oils, confectionery, preserved fruits and vegetables, dried fruits and grains, bamboo shoots preserved, cinnamon and cassia buds, tobacco, teas and flowers for scenting them, brick-tea, gelatinous substances, condiments and spices; nor must we omit pipes for tobacco and opium smoking, chopsticks, &c. Amongst these products may be noted soy and an oil prepared from the soy bean; tea-seed oil; cakes not unlike some of those made by European confectioners; various preserved fruits and vegetables in sealed canisters—for in the art of thus preserving such perishable products, the Chinese have long been skilful. The Chinese preserve some of their fruits, roots, flowers, &c., in brine or salt; some in treacle, and some in sugar. Arrowroot is largely made from the root of a water-lily in China, in the Tae-hoo lake districts. Amongst other Chinese foods, we may name several kinds of sea-weed, fish-maws, trepang, *bêche-de-mer*, sharks' fins, and edible birds'-nests.

Cases 140 to 143. *Japanese Foods.* Amongst these are wheat, rice, and many other cereals; gelose, a gummy substance prepared from seaweed, gelatinous in character, but free from nitrogen; dried and salted fish; sea-slugs, confectionery, &c. &c.

Cases 144, 145. *Siamese Foods.* Amongst these may be named various beans and seeds, ground nuts, betel nuts, sugars, tobaccos, spices, dried fish, dried meat, fish-maws, edible birds'-nests, sea-slugs, sharks' fins, and deer sinews.

§ 4.—Ancient Foods.

The tombs of Egypt have furnished us with specimens of grain and other products consumed as food by the ancient inhabitants. Olive oil has been found still liquid in a vase carefully closed up, which was recently discovered at Thebes; but the statement as to wheat, from a mummy case, having germinated is not authenticated. The best insight into the food of Roman towns and times is furnished by the wonderful series of vegetable products discovered from time to time at Pompeii, and now for the most part preserved in the National Museum at Naples. This collection includes even loaves of bread, blackened by the separation of their carbon, yet still retaining their shape, and inscribed with details of their manufacture. Were such tangible evidence of the nature of ancient Roman food wanting, we should still be able to obtain some acquaintance with the subject from the descriptive writings which are extant, and from the pictorial representations of articles of food which remain on the walls of the Pompeian houses. But even in England we find relics of Roman food in the bones of the pig, and in the oyster, mussel, and snail shells which abound near our Roman stations. Similar evidence with regard to other ancient European peoples is afforded by the waste heaps or kitchen middens so abundant in some parts of the

Continent, in the *débris* of bones discovered during recent years in many caves once inhabited by man, and in the lake-dwellings of Switzerland, Savoy, and Denmark. In these last instances the
Case 146. evidence of the use of many fruits and grains has been furnished by the perfect preservation of these substances. Fish-hooks have also been found, together with other proofs of the use of animal foods. One of the most productive of all the Swiss lakes is that of Pfäffikon, in the canton of Zurich. Here remains of many kinds of food were disinterred from the peat of the lake-dwellings of Robenhausen. These lake-dwellings were built on piles, covered above with planking. In the case of some of these structures, no evidence of the use of metals by their builders has been detected; they belong to a stone age, locally anterior to those of bronze and iron. The food remains of these very early inhabitants of Europe are of high interest.

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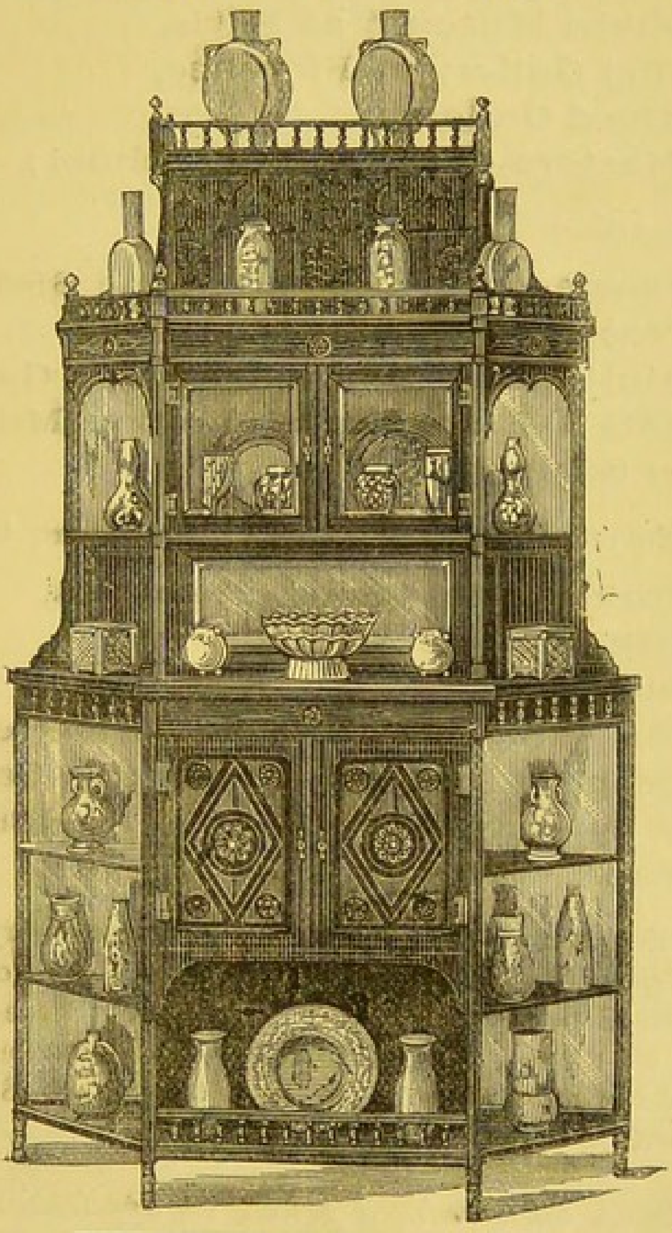

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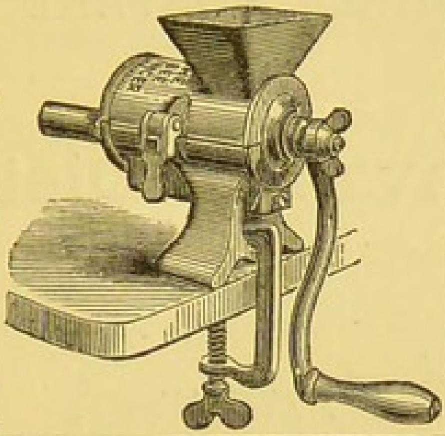

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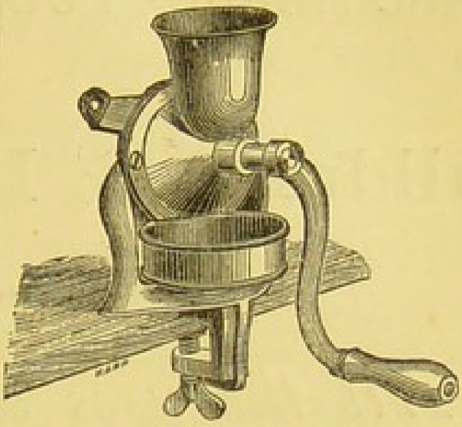

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