Food

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VICTORIA AND ALBERT MUSEUM
SCIENCE HANDBOOKS

[BRANCH MUSEUM, BETHNAL GREEN]

FOOD

1900.

CONTENTS.

PART I.—Of Food in General.

PART II.—Of Vegetable Foods.

PART III.—Of Animal Foods.

PART IV.—Of Food-Adjuncts.

PART V.—Of Diet and Dietaries.

FOOD.

PART I.—OF FOOD IN GENERAL.

§ 1.—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 warming of water and its conversion into steam or vapour form 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 of the available 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 energy, called potential 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°·4 Fah.), and partly in other forms, as that of work or mechanical motion. All the internal and external work of the body is thus done by the stored-up 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. The locomotive is a comparatively simple mechanism, constructed for one definite end; the human body, on the other hand, is most complex, and performs many different functions. Indeed it may be likened to a system compounded of a number of associated steam-engines, each member of the system possessing certain characteristic peculiarities of pattern, of use, and of fuel. Again, the activity of the body is at least twofold—muscular and nervous—and it has numerous differing parts, requiring different and constant nourishment. These parts include the nervous and muscular systems, membranes, glands, cartilages, bones and other tissues. Moreover the body is a living and thinking entity, and can vary at will within certain limits, the extent and direction of its own activities; in these peculiarities it differs strikingly from any mere mechanical contrivance. 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 nature of food and about the work which it has to do in the body, and to illustrate, or rather to indicate, the way in which that work is done.

§ 2.—Composition of the Human Body.

We may now consider the composition of the human body. Every one 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, mainly derived from numerous analyses of separate parts or organs, will afford some notions on this interesting subject. But it must be noted that the weights given are the roughest approximations to a general average. Very great discrepancies will be seen when the amounts set down, of the chief compounds in the human body, by different authorities are compared. These discrepancies arise mainly from three causes: (1), the varying weight of the several distinct important soft organs of the body; (2), the varying weight of the bones; (3), the varying amount of fat present. This third and last cause of variation is the most important. For with an increase of fat the amount of water present in the human body greatly diminishes, and *vice versâ.* So a recent writer, who assumes that a normal man (weighing 154 pounds), contains just 24 pounds of fat, assigns him no more than 94 pounds of water. The author of this handbook, working in part from original and unpublished data, finds no more than 4½ pounds of fat, but no less than 109 pounds of water. 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

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. ALBUMEN, MYOSIN, and similar substances, forming the chief organic material of muscular flesh, and also occurring in chyle, lymph, and blood -	16	8	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 or COLLAGEN: 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 or CHONDRIGEN: 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. CARBONATE OF LIME is found chiefly in bone - -	1	0	350
10. NEURIN, with lecithin, cerebrin, and several other nitrogenised, sulphurised, or phosphorised compounds, is found in brain, nerves, etc. -	0	13	0
11. FLUORIDE OF CALCIUM is found chiefly in bones and teeth - - - - - - - - -	0	7	175
12. PHOSPHATE OF MAGNESIA, chiefly in bones and teeth -	0	7	0
13. CHLORIDE OF SODIUM, or common salt, occurs throughout the body - - - - - - - -	0	7	0
14. CHOLESTERIN, INOSITE, and GLYCOGEN are compounds containing carbon, hydrogen, and oxygen, found in brain, muscle, and liver - - -	0	3	0
15. SULPHATE, PHOSPHATE, and ORGANIC SALTS OF SODIUM are found in all liquids and tissues -	0	2	107
16. SULPHATE, PHOSPHATE, and CHLORIDE OF POTASSIUM are found in all tissues and liquids - -	0	1	300
17. 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. It may be mentioned here that about 100 distinct organic compounds have been found in the human body.

Now that we have recorded 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; albumen 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*.

ALBUMEN, MYOSIN, OSSEIN, KERATIN, CARTILAGIN, contain *carbon*, *hydrogen*, *oxygen*, and *nitrogen*, and *sulphur* (in the first two).

HÆMOGLOBIN, all the above elements with *iron* as well.

NEURIN and CEREBRIN contain *carbon*, *hydrogen*, *nitrogen*, and *oxygen*.

LECITHIN contains *carbon*, *hydrogen*, *nitrogen*, *phosphorus*, 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:

ELEMENTS OF THE HUMAN BODY.

	lb.	oz.	gr.
1. OXYGEN: a gas, the great supporter of combustion. This gas constitutes $\frac{8}{9}$ths of the weight of water and more than $\frac{1}{5}$th of the air. The quantity in the human body (most of which is combined with hydrogen, in the form of water) would fill a space of some 1,290 cubic feet, and would weigh about - - - - - -	109	0	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	10	150
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 must be 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

	lb.	oz.	gr
7. CHLORINE: a greenish-yellow corrosive 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: a gas with a chemical activity exceeding even that of chlorine. It is found united with calcium in the bones and teeth. The quantity in the body would fill a space of 2 cubic feet and 510 cubic inches. It would weigh	0	3	300
9. SILICON: a non-metallic 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
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. These elements cannot be regarded as 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 them. 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; is present in large proportion where change is most active.

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*, *dextrin*, *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 "heat-givers," a term which is equivalent to "force-producers."

Appendix to Group iii. *Gum*, *mucilage*, and *pectose*, approach starch in chemical composition, and probably serve the same end. *Cellulose* may be named here, but its value as a nutrient is doubtful.

Group iv. NITROGEN COMPOUNDS, such as *albumen*, *myosin*, and *casein*, the chief formative and reparative compounds of food: they also may yield fat, and by their oxidation set free heat and motion. They are often named "flesh-formers," while the group is known as the *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, some of the same purposes in the body as those to which the true albuminoids are applied. This series of compounds may conveniently be designated the *osseids*.

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.

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.

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
Wheaten flour	13	Parsnips	81
Maize meal	14	Beetroot	82
Barley meal	14	Apples	83
Peas	14	Carrots	89
Haricot beans	14	Cabbages	89
Rice	15	Onions	91
Bread	40	Turnips	93
Potatoes	75	Lettuce	96

Animal Food.

	lb.		lb.
Butter	10	Mutton	71
Bacon	22	Eggs	72
Cheese	34	Lean of meat	73
Fat pork	45	Fowl	78
Fat beef	55	Herring	80
Salmon	64	Milk	87

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 about 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 should 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 likewise contains 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, etc., 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 a little more than 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. In the pages that follow this common usage will be followed, but the reader should clearly understand that by "impurities" *all* substances present in water are meant—everything that is not water, be it harmless or even useful. An impurity is therefore very far indeed from being necessarily noxious. 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, etc., 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 flat-bottomed porcelain dish, and then 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.

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 decolourised. 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 that peaty matters and iron salts, which are not necessarily unwholesome, give the same result, and that perfectly harmless water may destroy the colour of a good many drops of permanganate solution. Much organic matter is suspicious, but not necessarily harmful.

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 much 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.

Phosphates, shown by the molybdic acid test, are often another sign of animal pollution in a water. "Nessler's test" for ammonia affords also a useful means of measuring the pollution of a 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.

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

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, etc., 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 unfiltered river-water for drinking and cooking is not to be recommended. It is fraught with risk to health. Its great variation in temperature is another drawback to its use.

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 were 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—perhaps 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 some of 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, magnesium, 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 salt 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 unsuitable, because of the white, useless, curdy matter which is formed with soap, and which wastes it, 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.

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

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

Organic Matter in Water.

The organic impurities of water are even more important than the mineral impurities. Organic impurities are of two distinct kinds, organic compounds, and actual vegetable or animal organisms, which may be living or dead, and which, though invisible to the naked eye, may abound in waters which seem perfectly clear. Each kind of these organic matters may be further classed as harmless or dangerous. The great majority of all the varieties are perfectly innocuous. No water, save distilled water prepared with special care, is quite free from organic matter; there is always some organic carbon and organic nitrogen in it. Albuminoid matter in water is often spoken of as if it were necessarily dangerous; but there are perfectly harmless albuminoids in peaty rivers and mountain lakes, although certain albuminoids, such as some of those present in sewage, are really poisonous. So again, even amongst the microscopic animals and plants which abound in many waters, it is only in very rare cases that they have proved to be injurious. Chemistry alone, however, is not competent to decide whether the organic compounds or the organisms in any water are harmless or the reverse. Nevertheless, we look with suspicion upon any water which contains an unusual amount of organic carbon and nitrogen. We know how, in the majority of cases, they have been introduced, they have entered with *sewage*. If we assume that average London sewage contains 7 grains of combined nitrogen per gallon (10 parts in 100,000), then if we find 3½ grains in a gallon of water, we may conclude that the particular sample of water examined had received animal pollution *nearly* equal to half its bulk of sewage (we make a small deduction for the small amount of nitrogen compounds naturally present in rain-water). This pollution may not have arisen from actual house sewage, but from animal matters in decay, farm-yard manure, guano, etc. 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.

So far, little has been said about the visible suspended matters found in many water supplies, attention having been drawn chiefly to the invisible and the 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, etc., has not been properly renewed, *gives* impurities to a water instead of removing them.

The best materials for filters are these four :—

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

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, but they require constant cleansing and constant renewal of the filtering media, and there is often a difficulty in securing the thorough filtration of the whole of the water passing out of them. 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, spongy iron is excellent. It is even effective in reducing the hardness of water (often by two-thirds its original amount), and in removing the dissolved organic matter. There 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. Both it and porous porcelain, when properly used, remove all the minute organisms from water. These organisms are generally and for the most part perfectly harmless, but they *may* include those which are the specific cause of definite disease.

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.

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.

This is the plan of softening hard water by the use of lime, which was invented in 1841 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 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, with certain mechanical improvements, on a large scale at Canterbury, Tring, Caterham, and elsewhere. At Canterbury 110,000 gallons are softened daily by the addition of 11,000 gallons of lime-water, the total solid dissolved matter 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 (often iron also) 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.

The purification of water by boiling it until it has lost its dissolved gases is effective so far as regards the softening of those waters which contain carbonate of lime in considerable quantity. This earthy carbonate is held, for the most part, in solution by means of carbonic acid gas. This gas is dissolved by cold water, and not by hot. On boiling for some time it is discharged, and with it falls the earthy carbonate which it had served to hold in solution. Boiling water also, in some measure, renders innocuous the organic and organised impurities of a water, although implicit reliance cannot be placed on this method of purification.

The distillation of water separates all solid impurities which are left behind in the still. The dissolved gases and the trace of ammonia present are discharged, but condense in part when the steam condenses, and are found in the water which collects in the receiver. The water employed in the preparation of distilled water should be clear and free from objectionable smell and taste. Distilled water is now prepared in London, on a somewhat extensive scale, for drinking purposes. By taking suitable precautions, all metallic impurities are excluded from the product; it is also quite free from the disagreeable oily flavour which commonly characterises the distilled water of the laboratory. When charged with carbonic acid gas, under pressure, it becomes an agreeable and refreshing beverage, superior, in more ways than one, to the majority of the aërated waters in common use. Wholesomeness may be certainly predicated of it; it is not loaded with mineral salts, and for gouty and rheumatic patients it is a most desirable general beverage.

London Water.

London, with its inner suburbs, may be assumed to contain about 5¾ millions of inhabitants, and is supplied with water by eight private companies, which provide a daily supply of above 200 millions of gallons. The following table gives the names of these companies, the sources of the water which they supply, and the average daily amount :—

Water Companies.	Sources of Supply.	Daily delivery in Gallons.
East London	Thames above Sunbury, Wells, and Lea	39,136,258
New River	Lea, Springs, and Deep Wells	37,587,688
Southwark and Vauxhall	Thames near Hampton, etc.	32,743,059
Lambeth	Thames near Molesey	25,234,360
Grand Junction	Thames near Hampton	19,804,675
West Middlesex	Thames above Hampton	21,344,911
Kent	Deep Wells in Chalk	16,349,433
Chelsea	Thames near Molesey	11,853,571

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 four times that of Westminster Hall, but the walls would have to be carried up more than 100 feet above the top 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; in 1875 it amounted to 114,000,000 gallons; in 1883 to 139,800,000 gallons; and in 1898 to 204,053,955 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 14 Vegetable Products.

	lb.		lb.
Apples	4	Bread	12
Rice	5	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

Mineral Matter in 1,000 lb. of 8 Animal Products.

	lb.		lb.
Fat pork	5	Flesh of common fowl	16
Cow's milk	7	Bacon	44
Eggs (without shells)	13	Gloucester cheese	49
Lean of mutton	17	Salted herrings	158

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. It should be noted that 129 lb. of the 158 lb. of mineral matter in salted herrings are common salt.

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.

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 accumulates 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 amongst 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.

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, etc. etc. 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.

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 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. Iron is often, if not always, accompanied by a similar metal—manganese—which is present in the ashes of some vegetables, such as tea, in not inconsiderable amounts.

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 is formed from the sulphur of the albuminoid matters consumed.

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. Of these, starch and sugar, with many similar compounds, are often called *carbohydrates*. This term implies that they contain carbon along with such proportions of hydrogen and oxygen as exist in water. None of their hydrogen is available for heat-giving, since it is already associated with all the oxygen it can take up.

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 17 per cent. may be obtained from potato tubers; is 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 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, natïves 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 arrowroot. It is obtained chiefly from 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*, etc. In Japan starch is prepared from the bulbs of *Lilium auratum*, and of two other lilies; also from the rhizomes of the common brake, *Pteris aquilina*. 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 arrowroot, 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, 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.

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	Millet, without husks	64
Pearl barley	76	Scotch oatmeal	63
Rice	76	Haricot beans	52
Fine wheaten flour	74	Peas	51
Rye	71	Wheaten bread	48
Wheat	69	Wheaten bran	44
Maize	66	Potatoes	18
Buckwheat, without husks	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, for starch is insoluble in cold water. 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 maltose, a species 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 (by the diastatic ferment of the pancreas), in the small intestine; thence the sugar is absorbed into the blood.

Dextrin has the same composition as starch, but it is soluble in cold water. It may be made by heating starch to 320° Fah., or 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, Mellin, and Nestlé. Beer contains a little dextrin. Starch, during digestion, is partly and temporarily changed into dextrin. A gummy substance called galactin, having the same composition as starch, but differing from it in several properties, has been found in the seeds of lucerne, and in the tubers of a *Stachys*.

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.

The most familiar 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, sometimes even 18 or 20, 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 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 Java, British Guiana, Brazil, British India, 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, etc.—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 and Tate's crystals are the purest forms 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 grain.

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.

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 *Arenga saccharifera* and *Nipa fruticans*, palms of the Indian Archipelago, as well as from the date palm, *Phœnix dactylifera*, jaggary sugar is made.

Of sugar, raw and refined, mainly from the cane, beet-root, and certain palms, 1,560,658 tons were imported into the United Kingdom in 1898. Not less than 698,702 tons of all the sugar imported were from beet-root, and came from Germany and Belgium chiefly. Another species of sugar, called maltose, occurs in some cereal grains, and in larger quantity in malt. It has the same composition as cane sugar, but is less sweet.

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, etc.

SUGAR (SACCHAROSE AND MALTOSE) IN 100 LB. OF

	lb.		lb.
Dried carob beans	51	Malted barley	6
Sugar-cane juice	21	Parsnips	5
Chinese sugar-grass	13	Carrots	4½
Beet-root	12	Mahua flowers	3
Maize-stem juice	7	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 ferments of the juices during digestion, into the variety of sugar called grape sugar, or into maltose.

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 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! In 1898 foreign countries sent us 94,352 tons of glucose.

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, inosite, is found in some leaves, in the unripe pods of certain kinds of pulse, and in many muscles, and extract of meat. 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 crystallises with great difficulty, and is generally obtained either as a sirup or, when dried up, as 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 important vegetable products may be seen in the following table:—

GLUCOSE (THAT IS, DEXTROSE AND LÆVULOSE) IN 100 LB. OF

	lb.		lb.
Honey, or nectar of flowers	80	Grapes	13
Dried Turkey figs	57	Tomatoes	6
Mahua flowers	53	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 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 sweet, sugar-like substances of minor importance remain to be mentioned. There is *Mannite*, the sugar-like substance of common manna, a substance produced by several kinds of ash, chiefly by *Fraxinus ornus* and *F. integrifolia*, but occurring also in some seaweeds and mushrooms. 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. *Sorbite*, in mountain ash berries; *dulcite*, *pinite*, and *quercite* may also be named here. It is doubtful whether these sugar-like substances, mannite and glycyrrhizin, are of equal value as nutrients with the true sugars, for no experiments have been made with these compounds.

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 2⅓ 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 possibly of similar value as a nutrient, differs somewhat from oils and fats, notably in not yielding glycerin.

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 of 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	Hemp seed	32
Brazil-nuts (seeds)	67	Walnuts (kernels)	32
Almonds (kernels)	54	Gold of pleasure (seeds)	32
Ground-nut (seeds)	52	Cotton (seeds)	24
Sesame (seeds)	51	Sunflower (seeds)	22
Palm-nut (kernels)	47	Fresh Scotch oatmeal	10
Poppy (seeds)	45	Maize (grain)	5
Olives (kernels)	44	Wheaten bran	4
Cacao (whole seeds)	44	Millet (grain)	3½
Olives (pulp)	39	Peas (seeds)	2½
Linseed	38	Wheaten flour	1
Coco-nut (kernels)	36	Rice	0½

FAT IN ANIMAL PRODUCTS.

	lb.		lb.
Butter	87	Mackerel	13
Bacon	65	Eggs (yolk and white)	11
Mutton-chop (average)	35	Cows' milk	4
Cheese (Gloucester)	30	Flesh of poultry	1

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, etc.

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.

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.

Many writers on food and nutrition are in the habit of speaking of the oils and fats as *hydrocarbons*. This term can be applied properly only to compounds which contain nothing but the two elements—hydrogen and carbon. Without exception every kind of oil, fat, or wax, whether animal or vegetable, contains oxygen as well as the two elements just named. This incorrect usage of the term "hydrocarbon" is, moreover, peculiarly unfortunate, since of the innumerable true hydrocarbons not a single one can be ranked as a nutrient or is capable of being oxidized in the human body.

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 good ground for believing that they serve the same purpose in the animal economy. And this conjecture is confirmed by many experiments, especially upon the lower animals.

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.

Mucilage is found in many plants, as 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 probably undergoes solution and absorption in the body also.

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 usually 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.

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, etc., 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 closely associated in many of them with certain substances, which are richer in carbon than cellulose, though their exact nature is not yet made out. However, three groups of such complex celluloses appear to exist: (1), Ligno-celluloses; (2), Pecto-celluloses; (3), Adipo-celluloses. Many of the vegetable products described in the following pages contain one or other, indeed more than one, of the members of these groups. The term "fibre," or "indigestible fibre," has been commonly used to designate these substances when they form constituents of vegetable foods; many of them have not infrequently been described as consisting of mixtures of true cellulose with *lignose* or *lignin.* We have been content in the present handbook to speak of them generally as *cellulose.* When that constituent is named in an analysis it must be understood to represent a class of allied substances, possessing certain characters in common, resisting more or less completely the solvent action of the digestive juices and having little or no value as nutrients.

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, etc., being the same in each case. But after thorough cooking all starches require nearly the same time. Common sugar is rapidly and perfectly changed into grape sugar or into maltose before assimilation; while the latter need no alteration to fit them 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. It may be as well, however, at once to state that more recent determinations of the dynamic values of 1 lb. of the above nutrients give higher figures, namely, an average of 2,860 foot-tons for the carbohydrates, and of 6,450 foot-tons for the oils and fats.

§ 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.

Of these terms the first is to be preferred, and will be generally used in the present handbook. It involves no theory, but merely affirms that the members of the group resemble albumen (often spelt albumin), the characteristic constituent of the albumen or white of the egg. As a single member of this group seldom occurs alone in a vegetable or animal food, it will be simpler to use the general term "albuminoid" rather than to attempt to define, in each case, the two, three, or four allied substances which are believed to be present. The term *proteid* is very often employed in the same sense; but there is this objection to the word—that it implies the existence of a substance called protein, which was supposed, but it now appears incorrectly, to form the basis of all the members of the group. The term "flesh-former" has a physiological, not a chemical meaning. It correctly designates the main office which the nitrogen compounds under discussion perform in the nutrition of the human body, and which they alone are competent to fulfil.

Perhaps it would be more exact to say that without the assistance of the albuminoids, or of one of them, the substance of true muscular flesh could not be formed. But it is time to give an account of the several members of this group, although our knowledge of them is too imperfect to admit of a satisfactory classification.

Formerly the albuminoids were thought to be three in number, respectively designated as albumen, casein, and fibrin. These terms are still employed, although with a more restricted meaning; but there are several albuminoids which cannot be fairly included in any one of these classes.

1. *Albumen.* Forms of this substance exist in plants, in white of egg, and in blood-serum. They are known as plant-albumen, egg-albumen, and serum-albumen. They are all soluble in pure water; they all coagulate on heating their solutions to about 120° Fah.; they are not precipitated by weak acids, except by nitric and metaphosphoric, nor by solution of common salt or alkaline carbonates.

2. *Albuminates.* Casein of milk belongs here. This substance, with the derived albumen prepared by acting on natural albumen with an alkali, is not coagulated by heating its solution, but it is precipitated by weak acids. Another class of albuminates exists, known as acid-albuminates. These are made by acting upon albumen (and some other albuminoids) by dilute acids. One of the best known of these acid-albuminates is *syntonin*, which is derived from the chief albuminoid of muscle, called myosin, by dissolving it in exceedingly weak hydrochloric acid.

3. *Globulins.* This series includes the fibrino-plastin of blood-serum, the fibrinogen of blood, chyle and serous liquids, myosin, the chief part of dead, rigid muscle, and vitellin, the chief nitrogenous constituent of egg-yolk. These substances coagulate at different temperatures. They are all soluble in a 1 per cent. solution of common salt, and in dilute acids, and alkalies; they are insoluble in a saturated solution of common salt.

4. *Fibrins.* These are all insoluble in water and in dilute solution of common salt. The fibrin obtained by whipping blood, or by leaving it to coagulate, is a type of this section. Two or three of the albuminoids which occur in wheat flour probably belong here. One of these is called gluten-fibrin; this is accompanied by gliadin and mucedin.

5. *Legumins.* In the seeds of most, if not all kinds of pulse an albuminoid occurs, to which the name of legumin has been given. Conglutin, obtained best from lupines and almonds, and gluten-casein, which may be separated by exhausting crude wheat gluten with 70 per cent. alcohol, present many resemblances to legumin, but also certain differences, both of them containing, for instance, a higher percentage of nitrogen.

6. *Coagulated albuminoids.* It is convenient to arrange those members of the group which have been rendered insoluble in their proper solvents by coagulation into a single section.

7. *Albumoses.* When the albuminoids are submitted to the action of certain digestive ferments, such as the pepsin of the gastric juice, and the trypsin of the pancreatic secretion, they first yield a number of slightly modified albuminoids, which afterwards, by longer treatment with these ferments, pass into

8. *Peptones.* These are distinguished from the true albuminoids by the relatively considerable diffusibility, through membranes, of their solutions. Solutions of albuminoids proper do not pass through membranes. Peptones are very soluble in water; they are not precipitated by acids, or by alkalies, or by ebullition. Though most readily produced by pepsin or trypsin at the temperature of the body (98·4° Fah.), they may be obtained in other ways; they exist naturally in some seeds. They have, it seems, the same composition in 100 parts as the several albuminoids which, by a reverse process, they may reproduce.

In the muscular tissue or flesh of many animals eaten as food, and in the various liquids of their bodies, other albuminoids besides those 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*), that of the gastric juice (*pepsin*), and that of the pancreatic secretion (*trypsin*), 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.

Ossein, or collagen, 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; there is no sulphur in it. It is sometimes called *collagen*, for, 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 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. Ivory dust, which contains ossein, is sometimes used for making jellies.

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. The characteristic constituent of cartilage is sometimes called *cartilagin*, sometimes chondrigen.

Elastin and *keratin*, and similar matters from elastic tissue, skin, epidermis, etc., 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.

It is probable that all the albuminoids have nearly the same nutrient value and serve the same offices in the animal economy. The rate at which they are digested, however, differs, animal albumen being the most readily acted upon and absorbed. When certain albuminoids, or small percentages thereof, escape digestion, it may arise from several causes, amongst which the inclusion of these substances within indigestible matter, as in coarse wheat bran, is not the least frequent; and, as many of the older analyses of food products greatly exaggerated the percentages of albuminoids present, it is not to be wondered at that a considerable proportion of some of these substances seemed occasionally to escape digestion and absorption. It must, however, be admitted that legumin, and the other albuminoids of pulse, seem to be but partially utilised in the human economy, unless the daily diet contain but a moderate proportion of them.

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

This pepsin is an unorganised digestive ferment; by its aid, if acid be present and the temperature be suitable (about 98°), albuminoids are all converted into the peptones, described on p. 44. 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. Animal casein before it becomes a peptone, is curdled; legumin is rapidly changed and dissolved even by gastric juice deprived of its pepsin. Fibrin, whether animal or vegetable, as the gluten-fibrin 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 small intestine, where the pancreatic secretion is the active agent 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, is peptonised, and 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. So the formation of gelatin-peptone and chondrin-peptone by the peptonising action of the digestive ferments may be accepted as a fact. What we do not yet completely know is the nature of the nutritive functions performed by derivatives of the osseids; that they are incapable of wholly replacing the true peptones is, however, certain.

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

Carbon	50·8	to	54·5
Hydrogen	6·9	to	7·3
Nitrogen	14·5	to	18·4
Sulphur	0·6	to	2·0
Oxygen	20·9	to	23·5

With regard to gelatin and chondrin it may be said that they probably contain, when quite pure, no sulphur. In both the percentage of carbon just exceeds 50, but while gelatin contains 18·3 per cent. of nitrogen, chondrin shows only 14·5.

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 tissue. 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 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 and through 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, but it must be accompanied by an increased quantity of the carbonaceous nutrients, particularly of fat or oil.

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, etc., 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. Later results, obtained by means of two distinct methods of experiment, lead to the same conclusion as to the dynamic value of the albuminoids as compared with starch and sugar. But the *values* for these substances having been shown to be higher than those found by Frankland, we may accept 2,860 foot-tons as the average number for 1 lb. of albuminoid. 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. 41).

§ 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 its simplest outline, 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—

NUTRIENTS.	In 100 parts.	Each 24 hours.		
		lb.	oz.	gr.
Water - - - - - -	81·5	5	8	320
Albuminoids - - - -	3·9	0	4	110
Starch, sugar, etc. - - -	10·6	0	11	178
Fat - - - - - - -	3·0	0	3	337
Common salt - - - -	0·7	0	0	325
Phosphates, potash salts, etc. -	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 should 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—stimulate 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*. Too much stress must not be laid upon this argument, for experiment has proved that *during short periods* a very simple and monotonous diet has sufficed for all the needs of the body, and has been fully utilised therein even when it has been eaten with difficulty. But, in general, as it will be allowed that food should 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 just 32 ounces of the starchy matters which should accompany the 4¼ ounces of albuminoids —or, in other words, it would supply not more than the necessary daily allowance of *nitrogen*, but about one and a half times the necessary daily allowance of *carbon* in the form of starch. 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 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 from one and a half times to 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. 52); 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, etc.) 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 heat and energy, while 1 oz. of fat or oil will go as far as 2⅓ 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 to 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 2¾ oz. of fat in any form, we should have to add about 2⅓ oz. of starch or sugar to compensate for this reduction, thus consuming nearly 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. Here it will be enough to state that the bread consumed supplies chiefly starch, but along with this a good deal of albuminoid substance; the milk gives fat, albuminoids, and a kind of sugar, having nearly the same value as starch; the cheese contains much fat and albuminoid substance; the bacon and butter furnish chiefly 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.

The quantities of the several nutrients set down in the tabular statement on p. 52 as required in a day's ration must not be taken as admitting of no variation beyond the substitution, already explained, of starch and other carbohydrates for fat or oil. A considerable latitude is permissible, both as to the total amounts, and as to the relative proportions. Different authorities, therefore, give figures for a standard ration for the normal adult man, which vary within rather wide limits. This variation is independent of that far more important one, which is caused by the amount of work done or of energy expended externally. It may be attributed in part to individual or racial peculiarities, in part to the different vegetable and animal products which furnish the several nutrients, and in part to the power possessed by certain nutrients of fulfilling at least some of the offices naturally pertaining to others. Then, too, the influence of external temperature, and of dry or moist air, must not be neglected in this connection. It is found, for example, that the water taken may be considerably diminished or increased; that the albuminoids may be reduced to 3½ oz. or raised to 5 oz. provided that, in the former case, the fat be augmented, or, in the latter case, be lowered. So, if an excess of common salt be consumed, then the potash salts must receive a commensurate addition. The subject is important, but it need not be further dwelt upon here as it will be discussed in Part V., the first section of which is devoted to "Diet and Dietaries."

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 any 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 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 as given in the table on p. 52 :—

DAILY SUPPLY.

	lb.	oz.	gr.	lb.	oz.	gr.
Oxygen taken from 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, etc.				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 assumed to be resolved into their elements in the table of Daily Supply, nor in that which follows, representing

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 sufficiently near 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 energy is available, in one form or another of heat or mechanical work, which may be expressed as 4,297 tons raised 1 ft. high. Of course, where a more liberal ration is given and much harder work done, the number of foot-tons of energy may be much greater. This will be indicated by the greater quantity of oxygen absorbed and used—this may amount to 2 lb. 4 oz. per diem—or even more, instead of 1 lb. 10¼ oz. only.

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, both internal and external, is performed.

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

7. The daily waste and work 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 albuminoids, starch, etc., plus the starch-equivalent of the fat, saline matter, and water. The ratio may be expressed thus :—

Water.		Albuminoids.		Starch and Fat as Starch.		Salts.
25	:	$1\frac{1}{5}$	:	$4\frac{2}{3}$	:	$\frac{1}{4}$

9. But the most important ratio amongst the nutrients of the daily food is that between the albuminoids or "flesh-formers," and the carbohydrates plus the fat reckoned as starch, or "heat-givers." This relationship is often called *the* "nutrient-ratio." In the standard dietary adopted in the preceding pages the nutrient-ratio is 1 : $4\frac{3}{4}$. In other words, for one ounce of albuminoids present in the daily food, there should be $4\frac{3}{4}$ ounces of starch, sugar, dextrin, gum, mucilage, etc.—the starch-equivalent of the fat being added to make up this quantity.

10. For the sake of making a rough comparison between various foods, it is a convenient plan to add together the percentages of albuminoids, starch, dextrin, and sugar, and the starch-equivalent of any fat present. The sum of these constituents is called the "nutrient-value"; this value is that of 100 parts (100 grains, 100 ounces, 100 pounds, as the case may be) of the foods in question.

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*.

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 nearly 200 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, this 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.

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 55lb.; while in good years it may rise to 64lb. A plump, rounded, white smooth grain, without wrinkles, gives the heaviest weight per bushel. Wheat grain varies in specific gravity between 1·29 and 1·41, the harder and more translucent 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 mainly 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 as much as 18 or 20 per cent.; the starch in these latter grains being 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.

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

According to this analysis, wheat contains 1 part of albuminoids to 6½ parts of digestible carbohydrates and oil, reckoned as starch. This ratio is often called the "nutrient-ratio," and for brevity's sake will be so called in the pages that follow. If we add together the percentages of starch, of albuminoids, and of oil and sugar converted into their equivalents of starch, we arrive at the "nutrient-value" of 100 parts of a food such as wheat. If the above analysis be so treated this figure will be found to be 82. If we assume that all the albuminoid matter present could be so used, not more than 1¾ 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.

On account of the large imports of Indian wheat into this country, it may be useful to introduce in this place an analysis showing its average composition. It will be noticed that Indian wheat contains less water and more nitrogenous matter than home-grown wheat.

Average Composition of Indian Wheat.

	In 100 parts.		In 1 lb. oz.	gr.
Water	12·5	...	2	0
Albuminoids	13·5	...	2	70
Starch, with traces of dextrin and sugar	68·4	...	10	413
Oil	1·2	...	0	84
Cellulose	2·7	...	0	189
Mineral matter	1·7	...	0	119

The nutrient-ratio is here 1 : 5·2; the nutrient-value 84·6. Further particulars regarding Indian wheat will be found in my "Food Grains of India," pp. 90 to 98. It may be added that millers generally find it expedient to add some starchy cold-country wheat to the highly nitrogenous grains from India.

Some notion of the importance of wheat as a food staple in this country may be formed from the following figures. In 1899 there were imported into the United Kingdom great quantities of wheat from foreign countries and from our colonies and India, in order to supplement the home-grown produce. The tabular statement which follows shows the amounts in hundredweights :—

Home-Grown and Imported Wheat.

	Cwts.
Home-Grown (1898)	40,038,543
United States	34,651,000
British India	8,192,000
Argentine Republic	11,369,000
British North America	5,256,000
Chili	266,000
Germany	466,000
Australasia	3,703,000

In 1890, however, the wheat imports from Russia were 19,389,000, while those from the United States did not exceed 17,201,000 cwts. It should be remembered that large quantities of wheat meal and flour also reach this country from abroad, not less than 22,946,000 cwts. arriving in 1899.

There are several reasons why the grain of wheat is preferred to that of 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, etc. 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, for it contains a large percentage of that characteristic elastic albuminoid which is called gluten. 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, its heat and force-producing, and its bone-forming quality.

Mill-Products.

Wheat grain is nearly always prepared by some mechanical 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 matters, and also containing much oil and mineral matter. The embryo, chit, or germ, is still richer (than the above-named row of square cells) in nutritive matters, notably in oil, in potash, in phosphates, and in nitrogenous compounds. There are six thin coverings or coats to the wheat grain; these contain much cellulose and mineral matter. 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 general employment of rollers of steel or of hard porcelain has also greatly changed the milling process, and the character and variety of the products. The methods of "high-milling," as it is called, have indeed become so complicated that it would be impossible to describe, within the limits of space at our disposal, the scores of operations, including many re-grindings and siftings, to which the grain is submitted. But it may prove interesting and instructive if we endeavour to give, in a condensed form, an outline of a method of milling intermediate in complexity between the old and new systems.

The meal (designated here as No. 2) obtained by grinding the wheat (No. 1) with mill-stones, is separated, by means of silk-gauze dressing machines, into five products (Nos. 3 to 7), called respectively, flour, middlings, coarse middlings, pollard, and bran. The middlings (No. 4) are then further separated by means of a dressing machine, called the Purifier, into three products (Nos. 8, 9, and 10), called respectively, semolina, fine sharps, and coarse sharps. The semolina (No. 8 is so called by millers), after having been crushed once, twice, or even thrice, between steel rollers, or between the hard porcelain rollers invented by Wegmann, is separated, by means of a centrifugal fine silk dressing machine, into three products (Nos. 11, 12, and 13), called respectively, fine flour, seconds flour, and sharps. A chemical analysis of each of the above products as obtained from a quantity of a mixed wheat was made. The results, so far as they are necessary for comparison, are given in the annexed table :—

PERCENTAGE COMPOSITION OF MILL-PRODUCTS FROM A WHEAT.

	Nitrogen.	Fat.	Fibre.	Ash.
2. Original meal	1·69	2·02	2·40	1·83
3. Flour	1·61	1·40	0·17	0·79
11. Fine flour	1·68	1·67	0·15	0·68
12. Seconds flour	1·97	1·82	0·31	0·83
4. Fine middlings	2·07	2·75	1·70	1·30
5. Coarse middlings	2·37	4·97	6·77	2·90
6. Pollard	2·19	3·67	10·02	4·85
7. Bran	2·14	2·75	10·80	6·05
8. Semolina	2·02	2·65	0·67	1·06
9. Fine sharps	2·07	2·30	1·02	1·40
10. Coarse sharps	2·16	3·08	3·62	1·56
13. Sharps	2·61	3·50	2·25	2·51

These results may be briefly summarised thus: The 2 grades of fine flour (Nos. 3 and 11) contain least nitrogen, least fat, and least ash or mineral matters. The seconds flour (No. 12) shows a slight superiority over the two finer grades of flour in all three items.

The coarse middlings (No. 5) contains most nitrogen and most fat. The fine sharps, the coarse sharps, and the sharps (Nos. 9, 10, 13), which are by-products not further operated upon, are richer in nitrogen, in fat, and in mineral matter than any of the grades of flour, while none of them contains an excessive proportion of fibre. On the other hand, the two remaining final products, pollard and bran (Nos. 6 and 7), contain most fibre and most ash, along with a good proportion of nitrogen and fat.

In order, however, to form a just judgment as to relative richness in the important nutrients (other than starch) present in the various mill-products of wheat, it is necessary to look a little more closely into the above percentages. We need not discuss the quantities of fat or oil and of ash or mineral matter, for there can be no doubt of the nature and value of the fat or oil, while analysis of the ash of the several products shows that the amount of phosphates or "bone-formers" is largest in those products which give the highest percentage of ash. But the case is not so clear with respect to the nitrogen. There is no question that some of this nitrogen is not in the form of albuminoids, or what have been called "flesh-formers." We will therefore select for further scrutiny three products, namely, No. 3, flour; No. 9, fine sharps; and No. 13, sharps. These numbers have been chosen as representing products which contain the lowest percentage of nitrogen, the highest, and an intermediate percentage. By suitable methods the actual percentages of *true* albuminoids in these three grades have been ascertained. In the following table they are given as compared with the percentages calculated from the total nitrogen:—

	True Albuminoids.	Albuminoids from total Nitrogen.	Difference.
Flour (No. 3)	8·96	10·14	−1·18
Fine sharps (No. 9)	11·86	13·04	−1·18
Sharps (No. 13)	13·38	16·44	−3·06

The true albuminoids are here rather under-estimated in all three cases; but it is quite clear, from the above analyses, that those mill-products which contain the larger percentages of total nitrogen do also contain larger percentages of true albuminoids. True, the proportion of albuminoids does not rise *pari passu* with the nitrogen; but it is safe to affirm that sharps, middlings, and even pollard and bran, do always contain a considerably higher percentage of true albuminoids than fine flour made from the same meal. This conclusion is abundantly confirmed by a large number of analyses, for which we have no space here, of these coarser and more coloured mill-products. Further on, in discussing the question of bread, more will be said as to these materials which we so commonly reject for use as human food. Here it must suffice to mention that the albuminoids of the coarser products do not include so large a proportion of *gluten* as do those of the finer.

In the gradual grinding and purification of the grits lies the essence of high or grits milling. It has one advantage at least over the old system, in which the grinding is done at first and once for all, and this consists in the absence, or comparative absence, of the heating of the products which may injure the properties of the gluten in the flour for bread-making.

The particular series of mill-products, of which we have just given some analytical details, were made up of the following percentages:—

Flours (Nos. 3, 11, and 12)	73·0
Pollard and bran (Nos. 6 and 7)	17·0
Fine sharps and sharps (Nos. 9 and 13)	2·5
Coarse middlings and coarse sharps (Nos. 5 and 10)	4·5
[Loss	3·0]

The yield of flour was below the average, and that of offals above. In a good cereal year the numbers are:—

Flours	75·0
Offals	22·5
[Loss	2·5]

To these particulars we may add that the fine middlings

(No. 4), when separated in the Purifier, yields 77 per cent. of No. 8, 15 per cent. of No. 9, and 8 per cent. of No. 10. When the semolina (No. 8) is rolled and re-dressed, it yields 60 per cent. of No. 11, 20 per cent. of No. 12, and 20 per cent. of No. 13.

In the old 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; the loss amounts to 5 lb., but this consists partly of evaporated moisture.

		lb.
Flour	1. Finest flour	42
	2. Seconds flour	18
	3. Biscuit flour	9
	4. Tails, or tailings	3
Bran	5. Middlings, or fine sharps	8
	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.

There are two parts of the wheat grain which, in various milling-processes, are often removed. One of these is the germ, the other is the outermost coat of the grain. The germ is removed in roller-milling, because its presence tends to discolour the flour, and gives it a marked tendency, especially when kept under unfavourable conditions, to acquire a rancid taste and odour. That the exclusion of the germ is to be regretted on dietetic grounds is evident when its singular richness in oil, in nitrogenous matters, and in phosphoric acid, is considered. The following analysis was made on a pure sample of flattened germs from a roller-mill:—

	In 100 parts.
Water	12·5
Albuminoids, diastase, etc.	35·7
Starch, with some dextrin and maltose	31·2
Fat or oil	13·1
Cellulose	1·8
Mineral matter	5·7

More than half this mineral matter was phosphoric acid; indeed, it amounted to no less than 60·6 per cent. of the total ash, so that the original embryos contained nearly 3½ parts per hundred of this valuable constituent of bone. The nitrogenous matters amounted to thrice the proportion present in the whole wheat grain; the oil or fat was more than six times as much. It should be added that the albuminoid matter included little or no tenacious gluten, but a considerable quantity of the diastatic ferment.

But if, on some grounds, the exclusion of the germ from our mill-products is a procedure of doubtful utility, there can be no question that the removal of the fibrous outer envelope of the grain is of considerable advantage. The following figures were obtained in the analysis of a carefully prepared sample:—

	In 100 parts.
Water	15·2
Albuminoids (from total nitrogen)	10·4
Oil	2·5
Ash or mineral matter	2·6

To these analytical results it may be added that this ash contained no more than 15·3 per cent. of phosphoric acid. All these results, and the high proportion of fibre present, contrast very strongly with those previously given in the analysis of the germ.

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

	In 100 parts.		In 1 lb. oz.	gr.
Water	13·0	...	2	35
Albuminoids, etc.	10·5	...	1	297
Starch, with some malt sugar	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.

The nutrient-ratio in fine wheaten flour is 1 : 7¼ ; the nutrient-value is 86½. In calculating this nutrient-ratio it has been assumed that the whole of the nitrogen present in the flour exists in the form of albuminoids. This assumption is never quite correct; with low grade and damaged flours it will be far from the truth. In the case of the fine wheaten flour, which is now under discussion, it was found that the true albuminoid percentage was 9·9, and not 10·5 as given above. When this lower figure is adopted, the nutrient-ratio comes out 1 : 7·7, instead of 1 : 7·25.

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 :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	12·5	...	2	0
Albuminoids and cerealin	13·3	...	2	56
Indeterminate nitrogen-compounds	3·1	...	0	217
Starch, with some maltose	43·6	...	6	426
Fat	3·5	...	0	245
Cellulose	18·0	...	2	246
Mineral matter	6·0	...	0	420

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

If we include cerealin with the true albuminoids, the nutrient-ratio of this bran may be set down as 1:4; the nutrient-value will be 67. But in practice it is found that coarse bran, owing to its mechanical condition chiefly, is far from yielding the whole of its nutrients to the digestive juices.

In bran there is a remarkable substance called *cerealin*, which acts as a ferment in causing the change and solution of other substances.

There are many preparations of wheat which we can do little more than mention. Such are semolina and semola, which are made in milling wheat (and other grains also, as those of the oat). They consist of small fragments of the interior of the grain, and are often 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 a great proportion of the nitrogenous matter of wheat. This part of the nitrogenous matter may be obtained in an impure 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 of at least 4 albuminoids, called gluten-fibrin, gluten-casein, gliadin, and mucedin. 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 of *yeast*. Leaven is not much used in this country—it 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 albuminoids, which contain or produce a substance—a kind of ferment—which turns the sugar of the flour into alcohol and carbonic acid gas. The action of beer yeast is the same. Yeast, whether fresh or partially dried, has the power during its growth 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 almost completely 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 become *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, etc.—are now imported into England. From a sack of flour weighing 280 lb. about 95 quartern or 4-lb. loaves may be obtained. These will lose weight, some 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. Two such powders in common use gave on analysis the following percentages of their more important constituents :—

	I.		II.
Tartaric acid	12·8	...	27·6
Bicarbonate of soda	11·9	...	31·6
Common salt	1·0	...	0·4
Potato flour	—	...	19·0
Rice flour	47·0	...	1·0
Wheat flour	5·0	...	—
Rye flour	5·0	...	—

The cereal flours (or starches), above named, are introduced in a dried state. In some other baking powders the acid sulphate of potash, or bisulphate of potash, is substituted for tartaric acid; the resultant sulphates of soda and potash are strongly purgative salts. Alum has been found as an adulterant in some of these powders. 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 in taste from ordinary fermented bread. When first introduced it was perhaps less generally liked, but it certainly retains in a remarkable degree the aroma of the original pure wheaten flour from which it is made, while acetic acid, so often present in fermented bread, is entirely absent from aerated bread. Great improvements have been made in the machinery for mixing, kneading, and moulding, the whole of these operations being performed in closed vessels under pressure. To each sack of flour, weighing 280 lb., common salt, to the extent of 3 lb., is added. This proportion corresponds to 220 grains per quartern loaf, which is just 0·8 per cent., or 55 grains per pound of bread.

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 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 the whole grain without effecting any subsequent separation of the resulting product into various grades according to degree of fineness or coarseness. If the wheat has been previously thoroughly cleaned, and the outermost skin has been removed, a true brown bread or true wheat-meal bread may be obtained with this meal. And in such bread *all* the nutrients of the grain will be present, the albuminoids, the oil or fat, and the mineral matters existing in larger proportions than in bread made from fine white or even from seconds flour. The nitrogenous matters which are *not* albuminoid will, of course, also be present in larger proportion in this whole-meal bread. Another kind of wheat-meal bread is also now made. The meal used is prepared from grain deprived not only of the outermost, non-nutritious skin, but, in part, at least, of the other coats, and of the embryos; it is richer in albuminoids, oil and minerals, than fine white bread, but inferior in these points to true whole-meal bread.

But it must not be concluded from the above facts that whole-meal bread, and other kinds of brown bread, necessarily *furnish* more nourishment than white bread. Though richer in nutrients other than starch, they will, unless the meal of which they have been made has been uniformly and finely ground, contain numerous large, rough, branny particles, which so stimulate the action of the intestine that the material is hurried along the digestive tract without that complete digestion and absorption of its nutritious matters which white bread undergoes. And then there is another cause which renders useless a not inconsiderable part of the nutrients present in bread made from ordinary wheat meal. The large, branny particles enclose and protect from the action of the digestive juices a large portion of the nutrients they contain. Thus it happens that the solid excreta of persons consuming such bread are not only unusually bulky, but contain a large amount of unused nitrogenous matters. So 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, etc., in white bread, are made up by the use of eggs, milk, and other foods of animal origin.

Whole-meal bread can be most successfully made by the aeration-process. If yeast or leaven be employed the loaf is heavy and imperfectly vesiculated. This is due, in part at least, to the powerful diastatic action on starch of the cerealin present in those parts of the grain which, though absent from fine flour, are present in their entirety in whole meal. An analysis of a good average sample of whole-meal bread gave the following results:—

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	43·4	...	6	413
Albuminoids	9·1	...	1	199
Other nitrogen-compounds	1·3	...	0	91
Starch and dextrin	42·7	...	6	364
Fat	0·3	...	0	21
Cellulose	1·7	...	0	119
Mineral matter	1·5	...	0	105

The nutrient-ratio is here 1 : 4¾; the nutrient-value is 53. Highly nitrogenous hard wheats are evidently often used for whole-meal bread, for in many cases I have found the percentage of true albuminoids present to exceed eleven.

The demand for very white bread has compelled millers, at enormous cost, to revolutionise their machinery and methods. The fine flour now produced in English mills yields a bread beautiful in appearance, perfect in *pile* and texture, and pleasant in taste. For persons living in luxury, to whom a great variety of other food-stuffs, animal as well as vegetable, are accessible, the finest and whitest bread is suitable enough. But, unfortunately, for the poor, and for those obliged to live on a bare-sustenance diet, the predilection for the whitest bread amounts to an ignorant prejudice, injurious to their adequate nutrition; it is particularly prejudicial to the health and development of growing children. For them, bread made of seconds or biscuit flour, of finely-ground wheat meal obtained from well-cleaned and skinned grain, or of other cereal mill-products, *sufficiently comminuted*, affords a far better food, weight for weight, than pretty, fancy bread, the defects of which, in regard to its nutrient-ratio and its low percentage of phosphates, have been previously described.

A few words as to malt-bread, so called, may not be out of place here. When malt-flour is added to the ordinary flour used in bread-making there is a certain amount of dextrin produced through its diastatic action upon starch. But this action soon ceases in the oven, for this reason, that the activity of diastase is entirely destroyed by the heat, which, in the interior of the loaf, approaches 212° F. This diastatic activity is permanently lost, so that malt-bread cannot possibly have the power claimed for it of aiding the digestion of starch.

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.

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 increase 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, alum, 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 detected by chemical tests, while the adulterants named before (rice, etc.) require very skilful 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.

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.

MACARONI.

Macaroni (in Italian *maccheroni*), vermicelli, and pâtes d'Italie are prepared from dense, hard, translucent, and highly-nitrogenous varieties of wheat. Our supplies are obtained chiefly from Italy and France. In England these valuable and nutritious food-products are generally regarded somewhat in the light of luxuries. In some parts of the Continent, and especially in South Italy, they form a usual and substantive part of the popular diet.

Some notion of the composition of Neapolitan macaroni may be obtained from the two subjoined analyses:—

COMPOSITION OF MACARONI.

	In 100 parts. *a.*		*b.*
Water	13·0	...	10·0
Albuminoids, etc.	11·1	...	13·5
Starch, etc.	73·8	...	70·8
Fat	0·9	...	2·3
Cellulose	0·4	...	1·4
Mineral matter	0·8	...	2·0

Assuming that the nitrogen in these products is wholly albuminoid, the nutrient-ratio of *a* will be 1 : 6·8 and its nutrient-value 86·9. The corresponding figures for *b* will be 1 to 5·6 and 89·6.

As the macaroni *a* is the finest sort, costing in Naples 2·7d. per pound, while the macaroni *b* is the cheapest, and may be bought for 1·6d. per pound, it is important to note that the lower price commands a product which possesses not only a higher total nutrient-value than the more costly sort, but a better adjusted nutrient-ratio. Moreover, this is true even when we have made due allowance for the larger proportion of non-albuminoid nitrogen in the cheaper material. To these statements we may add the observation that the less costly product contains twice as much phosphoric acid as the dearer, namely 0·93 per cent., instead of 0·4 per cent.

Macaroni loses rather more than 3 per cent. of its original substance during cooking, but it takes up nearly three times its weight of water. Macaroni should be well soaked, previous to use, in such a quantity of cold water as will be slightly in excess of that which it is capable of absorbing.

Biscuits.

Biscuits are usually distinguished from bread by two differences: they are not, as a rule, 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. An analysis of the biscuits supplied to the ships of the British navy will illustrate some of the foregoing observations:—

COMPOSITION OF NAVY BISCUITS.

	In 100 parts.		In 1 lb. oz.	gr.
Water	10·2	...	1	277
Albuminoids	10·5	...	1	297
Other nitrogen-compounds	0·4	...	0	28
Starch and dextrin	75·0	...	12	0
Fat	1·6	...	0	112
Cellulose	1·2	...	0	84
Mineral matter	1·1	...	0	77

The nutrient-ratio is here 1 : 7½; the nutrient-value is 89.

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 the United Kingdom there were, in the year 1899, no less than 4,109,964 acres devoted to this crop, as against 2,159,396 under barley, and only 2,055,283 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 albuminoids. 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 albuminoids may be 14 to 16 per cent. Scotch oatmeal is the best and richest; it forms as porridge or oatcake a very nourishing though often somewhat laxative food. It is much richer in albuminoids than ordinary wheaten flour. Oat flour cannot alone be made into bread. As oats in the husk 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 or fibre and more mineral matter. A careful analysis of a fresh sample of Scotch oatmeal showed the following results:—

COMPOSITION OF SCOTCH OATMEAL.

	In 100 parts.		In 1 lb. oz.	gr.
Water	5·0	...	0	350
Albuminoids, etc.	16·1	...	2	252
Starch, etc.	63·0	...	10	35
Fat	10·1	...	1	269
Cellulose	3·7	...	0	259
Mineral matter	2·1	...	0	147

The following figures show the

COMPOSITION OF IRISH OATMEAL.

	In 100 parts.		In 1 lb. oz.	gr.
Water	5·0	...	0	350
Albuminoids	14·8	...	2	161
Other nitrogen-compounds	0·7	...	0	49
Starch, etc.	67·0	...	10	315
Fat	8·8	...	1	178
Cellulose	1·7	...	0	119
Mineral matter	2·0	...	0	140

In order that a fair comparison might be made between these two samples of oatmeal the results of analysis have been calculated on the assumption that 5 per cent. of moisture was present in both of them. This proportion of water, however, rapidly rises (to 10 or 12 parts per hundred) when the oatmeals are exposed to ordinary air. The analysis of the Irish oatmeal was rather more complete than that of the Scotch, for, in the former, the *true* albuminoids present were separately determined. To make the two analyses strictly comparable as to this constituent about 1·1 must be deducted from its amount as given for the Scotch oatmeal — the percentage for this will then stand at 15·0, practically identical with the 14·8 per cent. actually found in the Irish oatmeal, in which the only inferiority consists in its somewhat smaller proportion of fat. The corrected numbers for the nutrient-ratio and the nutrient-value in the two oatmeals are:—

Scotch;	nutrient-ratio,	1 : 5·7,	nutrient-value, 102
Irish;	,, ,,	1 : 5·9,	,, ,, 102

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.

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

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

Barley.

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

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 the United Kingdom, 2,159,396 acres were devoted to this crop in the year 1899, as against 2,036,810 acres in 1892. 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. The following particulars concerning the products obtained in the process of pearling barley may be useful:—

One hundred pounds of barley yield 12½ lb. of "coarse dust," and become "blocked barley."

This blocked barley yields 14¾ lb. of "fine dust," and becomes "Scotch or pot barley."

Pot barley yields 25¼ lb. of "pearl dust," and becomes "pearl barley." The quantity of pearl barley thus obtained is about 37⅝ lb.—a loss of 10 per cent. being unaccounted for.

The composition of the three waste products or "dusts" is, in 100 parts:—

	Coarse Dust.	Fine Dust.	Pearl Dust.
Water	14·2	13·1	13·3
Albuminoids	5·3	11·5	10·1
Other nitrogen-compounds	1·7	6·1	2·0
Oil	1·7	6·0	3·4
Starch, etc.	46·9	50·5	67·2
Cellulose	24·5	8·5	1·8
Mineral matter	5·7	4·3	2·2

Patent barley is pearl barley ground into flour. Pot and pearl barley are used in soups, puddings, etc. 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.	gr.
Water	14·6	...	2	147
Albuminoids	6·4	...	1	13
Other nitrogen-compounds	0·3	...	0	21
Starch, etc.	75·5	...	12	35
Fat	1·3	...	0	91
Cellulose	0·8	...	0	56
Mineral matter	1·1	...	0	77

The nutrient-ratio is here 1 : 12¼ ; the nutrient-value 85.

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.*)

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; 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.	gr.
Water	13·0	...	2	35
Albuminoids, etc.	10·5	...	1	298
Starch, etc.	71·0	...	11	157
Fat	1·6	...	0	112
Cellulose	2·3	...	0	161
Mineral matter	1·6	...	0	112

The nutrient-ratio is here 1 : 7; the nutrient-value is 85.

RICE.

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

Rice is a grass, a native of India. It is extensively grown in India, Ceylon, China, Japan, 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. There is, however, a mountain-rice, which thrives without artificial supplies of water. Many varieties of rice are cultivated, but they do not differ materially, so 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 albuminoids and in 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 cellulose and silica. It is largely used in adulterating many articles of human and cattle food. Rice is employed 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. In the making of saké, the favourite alcoholic beverage of Japan, a special organised ferment is used to effect the same change.

COMPOSITION OF CLEANED RICE.

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

The nutrient-ratio is here 1 : 10; the nutrient-value is 84.

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. As it is deficient in natural fat, oil, butter, fat bacon, or similar articles of food, should be eaten with it. 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.

Maize, or Indian Corn.

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

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	14·2	...	2	119
Albuminoids	9·0	...	1	193
Other nitrogen-compounds	0·3	...	0	21
Starch, etc.	66·5	...	10	280
Fat	5·0	...	0	350
Cellulose	3·0	...	0	210
Mineral matter	2·0	...	0	140

The nutrient-ratio is here 1 : 8½; the nutrient-value is 87.

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, etc. 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 carbonaceous to nitrogenous nutrients in the mixture. In 1 lb. of the so-called "corn-flour" from maize, we found but 18 grains of albuminoids; 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, etc.

Millet.

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

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. miliaceum*, *P. miliare*, *P. frumentaceum*, *P. colonum*, *Paspalum scrobiculatum*, *Setaria italica, and Pennisetum typhoideum* are amongst the chief species of millet grown. In Central and Southern Europe several of these 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 (HUSKED).

	In 100 parts.		In 1 lb. oz.	gr.
Water	13·0	...	2	35
Albuminoids	12·5	...	2	0
Other nitrogen-compounds	0·4	...	0	28
Starch, etc.	65·4	...	10	203
Fat	3·6	...	0	252
Cellulose	3·5	...	0	280
Mineral matter	1·6	...	0	112

The nutrient-value of this millet is 84¾; its nutrient-ratio is 1 : 5¾.

The nutrient-ratio in Italian millet, *Setaria italica*, is 1 : 7½.

Dari or *Durra* is the grain of certain varieties of *Sorghum vulgare*, and is largely consumed as food in some countries. It is imported into this country in some quantity, and used for feeding cattle, poultry, etc. The grain is large and white, and has the following composition :—

	In 100 parts.		In 100 parts.
Water	12·2	Fat	4·2
Albuminoids, etc.	8·2	Cellulose	3·1
Starch, etc.	70·6	Mineral matter	1·7

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*. The grain of *Eragrostis abyssinica*, or "teff," is an important food in Abyssinia.

BUCKWHEAT.

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

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.	gr.
Water	13·4	...	2	63
Albuminoids	15·2	...	2	189
Starch	63·6	...	10	77
Fat	3·4	...	0	238
Cellulose	2·1	...	0	147
Mineral matter	2·3	...	0	161

The nutrient-ratio in cleaned buckwheat is 1 : 4¾; the nutrient-value is 86.

§ 2.—Pulse—Peas, Beans, etc.

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 porportion of albuminoids, or flesh-formers, in the former. In consequence of this difference, the nutrient-ratio in the seeds now under consideration is about 1 to 2½, instead of 1 to 6½, 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 often 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; indeed, the digestibility of the albuminoids in pulse has been usually regarded as low. In general they are not only digested and absorbed at a slower rate, but a larger proportion of the total amount present remains unattacked and unused in its passage along the alimentary tract.

The proportion of unused to used albuminoids is proportionately highest when the pulse forms a large part of the ration; it is much reduced when it forms only $\frac{1}{4}$ of the daily food. Even under favourable conditions the unabsorbed portion forms $\frac{1}{14}$ or $\frac{1}{13}$ of the total albuminoids. The above-named legumin is not a single definite substance, but appears to consist of at least three albuminoids, which are known as gluten-casein, legumin, and conglutin. The first two present so decided a resemblance to the animal casein of milk, 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. We may here mention that 231,509 tons of various kinds of pulse were imported into the United Kingdom in 1899.

Peas.

French, *Pois*. German, *Erbsen*. Italian, *Piselli.*
(*Pisum sativum.*)

The cultivated garden pea is probably derived from a plant native of countries bordering the Black Sea. It has been long 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 matters in them are more easily digested than those 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. 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. Nearly the whole of the nitrogenous matter in ripe peas exists in the form of true albuminoids.

COMPOSITION OF PEAS.

	In 100 parts.		In 1 lb. oz.	gr.
Water	14·3	...	2	126
Albuminoids, etc.	22·4	...	3	255
Starch, etc.	51·3	...	8	92
Fat	2·5	...	0	175
Cellulose	6·5	...	1	17
Mineral matter	3·0	...	0	210

The nutrient-ratio is 1 : 2½, the nutrient-value 79.

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.

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.

Haricot and French Beans.

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

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 analysis of some pods of well-grown French beans, gathered when in the most suitable condition, showed that they contained 91·8 per cent. of water; 0·64 per cent. of mineral matter; and 2·05 of albuminoids calculated from the total nitrogen: in reality this proportion should be halved if the percentage of true albuminoids is desired. 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 washed on a colander or sieve with cold water, and then soaked for 12 hours at least, in a just sufficient amount of fresh water, before being boiled. They should be eaten with starchy foods, like rice, or with bacon, or other fat meats.

Composition of Haricot Beans.

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

The nutrient-ratio is here 1 : 2½; the nutrient-value is 80.

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*.
(*Lens esculenta*.)

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 albuminoids than either peas or beans, but rather less than lupines. The preparations so much advertised under the names of "Revalenta," "Ervalenta," etc., 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 (husked).

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	12·5	...	2	0
Albuminoids, etc.	25·0	...	4	0
Starch, etc.	56·1	...	8	427
Fat	2·0	...	0	140
Cellulose	1·9	...	0	133
Mineral matter	2·5	...	0	175

The nutrient-ratio is here 1 : 2·4; the nutrient-value is 86.

H

Ground or Pea Nuts
(*Arachis hypogæa.*)

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	87
Albuminoids, etc.	24·5	3	403
Starch, etc.	11·7	1	382
Oil	50·0	8	0
Cellulose	4·5	0	315
Mineral matter	1·8	0	126

The nutrient-ratio is here 1 : 5·2; the nutrient-value is 151.

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 (*Voandzcia subterranea*) nearly allied to the Vigna bean; and numerous Indian and Chinese species of *Dolichos*. A full account of Indian pulses will be found in the "Food Grains of India." One of these legumes is, however, of so much interest and importance, that a few particulars concerning it may be acceptable:

Soy Beans.

(*Glycine soja.*)

The soy bean forms a considerable article of food in China and Japan. It is grown to some extent in India, and has been successfully cultivated, since 1873, in some of the warmer parts of Europe. Although there are a number of varieties of this pulse, the chief differences between them lie chiefly in the colour, size, and shape of the seeds, rather than in divergence as to chemical composition. That composition entitles the soy bean to the highest place, even amongst the pulses, as a food capable of supplementing the deficiencies of rice and other eminently starchy grains. Very few vegetable products are so rich as this bean, at once in albuminoids and in fat or oil, the former constituent averaging 35 per cent., and the latter 18 or 19. The cultivation of the large pale-seeded varieties should be extended.

Composition of Soy Beans.

	In 100 parts.		In 1 lb. oz.	gr.
Water	12·5	...	2	0
Albuminoids, etc.	35·3	...	5	284
Starch, traces of dextrin	12·5	...	2	0
Sugar	12·0	...	1	402
Fat	18·9	...	3	10
Cellulose	4·2	...	0	294
Mineral matter	4·6	...	0	322

The nutrient-ratio is here about 1 : 2; the nutrient-value is 101. It should be added that a very active ferment is present in the soy bean. This acting upon starch, converts about two-thirds of it into sugar and the remainder into dextrin.

§ 3.—Roots and Tubers.

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 albuminoids of moist roots and tubers. It is also to be noted that roots, tubers, and underground stems, often contain much more of their nitrogen in the form of amides, and other non-albuminoid compounds, than is the case with the ripe grains and seeds which we have just been discussing.

Potatoes.

French, *Pommes de terre*. German, *Kartoffeln*. Italian, *Patate*.
(*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 parasite, mildew, or fungus, which is the immediate cause of the disease. Good drainage, earthing up, with plenty of air for the plants, and no excess of actively decaying matter in the soil, are amongst the best means of moderating the attacks of the fungus, which goes by the name of *Phytophthora infestans.*

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.

In 1899, 3,077,000 tons of potatoes were grown in Great Britain: large quantities are also imported from abroad: 257,895 tons arrived in 1899 from the Channel Islands, France, Germany, Holland, and Belgium.

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.

COMPOSITION OF POTATOES.

	In 100 parts.		In 1 lb. oz.	gr.
Water	75·0	...	12	0
Albuminoids	1·2	...	0	84
Extractives, as solanine and organic acids	1·5	...	0	105
Starch	18·0	...	2	385
Dextrin and pectose	2·0	...	0	140
Fat	0·3	...	0	21
Cellulose	1·0	...	0	70
Mineral matter	1·0	...	0	70

The nutrient-ratio is here 1 : 17 ; the nutrient-value is 22.

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, *Rape*.
(*Brassica campestris*.)

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 a variety (*napo-brassica*) of the same species.

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. Turnips contain no more than one-half per cent. of flesh-formers, instead of the 1 per cent. formerly assigned to them.

Composition of White Turnips.

	In 100 parts.		In 1 lb. oz.	gr.
Water	92·8	...	14	371
Albuminoids	0·5	...	0	35
Extractives, including amides	1·0	...	0	70
Pectose	3·0	...	0	210
Fat	0·1	...	0	7
Cellulose	1·8	...	0	126
Mineral matter	0·8	...	0	56

The nutrient-ratio is here 1 : 6; the nutrient-value is not quite 4.

Carrots.

French, *Carottes.* German, *Möhren.* Italian, *Carote.*
(*Daucus Carota.*)

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, according to my analyses—

	In 100 parts.		In 1 lb. oz.	gr.
Water	89·0	...	14	105
Albuminoids	0·5	...	0	35
Sugar	4·5	...	0	315
Gum, pectose, etc.	2·5	...	0	175
Fat	0·2	...	0	14
Cellulose	2·3	...	0	161
Mineral matter	1·0	...	0	70

The nutrient-ratio is here 1 : 14; the nutrient-value is 7½.

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.*)

The garden parsnip is a cultivated variety of the wild parsnip, which, like the carrot, is a native umbelliferous plant. The cultivated variety has been grown from 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	82·0	...	13	52
Albuminoids, etc.	1·2	...	0	84
Sugar	5·0	...	0	350
Starch	3·5	...	0	245
Pectose, dextrin, etc.	3·7	...	0	259
Fat	1·5	...	0	105
Cellulose	2·1	...	0	147
Mineral matter	1·0	...	0	70

The nutrient-ratio is here 1 : 12; the nutrient-value is 16.

Beet Root.

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

The sea-beet, 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, etc.

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, etc.

Roots of garden-beet contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	82·2	...	13	67
Albuminoids	0·4	...	0	28
Extractives, including amides	1·0	...	0	70
Sugar	10·0	...	1	262
Pectose	2·4	...	0	168
Fat	0·1	...	0	7
Cellulose	3·0	...	0	210
Mineral matter	0·9	...	0	63

The nutrient-ratio is here 1 : 29; the nutrient-value is 12.

Jerusalem Artichokes.

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

Jerusalem artichokes are the tubers of one of the *Compositæ*, a kind of sunflower, which is thought to have been a native of Mexico 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. The tubers of this plant contain a substance resembling starch known as *inulin*, as well as much levulin, a gum-like substance, together with some sugar.

The tubers of Jerusalem artichokes contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	80·0	...	12	350
Albuminoids, etc.	2·0	...	0	140
Gum (levulin)	9·1	...	1	200
Sugar	4·2	...	0	294
Inulin	1·1	...	0	77
Fat	0·5	...	0	35
Cellulose	2·0	...	0	140
Mineral matter	1·1	...	0	77

The nutrient-ratio is here 1 : 8; the nutrient-value is 16.

ONIONS.

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

The onion is a native of the Himalaya and other mountain-ranges of Central Asia. It belongs to the Lily Order. Although onions have been grown largely in the United Kingdom for 200 years or more, yet as late as the middle of the seventeenth century our supplies were drawn chiefly from Flanders. 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 superior to that of white turnips. Burnt, or rather scorched, onions are used for colouring soups.

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

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

If it be assumed that all the nitrogen is here albuminoid the nutrient-ratio becomes 1 : 3½; the nutrient-value lies between 6 and 7.

Some analyses show 3 per cent. less water in these bulbs.

SWEET POTATO.

(*Convolvulus Batatas.*)

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 largely in China and Japan, in Algeria, and even 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 (so called, but they are really swellings of the side roots) 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.	In 1 lb. gr.
Water	75·0	12	0
Albuminoids, etc.	1·5	0	105
Starch	15·0	2	175
Sugar	1·7	0	119
Dextrin and gum	2·2	0	154
Pectose	0·9	0	63
Fat	0·4	0	28
Cellulose	1·8	0	126
Mineral matter	1·5	0	105

The nutrient-ratio is here 1 : 13; the nutrient-value is 22.

There are several cultivated varieties of the sweet potato differing in size and shape, and in being early or late. Most of them have a pronounced odour of violets. One sort known in France as *Patate Igname*, sometimes attains a weight of 9 lb.

YAM.

(Dioscorea alata, and other species.)

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 sub-tropical countries. It flourishes in Japan, the East and West Indies, the South Sea Islands, and is an important article of food.

A kind of yam from China (*D. Batatas*), called in French *Igname de la Chine*, is cultivated with some success in France and Algeria; the produce has been known occasionally to exceed 23 tons of tubers per acre. It is quite hardy, the tubers or rhizomes are 2 or 3 feet in length, and weigh, when well grown, 2 or 3 lb. They keep well, and are floury and palatable.

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
Albuminoids, etc.	2·2	...	0	154
Starch, etc.	15·3	...	2	196
Fat	0·5	...	0	35
Cellulose	0·9	...	0	63
Mineral matter	1·5	...	0	105

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.

The small curiously-shaped tubers of a labiate (*Stachys tuberifera*), have been lately introduced as a vegetable. They contain very little starch, but a considerable amount of a substance which closely resembles the gum-like, digestible carbohydrate known as *galactan.* The complete analysis of these tubers gave the following percentages :—

Water	78·3
Albuminoids	1·5
Amides	1·7
Galactan, etc.	16·6
Fat	0·2
Cellulose	0·7
Mineral matter	1·0

The roots of the dwarf palm (*Chamærops humilis*), which grows wild in some parts of Southern Europe, are eaten by the inhabitants in the neighbourhood of St. Antisco at the south-west extremity of Sardinia. This food is known locally as *margallion.*

§ 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 ; it is probably very small.

Cabbage.

French, *Chou.* German, *Kohl.* Italian, *Cavolo.*
(*Brassica oleracea.*)

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. So late as 1582 cabbages do not appear to have been grown in England, but were imported from the Continent.

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.	In 1 lb. gr.
Water	89·0	...	14	105
Albuminoids, etc.	1·5	...	0	105
Sugar, starch, and gum	5·8	...	0	406
Fat, etc.	0·5	...	0	35
Cellulose	2·0	...	0	140
Mineral matter	1·2	...	0	84

The nutrient-ratio is here 1 : 4; the nutrient-value is 7½. Broccoli and cauliflower are rather richer in albuminoids and mineral matter than cabbage.

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. 100 parts of fresh spinach-leaves contain 90 of water, 1·2 of albuminoids, 0·5 of fat, 4·0 of carbohydrates, 1·0 of cellulose, and 2·0 of mineral matter. 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 or otherwise blanched.

SEA-KALE.

(*Crambe maritima.*)

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
Albuminoids, etc.	1·4	...	0	98
Mucilage, starch, etc.	3·8	...	0	266
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, in which, some undetermined nitrogen compounds, probably amides, are included with the albuminoids, etc.

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. One hundred parts of asparagus stems contain, according to my analysis, 89·8 water, 3·0 albuminoids, 1·5 sugar, 1·8 pectose and gum, 0·4 asparagine, 2·6 cellulose, and 0·9 mineral matter.

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.*)

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.	In 1 lb. gr.
Water	94·8	...	15	73
Albuminoids, etc.	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

The nutrient-ratio is here 1 : 5; the nutrient-value is 3½.

Tomatoes.

French, *Pommes d'amour.* German, *Liebesäpfel.* Italian, *Pomodori.*
(*Lycopersicum esculentum.*)

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 salads as well as sauce, and in other ways with cooked meat. Unripe tomatoes make a good pickle.

Ripe tomatoes contain—

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	89·8	...	14	161
Albuminoids, etc.	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

The nutrient-ratio is here 1 : 5; the nutrient-value is 8½.

Fungi and Mushrooms.

Amongst the vascular cryptogams the common brake furnishes in some countries a valued article of food. In Japan, for instance, the tips of the fronds are gathered before they unroll to be used in soups, and as a green vegetable. In the autumn the roots of this fern are dug up and used as a source of starch. In the Canary Islands and in Australia the rhizomes of a closely-allied species of brake are also used as food.

The nutrient-value of cryptogamic plants generally 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*.)

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.

The common mushroom, the champignon, and the morel, are nearly identical in chemical composition; the truffle contains less water (73 per cent.) than the common agaric; and proportionately larger quantities of the various nutrients. Mushrooms are highly nitrogenous; some kinds contain much fat or oil.

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

The chief constituents of the common mushroom are—

	In 100 parts.		In 1 lb. oz.	In 1 lb. gr.
Water	90·0	...	14	176
Albuminoids	3·0	...	0	210
Carbohydrates, digestible	2·1	...	0	147
Carbohydrates, indigestible	1·7	...	0	119
Amides, etc.	2·0	...	0	140
Fat	0·5	...	0	35
Mineral matter	0·7	...	0	49

Lichens.

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.*)

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

The nutrient-ratio is here 1 : 8; the nutrient-value is 79.

Sea-weeds.

Sea-weeds belong, like the fungi and the lichens, to 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 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 and Japan the people are very fond of sea-weeds, and many kinds are collected and added to soups, or are eaten 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 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 sea-weed is called

Irish Moss.

(*Chondrus crispus.*)

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 considerable variations in the percentage of albuminoids present shown by the published analyses (some being 2·2 only), arise from other species of sea-weed having been mistaken for the true *Chondrus crispus*.

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, generally contains—

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

The nutrient-ratio is here 1 : 5½; the nutrient-value is 64.

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. The greater part of the water adhering to the leaves, etc., should then be removed, either by means of pressure between absorbent cloths, or by enclosing the salad materials in a net, or in a vessel of wire-netting, and then swinging this round in the air so as to drive out the water centrifugally. 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, etc., after having been dug up and washed, 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. It contains in 100 parts, 94 of water, 1 of albuminoids, 1 of sugar, 2 of pectose and starch, 0·6 of cellulose, and 0·8 of mineral matter.

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 cucumber, 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.

Other leaves used in salads are those of the nettle (*Urtica dioica*); of the Dandelion (*Leontodon taraxacum*); of the Plantain (*Plantago major*); of *Portulaca oleracea;* and of *Chenopodium album.*

Beet Root has been already described (p. 104).

A fair idea of the composition of the fresh and juicy vegetables commonly used as salads may be gathered from the four following analyses. 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.*)

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 stalks of celery have the following composition :—

	In 100 parts.		In 1 lb. oz.	gr.
Water	93·3	...	14	406
Albuminoids	0·8	...	0	56
Other nitrogen-compounds	0·6	...	0	42
Mucilage and starch	1·6	...	0	112
Sugar	2·0	...	0	140
Cellulose	0·9	...	0	63
Mineral matter	0·8	...	0	56

The nutrient-ratio is here 1 : 4½ ; the nutrient-value is under 5.

Lettuce.

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

The cultivated lettuce may have originated from a wild form, a native of India or Central Asia.

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
Albuminoids, etc.	0·7	...	0	49
Starch, sugar, and gum	1·6	...	0	112
Leaf-green and fat	0·2	...	0	14
Cellulose	0·5	...	0	35
Mineral matter	1·0	...	0	70

The quantity of carbonaceous and nitrogenous nutrients in the lettuce is insignificant.

Watercress.

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

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 organisms.

Watercress contains—

	In 100 parts.		In 1 lb. oz.	gr.
Water	93·1	...	14	392
Albuminoids	0·7	...	0	49
Starch, gum, etc.	3·7	...	0	259
Leaf-green and fat	0·5	...	0	35
Cellulose	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 organic nutrients present, as it depends mainly upon the mineral matters, aromatic oil, and other minor ingredients.

Cucumbers.

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

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
Albuminoids, etc.	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 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 importance 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 the 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 positive 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, render 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.

A few examples only of characteristic and important fruits containing sugar can be described in these pages. 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.*)

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, etc.

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.	In 1 lb. gr.
Water	83·0	...	13	122
Albuminoids, etc.	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

The nutrient-ratio is here 1 : 27; the nutrient-value is 11½.

Pears.

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

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.	In 1 lb. gr.
Water	84·0	13	193
Albuminoids, etc.	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 (*Pyrus 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; this, however, soon afterwards takes place.

GOOSEBERRIES.

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

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
Albuminoids	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

The nutrient-ratio is here about 1 : 20; the nutrient-value is 9.

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 (89 per cent.) 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 myrtillus*) and WHORTLEBERRY (*V. uliginosum*) are common in many woods. Their fruits may be made into a preserve.

The CRANBERRY (*Oxycoccus palustris* and *O. macrocarpus*) 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; they keep well for a long time without undergoing fermentation.

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.*)

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, etc. The fruits of some varieties 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. In the year 1896 there were imported into the United Kingdom 49,333 tons of these currants, as well as 30,475 tons of raisins.

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.	In 1 lb. gr.
Water	80·0	12	350
Albuminoids	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

The nutrient-ratio is here 1 : 20; the nutrient-value is 16.

PLUMS, ETC.

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 a 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, the morello, is specially used in preparing the liqueur cherry brandy.

Many kinds of plums (*Prunus domestica*), as damsons, prunes, French plums, greengages, are now extensively grown here or on the Continent. In Bosnia, for instance, the most important crop is the plum. In good seasons no less than 40,000 tons, worth £200,000, of the dried fruits are exported, chiefly to Germany and Austria-Hungary. 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.*
(*Prunus persica.*)

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 "pectin 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	263
Albuminoids	0·5	...	0	35
Sugar	1·8	...	0	126
Malic acid	0·7	...	0	49
Pectin 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 less water and rather more sugar and pectin.

Rhubarb.

(*Rheum rhaponticum.*)

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.	In 1 lb. gr.
Water	95·1	...	15	94
Albuminoids, etc.	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.*)

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 is a small fruit, common in Egypt, from another species (*F. sycomorus*).

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 average weight of Italian dried figs is about half that of those of Smyrna. The fig is cultivated with success in warm and sheltered situations in the South of England.

Large quantities of dried and pressed figs are imported into England (7,167 tons in 1896). 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 or Smyrna figs contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	17·5	...	2	350
Albuminoids, etc.	6·1	...	0	427
Sugar (glucose)	60·5	...	9	298
Pectose and gum	5·4	...	0	378
Fat	0·9	...	0	63
Cellulose	7·3	...	1	73
Mineral matter	2.3	...	0	161

The nutrient-ratio is here 1 : 10; the nutrient-value is 68.

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.*)

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
Albuminoids, etc.	6·6	...	1	25
Sugar	54·0	...	8	280
Pectose and gum	11·3	...	1	354
Fat	0·2	...	0	14
Cellulose	5·5	...	0	385
Mineral matter	1·6	...	0	112

The nutrient-ratio is here 1 : 9⅓; the nutrient-value is 68.

BANANAS.

(*Musa sapientum.*)

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.

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; also dried meal of unripe bananas.

Fresh-peeled bananas contain—

	In 100 parts.		In 1 lb. oz.	gr.
Water	73·9	...	11	361
Albuminoids, etc.	1·7	...	0	119
Sugar and pectose	22 8	...	3	283
Fat	0·6	...	0	42
Cellulose	0.2	...	0	14
Mineral matter	0·8	...	0	56

The nutrient-ratio is here 1 : 14; the nutrient-value is 24.

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.*)

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 Africa, and grown at Amalfi, Sorrento, Monaco, and many districts of South Italy and the Levant. This tree has a dense crown of evergreen foliage.

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	6·4	...	1	10
Mineral matter	2·9	...	0	203

The nutrient-ratio is here 1 : 8½; the nutrient-value is 68.

Oranges.

French, *Oranges.* German, *Apfelsinen.* Italian, *Melaranci.*

(*Citrus Aurantium.*)

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 (var. *nobilis*), with an easily detached and very fragrant rind; the Malta blood orange (var. *melitina*), with red flesh; and the bergamot, which yields an essential oil much used in perfumery. The bitter or Seville orange (*Citrus Aurantium*, var. *Bigaradia*); the lime (*C. Limetta*); the citron (*C. medica*, var. *acida*); the lemon (*C. medica*, var. *Limonum*); the shaddock, pomaloe, or forbidden fruit (*C. decumana*); and the cumquat (*C. Aurantium* var. *japonica*), much resembling the lime, all belong to 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 Spain and Italy. From Florida in the United States good fruit is now sent. 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 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; 8·3 per cent. of sugar; 1 per cent. of albuminoids; 1·5 per cent. of cellulose; 0·5 per cent. of mineral matter; 2 per cent. of pectose and mucilage; and small quantities of citric acid and citrate of potash.

Whole lemons contain in 100 parts—81·7 water; 0·8 albuminoids; 1·1 essential oil; 5·0 citric acid; 1·3 sugar; 5·3 pectose and mucilage; 3·4 cellulose; and 1·4 mineral matter.

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 Granatum*), 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 generally accessible. Originally of Brazilian origin, this plant has rapidly spread in many tropical countries. It has been grown in England for 200 years.

§ 6.—Nuts and Oily Fruits.

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 sativa*, 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. A sample of Italian chestnut-flour of the first quality was analysed, with the result that the presence of large quantities of dextrin and sugar were discovered therein. The percentages of the several constituents were—

Water	14·0
Albuminoids, etc.	8·5
Starch	29·9
Dextrin	22·9
Sugar	17·5
Oil	1·3
Cellulose	3 3
Mineral matter	2·6

Whether this flour had been previously submitted to any process of fermentation or roasting, which might account for these high amounts of dextrin and of sugar, could not be ascertained; there is, however, very good reason to conclude that they are natural constituents of the chestnut-kernel. It may be added that these kernels, in their perfectly ripe but quite fresh condition, contain about half their weight of water.

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 other well-known kinds.

Walnuts.

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

The walnut-tree is a native of the Himalaya, 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
Albuminoids	12·5	...	2	0
Mucilage, etc.	8·9	...	1	185
Oil	31·6	...	5	24
Cellulose	0·8	...	0	56
Mineral matter	1·7	...	0	119

The nutrient-ratio is here 1 : 6·5 ; the nutrient-value 94.

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
Albuminoids	8·4	...	1	151
Oil	28·5	...	4	245
Mucilage, starch, etc.	11·1	...	1	340
Cellulose	2·5	...	0	175
Mineral matter	1·5	...	0	105

The nutrient-ratio here is 1 : 9 ; the nutrient-value is 85.

Another well-known oily nut is the Sweet Almond, the produce of a small Mediterranean tree (*Prunus communis*), belonging to a section of the Rose Order. The so-called Jordan almonds come from Malaga. In 1898 there were imported into the United Kingdom 170,274 hundredweights of almonds, chiefly from Italy, Spain, Morocco, France, and Portugal. 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.

COMPOSITION OF SWEET ALMONDS (shelled).

	In 100 parts.		In 1 lb. oz.	gr.
Water	6	...	0	420
Albuminoids, etc.	25	...	4	0
Oil	54	...	8	280
Mucilage, etc.	9	...	1	192
Cellulose	3	...	0	210
Mineral matter	3	...	0	210

The nutrient-ratio is here about 1 : 5⅓, and the nutrient-value 158. But as these kernels do not really contain more than 20 per cent. of true albuminoids, the above figures should probably be reduced to 1 : 6⅓ and 153 respectively.

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 known as amygdalin, 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.

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.

The PISTACHIO-NUT (*Pistacia vera*) is the produce of a small Mediterranean tree. The fruit resembles a small almond, 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	277
Oil	51·1	...	8	77
Mucilage, etc.	13·0	...	2	35
Cellulose	2·5	...	0	175
Mineral matter	3·3	...	0	231

The nutrient-ratio of these kernels is 1 : 5¾; the nutrient-value is 143.

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.

The Hickory-Nut is chiefly 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.

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 favourite localities for the coco-palm are low-lying coast-lands in the West Indies, tropical Africa, India, the Malay Archipelago, the Straits Settlements, and the islands of the South Pacific. In Fiji large plantations have been made since 1875. The trees should be planted 25 to 30 feet apart quincuncially. The variety of nut chosen should have a due proportion of edible kernel to fibrous pericarp. For the first three years other plants may be raised beneath the coco-palms. The trees yield a fair crop in their tenth, eleventh, or twelfth year, the produce increasing up to the eighteenth year; heavy crops continue for fifty years. An acre in Fiji yields 4,200 nuts.

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 leaves, when properly heated, 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 :—

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

The nutrient-ratio of this kernel is 1 : 16; the nutrient-value is 90.

Dika Bread.

(*Irvingia Barteri.*)

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 often 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
Albuminoids, etc.	9·5	...	1	227
Starch, etc.	7·2	...	1	66
Fat	73·0	...	11	298
Cellulose	3·0	...	0	210
Mineral matter	2·3	...	0	161

The nutrient-ratio in dika bread is 1 : 18; but it must be remembered that 100 parts of this food contain heat-givers equal to 175 parts of starch; the total nutrient-value stands at 184.

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 *L. Ollaria.*

Double Coco-nuts, *Loidicea seychellarum.*

Palm-nuts, *Elais guineensis.*

Candle-nuts, seeds of *Aleurites triloba.*

Souari-nuts, *Caryocar nuciferum.*

PART III.—OF 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, which is, in fact, an emulsion. 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 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, by the intervention of a minute organism, generally the *Bacterium acidi-lactici*, 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 of 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.

Some instances have been noted in which a poisonous substance (a ptomaine known as *tyrotoxicon*) has been developed in sour milk. The same poison has been occasionally found in cream and in cheese. It produces nausea, vomiting, colic, and purging. The conditions under which it is formed in sour milk appear to consist chiefly in the exclusion of air, and exposure to a rather high temperature—75° to 80° Fah.—for some days or weeks, in the presence of the butyric ferment. It need scarcely be said that the development of tyrotoxicon cannot occur in a clean and properly managed dairy.

The chief constituents of milk—whether cows' milk, human milk, goats' milk, asses' milk, or the secretion of other mammals —are casein and albumen, lactose or sugar of milk, milk-fat, and phosphates: a small quantity of citric acid, about 0·1 per cent., seems to be generally present in the form of a lime salt; milk also contains a small quantity of dissolved carbonic acid gas. 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, etc., will impoverish the milk; a small daily supply of oil-cake may add nearly 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	87·0	...	17	419
Casein, albumen, and lacto-protein	3·4	...	0	307
Milk-fat	3·8	...	0	343
Lactose, or milk-sugar	5·0	...	1	14
Mineral matter	0·8	...	0	63

Thus the total solids of milk amount to 13·0 per cent.; the solids, other than fat, being 9·2 per cent.; often 9·6. 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 8½ per cent.; but in such cases the food of the cows must have been deficient in solid nutrients, or very watery. The ratio of albuminoids to carbohydrates reckoned as starch, in average cows' milk, is as 1 to 4.

Cows' milk has the average specific gravity of 1032; one pint weighs rather more than 1 lb. 4½ 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 nearly 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.

Human Milk.—The milk of woman exhibits greater variations in composition, and is less rich in casein, than cows' milk. The latter requires the addition to each pint of about 10 oz. of warm water, and 1 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.
Water	86·9
Casein and other albuminoids	1·8
Milk-fat	4·0
Lactose, or milk-sugar	7·0
Mineral matter	0·3

The average specific gravity of human milk is 1031. The nutrient-ratio is as 1 to 9.

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

Constituents of Milk (in 100 parts).

	Ass.		Mare.		Goat.		Sheep.		Pig.
Water - -	89·0	...	90·1	...	86·4	...	81·8	...	84·8
Casein, etc. -	2·1	...	1·9	...	4·8	...	6·4	...	4·3
Milk-fat - -	1·5	...	1·1	...	4·2	...	6·0	...	5·0
Milk-sugar -	7·1	...	6·6	...	4·1	...	5·0	...	5·1
Mineral matter	0·3	...	0·3	...	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. A good 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 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. By means of mechanical separators, in which the milk is rotated at a great velocity, cream may be rapidly and nearly completely removed. 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 28 and 68.

CONSTITUENTS OF CREAM.

	In 100 parts.
Water	47·1
Casein	5·0
Milk-fat	45·0
Milk-sugar	2·5
Mineral matter	0·4

Devonshire and Cornish cream contain about 60 per cent. of milk-fat.

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 its nutrient-ratio is different from that of fresh milk, the albuminoids being in great excess. 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, which had been obtained by means of a centrifugal separator:

COMPOSITION OF SKIM MILK.

	In 100 parts.
Water	90·5
Casein and albumen	3·2
Milk-fat	0·4
Milk-sugar	5·1
Mineral matter	0·8

The nutrient-ratio is here 1 : 1¾; the nutrient-value is nearly 9.

Preserved and Condensed Milk.

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 portion 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 large quantity of cane-sugar present being less appropriate for infants than the corresponding amount of milk-sugar. Preserved milk is generally prepared by evaporating milk in a vacuum pan, after the addition of 12 lb. of cane-sugar to 100 lb. of milk, 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.		In 1 lb. oz.	gr.
Water	26·5	...	4	105
Albuminoids	9·3	...	1	213
Milk-fat	10·6	...	1	305
Milk-sugar	11·4	...	1	360
Cane-sugar	40·2	...	6	190
Mineral matter	2·0	...	0	140

For 1 part of flesh-formers in this preserved milk there are 8 parts of heat-givers, reckoned as starch. The nutrient-ratio in this condensed and sugared milk approaches 1 : 8; the nutrient-value is nearly 84. Some kinds of condensed milk contain no more than 25 per cent. of cane-sugar; and there is one sort which has received no addition of sugar, but has been evaporated down to one-third its bulk *in vacuo;* it will not, however, remain sweet for long after having been exposed to the air.

Adulteration of Milk.

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 arise 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, etc.; and the solids other than fat ought to amount to 9 or 9½ grains. The specific gravity of cows' milk is 1032.

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 nutrient-ratio 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 unreasonable to regard this tampering with the natural product as "injurious to health," nor is it difficult to foretell the results, The statements that chalk, brains, gypsum, etc., 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 thin 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-tenth to 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 name of "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 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 except by chemical analysis. It may be mentioned that 65,267 tons of margarine were imported in the year 1892, chiefly from Holland and France.

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.	In 1 lb. 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

The range of composition in a large number of genuine and well-made samples of butter recently analysed is here given:—

	In 100 parts. *Minima.*		In 100 parts. *Maxima.*
Water	9·0	...	16·1
Casein	0·1	...	3·3
Milk-fat	81·7	...	89·9
Milk-sugar	0·0	...	0·5
Common salt	0·0	...	2·8

It is scarcely necessary to say that butter contains too small a quantity of albuminoid material for it to be reckoned in comparison with its high amount of carbonaceous nutrients. 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, and by certain unorganised ferments. 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 saline 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 whole time occupied should not exceed one hour. The subsequent treatment of the curd, and the pressing, turning, and curing of the shaped cheeses, cannot be described here. In the cheese factories which are so numerous in the United States, and which have been established in England also, the whole process of cheese manufacture is carried out very quickly and uniformly. Some idea of the quantity of cheese necessary to supplement that which is made in this country may be gained from the fact, that during the year 1892 not less than 11,640 tons were received from abroad. About one-third of this came from British possessions, the remainder chiefly from the United States and Holland.

There are three chief kinds of cheese:—Whole-milk cheese, skim-milk cheese, cream cheese; but these 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 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 (or should be) 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.

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 and lactic acid	2·0	...	0	140
Phosphates	3·1	...	0	217
Common salt	1·8	...	0	126

The nutrient-ratio is here 1 : 2·4; the nutrient-value is 99.

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, macaroni, 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 much 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 fungus, called *Aspergillus glaucus;* the red mould is *Sporendonema casei.* Cheeses are also liable to the attacks of minute animals. The common cheese-mite is *Tyroglyphus Siro;* 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. Lard and margarine are sometimes introduced in the manufacture of skimmed-milk cheese, in order to replace the milk-fat which has been abstracted.

§ 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.

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. 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, lecithin, etc.	30·0
Pigment, extractives, etc.	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.	gr.
Water - - - - - - -	71·7	...	11	207
Albumen and casein - - - - -	14·0	...	2	105
Oil, lecithin, etc. - - - - -	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 more albuminoids but rather less fat than an equal weight of butchers' meat. Their nutrient-ratio is 1 : 1·9; their nutrient-value 40. One pound of the mixed yolks and whites can produce rather 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 1899 it was 16,174,760 of great hundreds. It has been calculated that 18 eggs would contain an amount of flesh-forming substance or nitrogenous 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 special 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 detected by the eye. It is caused by the presence of parasitic worms—species of *Trichina* and *Cysticercus.* It is believed that these animals, in part belonging to the tapeworms, are generally 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 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. 124. 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 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 palatable and more concentrated, but at the same time to reduce the proportion of fat. But cooking generally lessens the rate at which meat is digested; this is evident from the figures in the following table of the

Times of Digestion of

	Hours.		Hours.
Beef, raw	2	Mutton, roasted	$3\frac{1}{4}$
Beef, half-boiled	$2\frac{1}{2}$	Veal, raw	$2\frac{1}{2}$
Beef, well-boiled	$2\frac{3}{4}$ to 3	Pork, raw	3
Beef, half-roasted	$2\frac{3}{4}$ to 3	Pork, roasted	$5\frac{1}{4}$
Beef, well-roasted	$3\frac{1}{4}$ to 4	Fowls, boiled	4
Mutton, raw	2	Turkey, boiled	$2\frac{1}{2}$
Mutton, boiled	3	Venison, broiled	$1\frac{1}{2}$

We may add here that animal food is more digestible when cooked between 160° and 180° Fah. than at higher temperatures, and that the rate of its digestion is greatly increased by a fine state of division.

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 submitted to special examination, and then to present a more general view of the composition of the other kinds of flesh-meat.

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.	In 1 lb. gr.
Water	44·1	...	7	24
Albumen	1·7	...	0	119
Albuminoids	5·9	...	0	413
Osseids	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.	In 1 lb. 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, etc.	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, yet a few words may be usefully introduced on the meaning to be attached to three general terms which it will be requisite to use frequently in the analyses of meat which will be cited. These terms are "nitrogenous matter," "other nitrogen-compounds," and "extractives." Generally, by the first expression, when it is followed by the second, albuminoids *and* osseids are meant. We know that the albuminoids have a more complex composition than the osseids, are of much higher value as nutrients, and have more numerous offices to fulfil than the osseids. But in numerous analyses of animal products they have not been separately estimated, and the determinations that have been made are open to doubt. For this reason the nutrient-ratios of animal foods have been omitted from our descriptions in most cases, as they cannot at present be given accurately. By the phrase "other nitrogen-compounds," we imply substances containing nitrogen which cannot be ranked with the albuminoids or with the osseids, and which are of little or no nutrient-value. "Extractives" include organic substances soluble in water and not containing nitrogen; as nutrients they possess, in general, a value inferior to that of starch; they occur in small proportions only. Where, however, we use the two terms, "nitrogenous matter" and "extractives," in an analysis, not mentioning "other nitrogen-compounds," we include amongst the extractives all organic compounds, whether containing nitrogen or not, which can be extracted by water, and which are not comprised under albuminoids and osseids, and which are soluble either in cold water or in hot.

Before giving some analyses of other kinds of meat, it would be well to remind our readers of what was said on p. 162 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 numerous analyses made in this country and abroad of the various kinds of meat, without bone:—

CONSTITUENTS IN 100 PARTS OF

	Beef, well-fed.	Beef, fat.	Veal.	Pork, lean.	Pork. fat.	Mutton.
Water	69·4	55·0	61·8	71·1	44·5	70·8
Nitrogenous matter	19·5	16·5	18·2	20·8	12·6	19·0
Fat, etc.	9·7	27·3	8·9	6·9	42·4	9·0
Mineral matter	1·4	1·2	1·1	1·2	0·5	1·2

It must be understood that each of the fixed or solid constituents above named includes, under a single designation, several distinct compounds. For example, the "nitrogenous matter" represents (*a*) true albuminoids, (*b*) osseids, and (*c*) soluble, crystalline basic bodies known as creatine, creatinine, and carnine. The three last-mentioned nitrogenous matters exist in small proportions only—they are concentrated in the gravy of cooked meat, and constitute a large part of *extractum carnis*. So the main bulk of the nitrogenous matter consists of albuminoids—true muscle-formers—and of osseids, substances which have been fully described on page 45, and which, for the most part, give rise to gelatin and chondrin by long boiling with water. They exist in muscular flesh as membranes, tendons, and similar tissues. Their amount varies much in different meats, in different joints, and in different parts of the same joint. In the majority of analyses (of beef, mutton, veal, etc.) which have been made, they are not distinguished from the true albuminoids, though their nutrient-value being small, and their functions as food-material limited, their estimation is very important. In some instances they have been stated to amount to half the total nitrogenous matter.

Again, under the heading "fat, etc.," are included traces of *inosite* or muscle-sugar, and of two or three other non-nitrogenous matters; while the "mineral matter" comprises potash, soda, lime, phosphoric acid, sulphuric acid, chlorine, etc. To these observations we may add the general statement that the percentages of fat and of water in any kind or sample of butchers' meat are very nearly in inverse ratio—the more fat the less water, and *vice versâ.*

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.

The following further data relate to other meats, etc., 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

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 contains the following proportions of its constituents:—

	In 100 parts.
Water	77·4
Nitrogenous matter	18·5
Fat, etc.	3·0
Mineral matter	1·1

Here the ratio of flesh-formers to heat-givers reckoned as starch, is as 1 to 3-10ths—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."

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.	In 1 lb. 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.

SWEETBREAD 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.

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.

Bullocks' tongues, horses' tongues, reindeer tongues, and sheep's 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.

The following brief list includes the scientific names of the chief mammals to which reference has been made in the present section :—

Hare, *Lepus europæus.*

Rabbit, *L. cuniculus.*

Pig, *Sus scrofa.*

Ox, *Bos taurus.*

Sheep, *Ovis aries.*

Deer, *Dama vulgaris.* This, the fallow deer, was perhaps introduced by the Romans.

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

	In 100 parts.		In 1 lb. oz.	gr.
Water	77·8	...	12	196
Nitrogenous matter	17·3	...	2	336
Extractives	2·3	...	0	161
Fat	1·0	...	0	70
Mineral matter	1·6	...	0	112

The two analyses which follow represent the percentage composition of the flesh of the pigeon and the partridge :—

	Pigeon.		Partridge.
Water	77·0	...	71·9
Nitrogenous matter	19·5	...	23·5
Extractives	1·5	...	1·8
Fat	0·9	...	1·4
Mineral matter	1·1	...	1·4

Altogether about thirty different species of birds are commonly used for food in Great Britain, very large numbers of some of these kinds being imported from abroad. Amongst the birds not previously mentioned may be named wild ducks, plover, snipe, widgeon, pheasants, quail, grouse, woodcock, capercailzie, ptarmigan, and teal; also, we regret to add, larks, 400,000 of which are said to be sold annually.

The flesh of the hare approaches very nearly in texture and composition to that of the majority of game-birds, and yields, on analysis, numbers almost identical with those given above for the partridge. The flesh of the rabbit corresponds more nearly with that of the common fowl. Venison may be classed, from the chemical point of view, with the flesh of the pigeon, but it sometimes contains much more fat.

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—

Edible Birds' Nests.

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.

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 (*Chelone viridis*), and of some parts of the South American coast, is the best known and most highly appreciated of the reptiles used as food. 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 fresh turtle. The land-tortoise (*Testudo graeca*), which is common on the Mediterranean coasts, is eaten by the inhabitants of Italy and the Levant. A small fresh-water tortoise, the terrapen, is eaten in America, and is imported into this country.

A large frog (*Rana esculenta*) is eaten in many parts of Europe: it has been introduced into this country, and has thoroughly established itself in some parts of Norfolk. 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 teguexin (*Tupinambis teguexin* and *T. nigropunctatus*) in Brazil, the axolotl (*Amblystoma tigrinum*) in Mexico, and the green lizard (*Lacerta viridis*) in Rome.

§ 5.—Fish, etc.

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
Organic matters, undetermined	2·0	...	0	140
Common salt	0·2	...	0	14
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.

It must also be noted that the true albuminoids have not been separately estimated apart from the osseids; consequently the percentage of available nitrogenous nutrients present in mackerel is here somewhat exaggerated. The particular specimen analysed was in a rather fat condition; it was caught in the middle of May. An average degree of fatness is exemplified in another analysis included in the following table:—

Composition of Fish (Edible portion – In 100 parts).

	Mackerel.	Salmon.	Flounder.	Eel.	Herring.
Water	72·5	64·0	80·4	61·0	80·0
Nitrogenous matter	17·5	22·0	14·0	10·8	10·9
Fat	8·0	12·2	2·0	27·2	7·1
Mineral matter	2·0	1·8	3·6	1·0	2·0

Amongst the numerous kinds of dried fish which are occasionally imported into this country, the bummeloh fish of the Chinese Seas and Indian Ocean are known, oddly enough, by the name of "Bombay ducks" in Bengal. They are of delicate flavour when fresh, but by drying and salting acquire a very strong smell and taste.

The large amount of salt which is introduced in the salting of fish may be judged of from the following analysis of salted herrings:—

	In 100 parts.		In 1 lb. oz.	gr.
Water	49·5	...	7	403
Nitrogenous matter	19·2	...	3	31
Extractives	1·2	...	0	84
Fat	14·3	...	2	126
Common salt	12·9	...	2	28
Other mineral matter	2·9	...	0	203

In the following list are included many of the best known and most important of the food-fishes.

Black bass, *Huro nigricans.*
Red mullet, *Mullus barbatus.*
Common mackerel, *Scomber scomber.*
Common cod, *Gadus morrhua.*
Haddock, *Gadus æglefinus.*
Whiting, *Gadus merlangus.*
Hake, *Merluccius vulgaris.*
Ling, *Molva vulgaris.*
Holibut, *Hippoglossus vulgaris.*
Turbot, *Rhombus maximus.*
Brill, *Rhombus lævis.*
Plaice, *Pleuronectes platessa.*
Flounder, *Pleuronectes flesus.*
Sole, *Solea*, sp.
Tench, *Tinca tinca.*
Trout, *Salmo fario.*
Herring, *Clupea harengus.*
Sprat, *Clupea sprattus.*
Pilchard or sardine, *C. pilchardus.*
Eel, *Anguilla vulgaris* and *latirostris.*
Sturgeon, *Acipenser ruthenus*, *A. gueldenstædtii*, and other species.

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 effect of cooking fish is illustrated by an analysis of raw and boiled salmon, which we quote from Mr. Wynter Blyth—

	In 100 parts. Uncooked.		Boiled.
Water	71·5	...	65·3
Albuminoids and osseids	18·7	...	25·9
Extractives	3·0	...	2·1
Fat	6·2	...	5·9
Mineral matter	0·6	...	0·8

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 several species of 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. Salted caviare contains about 32 per cent. of nitrogenous matter, 14 of fat, and 8 of salt.

Oysters and other molluscs may be briefly noticed here. Oysters are more 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, when in average condition, about 6 per cent. of albuminoids, 3 of nitrogen-free extractives, 1 of fat, 2 of mineral matter, and 88 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, chiefly by the Latin races. 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. In the neighbourhood of Dijon a small farmer has been known to clear £300 annually by the collection and sale of snails. From certain *escargotières* near Ulm ten million snails are sent each year to be fattened in other snail-gardens for the use of the Austrian convents during Lent. Snails of the annual value of £20,000 are sent from Troyes to the Paris markets. They are valued at 4*s.* per hundred. This snail 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.

Amongst the other Gastropod molluscs largely used for food, the following may be named: the whelk, *Buccinum undatum;* the periwinkle, *Littorina littorea;* the earshell, *Haliotis tuberculata* (this species is eaten in the Channel Islands and northern France; other species are commonly used for food in New Zealand, China, Japan, West Africa, etc.); the limpet, *Patella vulgata* (eaten in some parts of Ireland). Amongst the Pelecypod molluscs or bivalves may be named: the cockle, *Cardium edule;* the mussel, *Mytilis edulis* (largely imported from the Dutch coast); the scallop; and the oyster, *Ostræa edulis.* With the exception of the last-named, the chemical composition of the flesh of molluscs remains almost undetermined.

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.

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 having been kept without food for twenty-four 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 twelve 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 blades 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, four 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 twelve 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:

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	22·3	3	248
Nitrogenous matter	8·1	1	130
Fat	65·2	10	189
Salt	3·8	0	266
Phosphates, etc.	0·6	0	40

For one part of flesh-formers in the bacon examined there are 18½ parts of heat-givers, reckoned as starch, the 65·2 per cent. of fat being equivalent to 150 parts of starch: it must, however, be 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 1899 the imports of bacon, pork, and hams amounted to 436,845 tons, and the imports of lard to 109,402 tons.

Preserved Meats.

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 always 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 latter 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 and bisulphites 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 wholesome. 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 in these directions; much has been accomplished by the application of cold to the preservation of carcasses of fresh meat during their transport from New Zealand, Australia, and Argentina to Europe, all deleterious changes being prevented. Imports of frozen meat are very large. 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 smoked and dried legs of mutton of excellent quality have been imported.

The importation of various tinned meats has assumed very considerable proportions since its origination thirty-five years ago. During 1896 no less than 35,087 tons were imported. 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. An analysis (by the late Mr. Wigner) of tinned corned-beef gave in 100 parts: 64·1 water, 24·4 nitrogenous matter, 6·7 fat, and 4·4 mineral matter. One caution about the tinned meats is necessary. Sometimes—though rarely—they have been found to contain a little lead, and even tin, in solution in the gravy; sometimes a large number of small globules of soft solder, containing much lead, at the bottom of the can. 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 Fibre.

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, as a stimulant, 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 fibre of the meat which has been used in the preparation of these extracts is valuable when dried and powdered, or made into "fibrin" biscuits, etc., as a rich muscle-forming nutritive material. It also contains all or most of the fat originally present in the meat employed—that is, when care is taken to prevent the loss of this constituent.

The following percentages, derived from twenty-five analyses of different samples of meat-extract prepared according to Liebig's process, will furnish an idea of the chief characteristics of this product :—

Water	21·7
Organic matter	58·0
Mineral matter	20·3

The organic matter, although 8 parts of nitrogen are present therein, contains traces only of albuminoids. In 100 parts of the above-named mineral matter there are 42 parts of potash, 13 of soda, and 28 of phosphoric acid.

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, etc., 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 found that the active principles of certain food-adjuncts have some power of economising the true nutrients by arresting the rapid changes of tissue, etc., 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 some, at least, of the food-adjuncts.

The order in which we shall consider the several groups of food-adjuncts has been already indicated (p. 10). 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 oxidized 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. This liquid, which consists of several bodies belonging to the same series of chemical compounds as that which includes alcohol itself, is definitely and distinctly poisonous. 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*.

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 common practice, it remains 20 hours, and where the chemical changes begin. 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; when it is six days old, the sprout, or *acrospire*, as it is called, is much longer. 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:—pale malt, for the palest ales, at about 100° Fah.; amber malt, for other ales, at about 120° Fah.; brown malt, for porter, at about 160° Fah.; 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, known as *maltose*. 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, 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 and then infused in water, by which its soluble constituents are dissolved out, "wort" being produced, and brewers' grains left. 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 51,000 acres are devoted to the culture of this plant in England, chiefly in Kent, Sussex, and Herefordshire, while large quantities (180,233 cwts. in 1899) are yearly imported from Bavaria, Wurtemberg, and Belgium. The exhausted or spent hops 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 the 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 a solution of tartaric acid, in sour beer, or in weak sulphuric acid. There are many other fining materials which may be used.

The finished beer, which has a specific gravity between 1·014 and 1·024, holds in solution a large number of substances, but the quantities of these substances present are not large—this fermented liquor always containing between 85 and 90 per cent of water. The following is the 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. GLYCERIN, about 0·22 per cent.
7. CARBONIC ACID GAS, about 0·22 per cent.
8. MINERAL MATTER, about 0·3 per cent.

In the following analyses only some of the above constituents are separately entered, the items 2, 3, 4, and 6 above being, for instance, set down as "extractive matter," a term which includes also several substances not named above (caramel, hop-extract, etc.).

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 several 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 and are employed as partial substitutes for hops. Amongst these may be named quassia wood, chamomile flowers, and colombo root. 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, cannot 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 in the presence of the acetic ferment, *Bacterium aceti*, at a temperature of 77° to 86° Fah., loses hydrogen and gains oxygen, being 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 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.

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. 129) 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, etc., 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.

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, Hungarian, and Australian vintages. When the quantity of absolute alcohol exceeds 14 or 14½ 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 30° of proof spirit pay on import (in casks) a duty of 1*s.* 3*d.* a gallon; those over 30° and under 42° pay 3*s.* 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. In 1899 there were imported, for home consumption, 16,661,975 gallons of wines, chiefly from France, Spain, and Portugal.

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	,,	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, etc., 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. Glycerin, for instance, has not been yet mentioned, still it may amount to no inconsiderable proportion of the fixed organic matter of the wine. It is present, as we have seen, in beer also.

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, etc. 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.

Saké or Seishū is the favourite alcoholic beverage of the Japanese. It is prepared from rice, which has been made to ferment by means of a peculiar fungus, grown for the purpose, and known to botanists as *Eurotium oryzæ.* Saké, which is usually consumed hot, has about the following composition:—

	In 100 parts.
Water	85·0
Alcohol	12·5
Sugar	0·5
Dextrin	0·2
Glycerin	1·1
Free acids	0·2
Other substances	0·5

The total annual consumption of alcoholic liquors, of native production, in Japan, amounts to 6¼ gallons per head of the population.

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.

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, etc. 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, etc., 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, etc., 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.

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, etc., 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, etc. etc. A Japanese spirit, called "shōchū," is distilled from the dregs, in the press, in the preparation of rice-beer or "saké." It contains, on an average, about 40 per cent. of alcohol.

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.

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. Noyeau is flavoured with the essential oil of bitter almonds, which is identical with that distilled from peach kernels, laurel leaves, etc. Chartreuse contains a peculiar kind of turpentine, with the essential oil of angelica, as well as other aromatic oils. 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 home-made spirits annually consumed in the United Kingdom may be gained from the following figures, which represent the quantities for the year ending March 31st, 1899:—

	Gallons.
England and Wales	23,145,797
Scotland	7,078,514
Ireland	4,109,773
Total	34,334,084

Add to this total one-fourth more, or 8,583,521 gallons imported from abroad.

The duty payable on imported spirits is 10*s.* 10*d.* per gallon. Most of the rum imported (4,112,427 gallons were retained for home consumption in 1899) came from British Guiana and the British West Indies. 2,613,923 gallons of brandy were kept in

1899, most of it from France, and of Geneva and other kinds 1,398,980 gallons.

§ 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, etc., 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.*

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.

White Mustard, the seeds of *Brassica alba*, does not yield a pungent oil, but only a non-volatile rubefacient. Its cultivation is extending in England, as in Essex and Cambridgeshire.

Pepper.

French, *Poivre*. German, *Pfeffer*. Italian, *Pepe*.

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, etc. Pepper owes its pungency to about 1½ per cent. of an essential oil: it contains also from 5 to 13 per cent. of piperine, as well as ½ per cent. of the volatile alkaloid piperidine.

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. They are also derived from *C. minimum*, another Indian species, which is grown likewise in Zanzibar and Sierra Leone. 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, etc. The sweet red pepper of Spain is produced by

C. tetragonum. The capsicum belongs to the *Solanaceæ,* the Order which includes the potato, the tomato, and tobacco. Japan pepper consists of the fruit capsules of a plant belonging to the Rue Order, *Zanthoxylum piperitum.*

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, *Frezzamolo.*

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 capillaceum*), 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 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, etc.: 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 (*Allium sativum*) 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 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—

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, etc., 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 (*C. Cassia*).

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, etc., 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 chiefly 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 syrup, yield a pleasant sweetmeat; the fruits are employed 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, etc., 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:—

1. *Essential Oils 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 syrup as candied peel, and in several other forms.

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.

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 cultivation of vanilla was introduced into the French colony of Réunion in 1817. The produce has increased from a few pounds in 1820 to nearly 500,000 lb. in 1888. The plant continues to bear until its thirtieth year, producing annually forty to fifty-five pods. Vanilla is also grown in Guadaloupe, Guiana, Java, Mauritius, Tahiti, the West Indies, etc. 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 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.

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, etc. 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.

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. The same statement must be made with regard to a large number of similar preparations, sold under various names, and often flavoured with pepper and salt. They contain no albuminoids.

§ 3.—Vinegar, Pickles, and Acids.

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 taken 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.

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.

Tartaric Acid is the characteristic acid of grapes. It occurs chiefly 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.

P 2

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, etc. 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, 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 in vinegar containing free sulphuric acid or sulphates; the latter salts occur naturally in malt vinegar.

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 alcoholic liquor, 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, etc., 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*.
(*Camellia thea.*)

The plant which yields the tea of commerce is a native of Bengal: it is a shrub belonging to the same genus as the camellia. It has been long grown in China, and may indeed be indigenous to parts of that empire. The regular importation of tea into England from China began in the year 1673, when 4,713 pounds were received. Our supplies now come mainly from China, India, and Ceylon, but a good deal of tea is grown in Japan. In the last-named country the tea-plant occupies about 2½ per cent. of the cultivated land; much of the produce is retained for home consumption, but a good deal is exported, chiefly to Canada and the United States. Japanese tea is green. The recent extension of tea-cultivation in British India and in Ceylon, and the improved methods of curing the leaf there adopted, have greatly increased the consumption of Indian and Ceylon teas in this country, and have greatly diminished the imports of tea from China, as the following comparison will show :—

Imports of Tea, for Home Consumption, in lbs.

	1877.		1898.
From China	154,990,873	...	14,695,334
,, India	30,940,724	...	133,430,351
,, Ceylon	492	...	82,471,745

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 were formerly 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 hue 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.

Good average black tea, as imported, may be fairly represented by the following figures:—

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	8·0	1	122
Albuminoids	17·5	2	350
Theine	3·2	0	224
Tannin	17·5	2	350
Chlorophyll and resin	4·5	0	315
Essential oil	0·4	0	28
Minor extractives	8·6	1	164
Cellulose, etc.	34·0	5	193
Mineral matter	6·3	1	4

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. The amount consumed per head varies greatly in different countries: in England it amounts to $5^1/_5$ lb.; but in Germany to no more than 0·05 of a lb.

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.

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, being more robust, flourishing at lower elevations, and yielding a larger berry. 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 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.

Roasted coffee generally contains—

	In 100 parts.	In 1 lb. oz.	gr.
Water	2·0	0	140
Albuminoids	12·5	2	0
Theine (Caffeine)	1·0	0	70
Fat or oil	12·5	2	0
Tannin	5·0	0	350
Minor extractives	14·4	2	133
Cellulose, etc.	48·0	7	297
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. For household use Fletcher's rapid gas coffee-roaster is well adapted.

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, the British West Indies and Ceylon. There are four species of *Theobroma* known; the beans of the Guatemala cocoa (*Th. angustifolia*) are of particularly fine quality. 49,256,948 lbs. of cocoa, raw and manufactured, were imported in 1896, chiefly from the British West Indies.

A single fruit of this tree contains many seeds closely packed in a little pulp. Cocoa beans should be fermented for three to seven days, with plantain and other leaves, before being dried in the sun. 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.

Good cocoa-nibs contain—

	In 100 parts.	In 1 lb. oz.	In 1 lb. gr.
Water	5·0	0	350
Albuminoids	12·5	2	0
Fat	50·0	8	0
Theobromine	1·0	0	70
Cacao-red	3·0	0	210
Tannin	6·0	0	420
Gum, etc.	7·0	1	52
Cellulose and insoluble matter	12·5	2	0
Mineral matter	3·0	0	210

Theobromine is the active principle of cocoa; the taste and aroma of cocoa are due mainly to an essential oil. For general use cocoa is a milder, less stimulating, and more nutritious 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 carbohydrates and fat equivalent to 132 parts of starch, while the albuminoids present amount to 12 or 13 parts—the ratio of the latter to the former being thus as 1 to 11.

The chief forms of prepared cocoa are—

Soluble Cocoa. Mixtures of ground cocoa, with starch, etc., are called soluble cocoa. With boiling water a thick mucilage is produced, in which the finely-ground cocoa remains suspended—it does not dissolve—the term "soluble" is therefore incorrect.

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. There are, however, three grades, the second and third containing an excessive proportion of husk.

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.*)

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, Yapon tea (*Ilex cassine*), 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 they are 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 1·5 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.

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, which in good samples of the dry coca-leaves may amount to 1½ per cent. The employment of cocaine, as an anodyne and local anæsthetic in surgery and medicine, has extended greatly during recent years. 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*.

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, and Yapon tea, 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*);
Yapon tea (*Ilex cassine*);
Appalachian tea (*Prinos glaber*);
Corossal tea (*Anona muricata*);
Sumatra tea (leaves of *Coffea arabica*);
Phaskomylia tea (leaves of *Salvia triloba*);
Kaffir tea (*Helichrysum nudiflorum*);
Botany-Bay tea (*Smilax glycyphylla*);
Anise tea (*Vaccinium hispidulum*);
Bourbon tea (*Angræcum fragrans*).

§ 5.—Tobacco and Opium.

Amongst the food-adjuncts we give the last and lowest place 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. It is remarkable that the United States, although the largest tobacco-growing country in the world, actually took in 1887 no less than 5,771,000 lb. of tobacco grown in Sumatra for the use of the cigar manufacturers of New York. In the year 1898, the total amount of raw and manufactured tobacco imported into the United Kingdom for home use was 73,794,197 lb., chiefly from the United States, Holland, Turkey, Japan, China, and the East Indies. The customs duties on the various kinds of raw and manufactured tobaccos range, per lb., between 5*s.* 6*d.* on cigars and 3*s.* on raw tobacco containing at least 10 per cent. of moisture.

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* yields much of the East Indian tobacco, 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 in all cases.

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 belonging to the group of the alkaloids. This nicotine has a very powerful action upon the nervous system, being a narcotic, like the morphine, narcotine, etc., 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, etc.) 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. The leaves of *Liatris* *odoratissima* are used largely for scenting snuff. This composite plant is abundant in the moist lowlands of North America, particularly in Florida. Tonquin beans (*Dipteryx odorata*), from Guiana, are used for the same purpose.

The consumption of tobacco per head of the entire population may be approximately set down as :—

	lb.		lb.		lb.
Netherlands	7·1	Belgium	3·2	Sweden	2·0
United States	4·5	Germany	3·0	Spain	1·7
Austria	3·8	Norway	2·3	United Kingdom	1·85
Denmark	3·7	Europe	2·3	Italy	1·25
Switzerland	3·3	France	2·1	Russia	1·2

Opium.

Opium is the dried latex or milky juice of the opium poppy (*Papaver somniferum*). It is procured by making cuts in the 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 partly from British India; but the opium-poppy is now grown in every province of the Chinese Empire, the islands of Formosa and Hainan being the only places where it is not cultivated. Szechuen alone produces annually no less than 89,263 tons; in this province seven-tenths of the adult males are now opium smokers. In the province of Yunnan the poppy-fields occupy one-third of the cultivated area. The imperial Chinese edicts prohibiting the production of opium are a dead letter. The opium imported from India to China is now mainly consumed by the wealthier natives. 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, seventeen of these having been already described. The most important of these constituents is morphine, to which alkaloid the chief characteristic properties of opium are mainly 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 as a sedative and anodyne, alleviating pain, and producing a quiet sleep. When smoked, as in China and many other parts of the world, it is sometimes 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 and excessive 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-resin, the narcotic substance produced by the common hemp-plant (*Cannabis sativa*), when grown in India and other tropical and sub-tropical countries. The betel-nut (*Areca Catechu*) is the seed of a palm. It is chewed along with the leaf of the betel-pepper (*Chavica betle* and *C. Siriboa*). The mixture contains much tannin, an aromatic oil, and one or more alkaloids. It is a mild intoxicant.

PART V.—OF DIET AND DIETARIES.

THE work and offices performed by human food have been already sketched in the First Part of this handbook. 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, etc., 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.

Not only must these elements be taken in the form of compound substances of which they form a part, but our selection of such compounds is restricted. So nitrogen must be supplied mainly by albuminoids, although osseids can be substituted for them to a limited extent and for some purposes. And the supplies of carbon must come either from oils and fats or from such carbohydrates as starch, dextrin, and sugar, the albuminoids and osseids themselves being, however, capable of furnishing carbon as well as nitrogen. Neither uncombined nitrogen (as that in the atmosphere), nor uncombined carbon (as that of charcoal), is of the least value in food. And the same statement may be made as to the nitrogen in nitrates and the carbon in carbonates—these two classes of salts being cited as instances from a very large number which might have been named, and these remarks as to nitrogen and carbon may be supplemented by similar statements as to hydrogen. This element in a free state is of no service in the animal economy, nor is it of any use when combined with carbon only, as in the large class of hydro-carbons. Its more important compound with oxygen—namely, water—has many functions to fulfil, as we have previously pointed out. But hydrogen as it exists in the oils or fats and in the albuminoids, performs one important office in a dietary: it gives heat and therefore actual energy during its combination with oxygen. The hydrogen in the carbohydrates cannot be regarded as having any potential energy, since it is already associated, in these compounds, with all the oxygen with which it can unite.

The *proportion* which the above nitrogen-compounds bear to these nutrient carbon-compounds has also to be considered. Something has been said on this subject in Part I., but further details will be given presently as to this "nutrient-ratio." Meanwhile we may state that there are three methods of estimating the practical value of any actual or given dietary or daily ration—methods which may be used also in constructing new dietaries, and new rations for a day. One of these methods is to ascertain the amount of energy stored up in the nutrients of the ration, and to compare the number or value thus calculated with the value required. Alone, this method is insufficient, for it takes no account of the nutrient-ratio, and thus a ration in which there was ample energy for the day's work, internal and external, might be quite unsuitable as containing an excess or defect of albuminoids, of fat, or of carbohydrates. The two other methods involve the calculation of the nutrient-ratio—one or other of them should be used in connection with the first method. We may ascertain the amounts of nitrogen and of carbon; or the amounts of albuminoids and of carbohydrates, adding to these the starch-equivalent of any oil or fat present in the rations. Of course having ascertained these *amounts*, we may learn their ratios.

Now as to the valuation of a dietary by means of the first method. In order to find out the amount of energy which it can yield we multiply the number of ounces in it of albuminoids by 178·3, the number of ounces of fat or oil by 401·9, and the number of ounces of digestible carbohydrates by 178·3; in practice, we first add together the albuminoids and carbohydrates and multiply the sum by 178·3. The resulting values are *foot-tons* (see p. 41), and will prove somewhat higher than the earlier results obtained by Dr. Frankland, several of which, however, we shall retain, as they are frequently quoted in books on food and dietetics. An example will make this calculation clear. We take the standard dietary given on p. 52. The albuminoids and carbohydrates added together amount to 15 oz. 288 gr., which is just 15·6 oz. This multiplied by 178·3 gives 2781·5 foot-tons. We then multiply the fat, 3 oz. 337 gr. or 3·77 oz., by 401·9, and get 1,515·2 foot-tons. Adding these products together, we reach a total of 4,296·7 foot-tons. We may now adopt the same plan with individual articles of food. The following table includes a few of such calculated values, the analyses given on the previous pages of this handbook providing the necessary data. The foot-tons recorded in this table are those furnished by one pound of the edible part of each food; the figures set down in the last column give the number of pounds, ounces, and tenths of an ounce of each food needed in order to supply the daily quantum of energy, and may be called, from this point of view, food-equivalents :—

Foods.	Foot-tons from 1 lb.	Equivalents. lb.	Equivalents. oz.
Butter	5,681	0	12·1
Oatmeal	2,797	1	8·6
Cheese, Gloucester	2,789	1	8·7
Maize	2,475	1	11·8
Pearl barley	2,416	1	12·4
Rice, cleaned	2,413	1	12·5
Peas	2,194	1	15·4

Foods.	Foot-tons from 1 lb.	Equivalents. lb.	oz.
Bread	1,605	2	10·5
Beef, rather fat	1,564	2	12·0
Beef, rather lean	1,179	3	10·4
Eggs	975	4	6·6
Potatoes	580	7	6·6
Milk, cows'	483	8	14·6
Flounder	355	12	1·8
Turnips	97	44	3·3

The practical deductions from the figures in this table are easily drawn. We see that a little over 12 oz. of butter will supply the same amount of energy (heat and work) as 1 lb. 8½ oz. of oatmeal or 7 lb. 6½ oz. of potatoes. But as the first of these foods contains no nitrogen, and the second and third an insufficient proportion, it is clear that we must replace a portion of these amounts, in any daily ration, by means of a suitable quantity of a food containing an excess of nitrogen, such, for instance, as No. 3 in our table—cheese. We shall recur to this subject presently; meanwhile we give a more extended table, in which the number of foot-tons of work producible from 1 lb. of different articles of food is recorded. These figures are those previously mentioned as having been obtained by Dr. Frankland:—

Foods.	Foot-tons from 1 lb.	Foods.	Foot-tons from 1 lb.
Beef fat	5,649	Lean of boiled ham	1,041
Butter	4,507	Mackerel	1,000
Cheese, Cheshire	2,704	Lean of beef	885
Oatmeal	2,439	Lean of veal	726
Arrowroot starch	2,427	Guinness's stout	665
Wheaten flour	2,383	Potatoes	618
Pea meal	2,341	Whiting	491
Ground rice	2,330	Bass's ale	480
Gelatin	2,270	Apples	400
Cane sugar	2,077	Milk	390
Egg yolk	2,051	White of egg	357
Grape sugar	2,033	Carrots	322
Egg, hard-boiled	1,415	Cabbage	261
Bread crumb	1,333		

We may here remind the reader that the greatest amount of work outside the body which the oxidation of 1 lb. of the above substances within the body could enable a man to perform would be about one-fifth of the several amounts given in the table.

The relative cost of the several quantities of the above substances, which would contain the same amount of 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 lbs.	Price per lb. s.	Price per lb. d.	Cost. s.	Cost. d.
Ground rice	1·341	0	1½	0	2
Oatmeal	1·281	0	1¾	0	2½
Wheaten flour	1·311	0	1¾	0	2½
Bread	2·345	0	1¼	0	3
Cane sugar	1·505	0	2¼	0	3½
Pea meal	1·335	0	3	0	4
Beef fat	0·555	0	8	0	4½
Potatoes	5·068	0	1	0	5¼
Commercial grape sugar	1·537	0	3½	0	5½
Cocoa nibs	0·735	1	2½	0	10½
Cheshire cheese	1·156	0	9	0	10½
Apples	7·815	0	1½	0	11¾
Cabbages	12·020	0	1	1	0¼
Butter	0·693	1	6	1	0½
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
Cod-liver oil	0·553	2	8	1	5½
Mackerel	3·124	0	8	2	1
Guinness's stout	6¾ bottles	0	5 per bottle	2	9¾
Lean beef	3·532	1	0	3	6½
Bass's pale ale	9 bottles	0	5 per bottle	3	9
Lean veal	4·300	1	0	4	3½
White of egg	8·745	0	6	4	4½
Lean ham, boiled	3·001	1	6	4	6
Whiting	6·369	1	4	9	4
Isinglass	1·377	14	6	20	0

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, not more than about 1 oz. per 24 hours being thoroughly oxidized.

It is clear, from what we have already stated, that to construct a daily ration it will not suffice merely to provide food-stuffs adequate to furnish energy equal to 4,300 foot-tons, we must bring in one or other of our methods for adjusting the nutrient-ratio of the day's food. This was formerly done by assuming the standard food of a day to contain about 300 grains of nitrogen to 4,900 grains of carbon. We give, in the two tables that follow, the quantities of various food-stuffs which would be required in order to furnish these amounts of nitrogen and carbon respectively. We assume the albuminoids to contain 16 per cent. of nitrogen; the fats to contain 75 per cent. of carbon; the carbohydrates 42 per cent.; and the albuminoids 53 per cent.

The NITROGEN required for one day would be supplied by—

	lb.	oz.
1. Cheese, Gloucester	0	14·8
2. Dry peas	1	3·3
3. Pure lean of beef	1	4·2
4. Oatmeal, Scotch	1	10·8
5. Eggs, mixed yolks and whites	1	14·9
6. Wheaten flour	2	9·1
7. Bacon	3	5·3
8. Rice, cleaned	3	9·6
9. Wheaten bread	3	13·7
10. Cows' milk	7	15·0
11. Potatoes	22	8·0
12. White turnips	54	0·0

The CARBON required for one day would be supplied by—

	lb.	oz.
1. Bacon	1	5·0
2. Scotch oatmeal	1	10·4
3. Cheese, Gloucester	1	13·2
4. Rice, cleaned	1	14·8
5. Wheaten flour	1	14·0
6. Dry peas	1	15·7
7. Wheaten bread	2	13·3
8. Eggs, mixed yolks and whites	4	7·5
9. Pure lean of beef	5	9·5
10. Potatoes	8	7·6
11. Cows' milk	10	5·9
12. White turnips	40	14·9

A glance at the preceding tables 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; oatmeal, however, occupies nearly the same position in both tables. Potatoes, on the other hand, are so deficient in available nitrogen that 2½ 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 tables of dynamic values previously given.

But there is another method, at once easier and more exact, for the construction and control of a daily ration. Instead of determining the available nitrogen and carbon we concern ourselves with the albuminoids on the one hand, and, on the other, with the starch and other digestible carbohydrates, to which we add the starch-equivalent of any oil or fat present. Now this nutrient-ratio has been ascertained for a large number of food-stuffs, and also for many dietaries specially adapted for bare sustenance, moderate work, hard work, and very hard work; also for persons of both sexes and different ages, as well as for variations in the external conditions of life. We shall consider these dietaries in the next section, confining ourselves in this place to the one standard dietary given on page 52, and to the way in which it may be constructed from a few of the food-stuffs in common use. It should, however, be stated that in order to secure a perfectly wholesome ration, suitable for continued use, a portion of the starch or other carbohydrates should always be replaced by its equivalent in oil or fat—this is particularly necessary in strenuous labour and in cold climates, and has the advantage of reducing the bulk of the food as well as of bringing into action certain digestive and absorptive processes which would otherwise be unemployed.

Standard rations have been constructed not merely by analysing the best of those in actual use, but also synthetically. The quantity and composition of the daily food have been varied until the body-weight suffered neither loss nor gain, while at the same time health was fully maintained and the required work properly performed. The nutrient-ratio generally adopted for the standard diet is 1 : 4¾. The proportion of fat or oil to starch and other carbohydrates may vary a good deal, but 1 of fat to 3½ of starch is found satisfactory.

Before proceeding further with the discussion of this nutrient-ratio, it will be convenient at once to state that many of the data upon which the nutrient-ratios of food-stuffs and dietaries depend are not quite exactly determined in three respects: (1) as to the proportion of digestible matter (albuminoids mainly) in some of the food-stuffs; (2) as to the proportion of *true* albuminoids present in some of the food-stuffs (animal products mainly); and (3) as to the accuracy of some of the older analyses of standard dietaries. These probable sources of error in a measure correct one another, but are too complex to be more than mentioned in an elementary handbook.

Having fixed upon a normal or standard nutrient-ratio, the first step we take is to see how far it is realised by the most important food-stuffs. The following table gives the nutrient-ratio in a number of vegetable and a few animal food-stuffs :—

Foods.	Nutrient-ratio.	Foods.	Nutrient-ratio.
1. Calves' liver	1 : $\frac{3}{10}$	12. Flour	1 : $7\frac{1}{4}$
2. Eggs	1 : $1\frac{9}{10}$	13. Maize	1 : $8\frac{1}{2}$
3. Gloucester cheese	1 : $2\frac{4}{10}$	14. Filberts	1 : 9
4. Peas	1 : $2\frac{1}{2}$	15. Cleaned rice	1 : 10
5. Milk	1 : 4	16. Dried figs	1 : 12
6. Cabbage	1 : 4	17. Pearl barley	1 : $12\frac{1}{4}$
7. Vegetable marrow	1 : 5	18. Carrots	1 : 14
8. Ground-nuts	1 : $5\frac{1}{4}$	19. Potatoes	1 : 17
9. Scotch oatmeal	1 : $5\frac{3}{4}$	20. Bacon	1 : $18\frac{1}{2}$
10. Turnips	1 : 6	21. Apples	1 : 27
11. Walnuts	1 : $6\frac{1}{2}$	22. Beet-root	1 : 29

It will be seen at once that the great majority of the foods named in the table show a wide divergence from the standard nutrient-ratio. Lean meats of various animals have not been included in our list because our information as to the true albuminoids in them is meagre, much of the nitrogenous matter in them belonging to the group of osseids. By associating them with some of the starchy and saccharine foods (Nos. 10 to 19), there is, however, no doubt that the excess of non-albuminoid matter in these may be corrected. In like manner peas and other pulse, with the nutrient-ratio 1 : 2½, may be taken along with the cereals (wheat, maize, rice, barley) having a nutrient-ratio of 1 : 7¼ to 1 : 10, and the deficiencies of both classes of food supplied. The small quantity of oil or fat present in the mixture may be supplemented by the addition of fat bacon, butter, oil, etc. A very convenient way of constructing a compound standard ration is to prepare two tables, in one of which all the food-stuffs having an excess of albuminoids are included, in the other all the food-stuffs having an excess of starch or of its equivalent in fat. These tables give the amounts in ounces and decimals of an ounce of the albuminoids, and of the starch or of the fat, present in an ounce, two ounces, three ounces, and so on up to nine ounces, in the several food products. Examples quoted from two such tables are—

RICE.	1 oz.	2 oz.	3 oz.	4 oz.	5 oz.	6 oz.	7 oz.	8 oz.	9 oz.
Albuminoids	·073	·146	·219	·292	·365	·438	·511	·584	·657
Starch - -	·793	1·594	2·391	3·188	3·985	4·782	5·579	6·376	7·173
PEAS.									
Albuminoids	·236	·472	·708	·944	1·180	1·416	1·652	1·888	2·124
Starch - -	·575	1·150	1·725	2·300	2·875	3·450	4·025	4·600	5·175
MUTTON.									
Albuminoids	·190	·380	·570	·760	·950	1·140	1·330	1·520	1·710
Fat - - -	·090	·180	·270	·360	·450	·540	·630	·720	·810
BACON.									
Albuminoids	·081	·162	·243	·324	·405	·486	·567	·648	·729
Fat - - -	·652	1·304	1·956	2·608	3·260	3·912	4·564	5·216	5·868

Let us suppose that we have to construct a daily ration from rice, peas, bacon, and mutton. We must keep the pulse rather low in quantity, since its nutrients are imperfectly utilised when it forms a large proportion of the day's food. The bacon we introduce mainly to supply the required fat or oil, the mutton will supply a large amount of albuminoid or at least of nitrogenous matter. If we arrange the proportions and amounts of the several nutrients so that the nutrient-ratio required is realised, and at the same time the necessary quantity of nutrients is supplied, then we may be sure that the dynamic value (in foot-tons) of the proposed ration will be sufficient. The calculation may be thus set down :—

	Oz. of Albuminoids.		Oz. of Starch.		Oz. of Fat.
Rice, 10½ oz. furnish	·766	...	8·328	...	—
Peas, 6 oz. furnish	1·416	...	3·450	...	—
Mutton, 10 oz. furnish	1·900	...	—	...	·900
Bacon, 4 oz. furnish	·324	...	—	...	2·605
Totals	4·406	...	11·778	...	3·505
Required	4·250	...	11·410	...	3·770

There is a sufficient agreement between the two sets of quantities; and in reality it is closer than it appears. The slight excess of albuminoids, which seems to be supplied by these four food-stuffs, is due to reckoning all the nitrogen of the mutton and bacon as if it existed in the albuminoid form: the excess of starch arises from our having included under that heading the starch-equivalent of the small quantity of oil in the rice and the peas; and in the same way the deficiency (of 0·265 of an ounce) in the fat is really balanced, in great measure, by the vegetable oil just named. But the caution we have given before must not be forgotten. We must bear in mind that, while a part of each nutrient always remains unused, this proportion is largest in the case of the albuminoids. So in all standard dietaries, the amounts of albuminoids required and the amounts furnished by any series of associated food-stuffs, are always exaggerated. In very few cases, however, have we the data for correcting the figures; we know that in some instances one-fourth of the total should be deducted. It is evident that such corrections will seriously modify both the theoretical and the actual nutrient-ratios.

§ 2.—Official and other Dietaries.

In calculating the total amount of nutrients required per 24 hours for an adult, and the most desirable nutrient-ratio, there are three conditions which have to be more particularly considered. These are (1) the body-weight; (2) the amount of work required to be done; (3) the climate, or rather, the temperature of the air. Of these conditions, 1 and 2 are the chief. Most European standard dietaries have been constructed for the sustenance of individuals weighing from 140 lb. to 154 lb., and the amount of work these individuals have been supposed able to perform is nearly proportional to such weight. The work of an average European labourer, weighing 150 lb., corresponds to about 300 foot-tons—300 tons lifted one foot. A very hard day's work equals 400 foot-tons. Natives of India, weighing, say, 115 lb., can and do perform an amount of daily work equal to 230 foot-tons; if their weight be 105 lb. only, they accomplish work equal to 215 foot-tons. When the famous pedestrian, Weston, was walking his 50 miles a day on level ground, he did external work which Mr. Wynter Blyth calculated at 793 foot-tons. The following table shows in ounces and decimals of an ounce the approximate amounts of the several chief nutrients which are demanded per diem under the above-named circumstances:—

	Albuminoids.	Fat.	Starch, etc.
A. European labourer of 150 lb., doing fairly hard work	4·8	4·4	14·4
B. East Indian of 105 lb., doing fairly hard work	3·6	2·5	11·2
C. Pedestrian, walking 50 miles a day	7·9	2·3	27·0

The nutrient-ratio in A is 1 : 5·1; in B, 1 : 4·7; in C, 1 : 4·2. In C it would be an improvement, where individual liking allowed it, had the starch been reduced by 4·6 oz. and the fat increased by 2 oz., the equivalent of the starch withdrawn. It may be added here that the daily allowance of water in food and drink, during very hard work, such as that in C above, must be greatly increased. Weston took 135 oz.

In general it will be found that the dietaries of the army and navy, as well as those of hospitals, prisons, and workhouses, correspond fairly well with the amount and character of the work demanded from the persons concerned. Thus, in various European armies and navies, the rations furnish from 3½ oz. to 6 oz. of albuminoids per day, the amount being raised during warfare and manœuvres. The chief defects of several of such dietaries, namely their monotony, the limited supply of fresh vegetables, and an occasional deficiency of fat and of albuminoids, are being remedied by the application of scientific knowledge.

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 (2·7 oz.) required by active men, and about three-fourths (10 oz.) the quantity of starch and fat. 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 the nitrogenous matter of flesh.

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.

The daily rations of some official and some special dietaries will contain about the following quantities of—

Diet.	Albuminoids.	Fat.	Starch, Sugar, etc.	Mineral matter.
	oz.	oz.	oz.	oz.
Prisoners' punishment (= 1 lb. bread)	1·3	0·26	8·2	0·4
Prisoners for seven days (= 1 lb. bread and ¼ lb. oatmeal)	1·8	0·5	10·7	0·6
Subsistence or famine	2·3	0·8	11·6	0·7
Prisoners' light labour	3·5	1·3	16·7	1·0
Prisoners' hard labour	4·1	1·6	18·9	1·3
Healthy adults with moderate exercise	4·2	1·4	11·6	0·7
Hard-working artisans	5·1	2·9	22·2	0·9
Navvies, blacksmiths, and others working very hard	5·6	2·5	20·4	0·9

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.

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 action of malt. Still, there is often a deficiency of fat and very much starch in substitutes for mothers' milk.

That many of the preparations sold under various names for infants' food do not fulfil the primary condition of appropriateness, so far as comparative freedom from starch is concerned, is shown by the following analyses of six kinds prepared by different makers whose names I suppress. Of these six foods the first only can be recommended :—

ANALYSES OF SIX FOODS FOR INFANTS.

Percentages.	I.	II.	III.	IV.	V.	VI.
Water	4·6	7·5	12·4	7·9	7·1	12·8
Albuminoids, etc.	11·3	11·4	12·7	12·0	12·7	11·0
Starch	29·2	62·1	57·2	68·3	71·5	69·4
Dextrin and sugar	46·7	15·1	8·3	8·4	3·7	4·4
Fat	5·5	1·9	3·1	1·7	2·8	1·0
Cellulose	0·6	0·9	0·9	0·7	1·0	0·6
Mineral matter	2·1	1·1	5·4	1·0	1·2	0·8
Phosphoric acid	(0·44)	(0·49)	(0·67)	(0·38)	(0·72)	(0·36)
Common salt	—	—	(1·34)	—	—	—

The nutrient-ratio of these preparations is fairly constant: in No. I. it is 1 : 7·8, a figure not far removed from that of human milk, which is about 1 : 9.

In the dietaries considered suitable for invalids, attempts have been made to devise food-preparations from which certain nutrients are wholly excluded. For diabetic patients gluten bread, gluten biscuits, gluten macaroni, bran biscuits, as well as cakes made with sweet almonds and eggs, are prepared. From such preparations both starch and sugar are supposed to be absent. But the above-named gluten preparations, however well made, always contain some starch; gluten macaroni and bran biscuits a good deal. Amongst other allowable vegetable products, turnips and boiled celery, Irish moss and other seaweeds, walnuts and pistachio-nuts, may be named. Fluid 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. Although milk is forbidden, cream, butter, and cheese, as well as all kinds of meat, poultry, game, and fish, and shell-fish are permitted to diabetic patients. Eggs are also allowable.

§ 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 of nearly 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 especially those which are in common use in India, China, Japan, and Siam.

Indian Foods. Rice; various kinds of millet; numerous varieties of pulse; wheat; many fresh vegetables and fruits; milk, butter, and cheese; oil; with a not inconsiderable number of fresh and dried animal foods, constitute the chief food-staples of India. So far as rice, millet, pulse, and other dry food grains are concerned, the subject has been fully treated in my "Food Grains of India." As to other materials analytical data are still very imperfect. The fruits and fresh vegetables doubtless are useful in supplying, besides sugar and oil, certain organic acids, as malic, citric, and tartaric, as well as mineral nutrients, notably phosphoric acid and potash. Other saline compounds, such as nitrates, also exist in some of these vegetable products and are not without dietetic value. Rice, the great food-staple of a large part of India, has some of its deficiencies supplied in this way, others by the use of numerous condiments, spices, and flavourers, and by the employment of a fair proportion of pulse and of clarified butter or of vegetable oil. The millets are foods presenting generally a better nutrient-ratio, with more oil and mineral matter than rice. To buckwheat, to the seed of *Chenopodium album*, as well as to the grain of *Coix gigantea*, the same remark applies. Amongst the chief pulses raised and consumed in India may be named the following: Guar-beans (*Cyamopsis psoralioides*); Peanuts (*Arachis hypogæa*); Chick-peas (*Cicer arietium* and *C. soongaricum*); Peas (*Pisum sativum*); Lentils (*Lens esculenta*); Soy-beans (*Glycine soja*); Mung-beans (*Phaseolus Mungo*); Catiang-beans (*Vigna Catiang*); Lablab-beans (*Dolichos Lablab*); Pigeon-peas (*Cajanus indicus*).

Amongst the curiosities of Indian foods we may name the corollas of *Bassia latifolia*, known as Mahua flowers. These, in their usual air-dried state, are remarkable for containing more than half their weight of sugar. In some parts of India these tree-blossoms form a really important article of food ; a single tree of fair size yields from 200 to 400 pounds of the fresh corollas. An analysis showed them to contain, when air-dried, the following percentages : Water, 15·0 ; Albuminoids, 2·2 ; Cane-sugar, 3·2 ; Grape-sugar, 52·6 ; Cellulose, 2·4 ; and Mineral matter, 4·8.

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, etc. 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, etc., 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.

Japanese Foods.—Amongst these, rice, of which numerous varieties are in general cultivation, must be regarded as the most important. Although barley and the millets form the chief food of the Japanese mountaineers, rice is the staple food of the dwellers in the plains. It appears that both swamp-rice and mountain-rice, when grown in Japan, contain a higher percentage of albuminoids than is usual with this grain. Glutinous rice is a remarkable variety, the starch of which does not strike a blue colour with iodine *Panicum crus-galli*, *P. frumentaceum*, *P. miliaceum*, *Setaria italica*, *Eleusine coracana*, and *Sorghum vulgare*, are the chief millets cultivated in Japan. Wheat and maize are also grown. Besides common barley, the naked-grain variety is met with. Buckwheat is another starchy food which may be named here. Various kinds of pulse form a very important food-staple in Japan. Of these the soy-bean (*Glycine hispida*), of which several varieties occur, is the chief. The seeds of this plant often contain no less than 37 per cent. of albuminoids, along with as much as 15 to 20 per cent. of oil or fat; soy-beans nearly approach the composition of an ideal food. Other legumes grown to a considerable extent in Japan are, *Phaseolus radiatus*, *Ph. vulgaris*, *Pisum sativum*, *Vigna Catiang*, *Canavalia ensiformis*, *Lens esculenta*, *Lupinus flavus*, *Arachis hypogæa*, and several species of *Dolichos*. Bulbs, rhizomes, and tubers of many kinds, both indigenous and introduced, are largely consumed as food in Japan. The rhizomes of the lotus (*Nelumbium speciosum*) and of the arrow-head (*Sagittaria sagittæfolia*), the tubers and bulbs of the sweet potato (*Convolvulus Batatas*), of several species of *Colocasia* and *Arum*, and of *Dioscorea*, are largely grown. The bulbs of the beautiful golden-rayed lily (*Lilium auratum*) are sometimes eaten by the poorer people. The giant radish (*Raphanus sativus*) is used in a great variety of ways, especially with rice. Favourite vegetables are many kinds of melon, pumpkin, and gourd. A few fungi are eaten, but sea-weeds are consumed in immense quantities, and are also largely exported. Sea-weed jelly, or Agar-agar (in Japanese, Fu-nori), is prepared from many different species of marine algæ to a great extent. It contains much mucilage, together with a large but variable amount of albuminoid matter. Fruits of many kinds, some indigenous, some introduced from Europe and from India, are much consumed in Japan, but, with few exceptions, they are of inferior character. Of animal foods, fish, much of it dried, is very popular. Considerable quantities of other marine animals are also eaten; they are also exported, after having been dried, to China. Among these may be named, sea-slugs (*Holothuria edulis*), Hoshi-awabi (*Haliotis gigantea* and *H. japonica*), crabs, shrimps; dried sharks' fins are also exported. A few observations on Japanese tea will be found on p. 214; as to tobacco, it may be said that it became rapidly popular very soon after the first introduction of the plant into the country. Tobacco smoking is now general. A small quantity of tobacco is exported to Great Britain.

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.

Siam produces a variety of fruits and vegetables, the great majority of which have not been examined chemically—many of them have not, indeed, been as yet botanically identified. They include, however, a large number of familiar fruits, such as the mango, rose-apple, litchi, jak-fruit, durian, tamarind, plantain, pumpkin, orange, lemon, jujube, etc. etc.

Maori Foods. An idea of the foods in use among the New Zealand aborigines may be gained from the following list of different kinds which were presented, in neatly woven baskets, before Sir George Grey's tent on the occasion of a Maori feast in 1878.

POHUA; roots of *Convolvulus sepium.* They were slightly bitter, and resembled floury potatoes.

PARA; scales from the root-stock of the grand fern, *Marattia fraxinea.* These were pinkish, rather tough, with a slightly bitter taste.

MARNAKU; junks, one foot long, of the mucilaginous pith of the great black tree-fern, *Cyathea medullaris.* These were soft and sweet when boiled or baked.

ROI; rhizomes of the brake, *Pteris aquilina*, var. *esculenta.*

TAWHA; prepared berries of a common forest tree, the *Nesodaphne tawha.*

HAKEKE; Jews' ear fungus, *Hirneola auricula-judæ.*

SOWTHISTLE; *Sonchus oleraceus.* This, when cooked, affords a substantial food.

The subject of national foods would obviously require, for its adequate discussion, a volume of no inconsiderable size. There are many points which are not yet cleared up, and the data, although abundant, are by no means complete. Several topics of great interest would have to be considered in the light of chemical and physiological knowledge. It is strange to find, for example, that a part of a single nation or race lives on food entirely different from that of another part. The Arabs of the desert live on the flesh and milk of the camel. But where the date-palm flourishes the fruit of this tree affords the chief sustenance to the Arab. The French and Spanish peasants live chiefly on vegetable food, eating but little meat; they consume, however, large quantities of oil. The Eskimo and North American Indians use animal fat to a very great extent; they rarely, if ever, have the chance of touching vegetable foods, and consequently starch cannot be reckoned amongst the nutrients which support their life.

§ 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 Romano-British 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 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.

INDEX.

THE END.

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