DIET IN RELATION

TO

HEALTH AND WORK.

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PREFACE.

THIS brief treatise was at first advertised under the title of 'Food,' but the title has been changed to that which it now bears, for fear lest there be any confusion between 'Food,' and 'Foods, their Composition and Analysis,' which latter is a work of an entirely different scope.

The design of the present "Handbook" is to give a clear, popular, and concise exposition of the composition and nutritive powers of the chief foods, and the general principles of diet.

Special Handbooks belonging to the same series having been prepared by other writers on such accessories to food, as alcoholic drinks and condiments, a description of these has been omitted.

I have for the most part given the components of the various forms of nutriment in the familiar household weights of pounds and ounces as well as percentages. The composition of a great many foods—limited space forbidding a full description—will be found tabulated in the Appendix.

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THE PRINCIPLES OF DIET.

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DIET

IN RELATION TO

HEALTH AND WORK.

DIVISION I.

FIRST PRINCIPLES—FOOD AND WORK.

CHAPTER I.

MOLECULAR LIFE.

Description of the smallest molecules of life.

§ 1. THERE are little masses of jelly to be found in ponds and brooks which possess the power of digesting without a stomach, of breathing without lungs, of feeling without nerves, of moving without muscles, and of multiplying without marriage. A few of these jellies develop into higher forms of life, others, as they commenced, so they complete the cycle of their existence; among the latter is a common microscopic object called the amœba. In strict biological language the amœba is described as composed of "*undifferentiated protoplasm*" (protos, first; plasma, form), that is, a *first-form*, no single part of which differs from any other part. The amœba takes its food by flowing round the substance, embedding it in the jelly of its body, and thus at once digesting and swallowing. After a time those portions which it cannot assimilate are ejected. The amœba breathes by absorbing oxygen from the dissolved air in water, and excreting it as carbonic acid; it is in a continual flux, for pushing out first one part and then another, it moves, or more correctly "flows," from place to place. It propagates its kind by simple buds, a little bit becomes detached, starts life on it own account, and like its parent, lives, grows, moves, eats, buds and dies, having been the whole period nothing but a shapeless little mass of protoplasm.

Man but a community of protoplasmads (plastitudes).

§ 2. Now the higher animals, including man, the highest of all, are but a collection—a multitude or a crowd—of just such minute masses of protoplasm, the nearest approach to the amœba being seen in the white corpuscles of the blood, which, when examined under proper conditions, can be observed, even when removed from the body, to be in shape, structure, and automatism precisely like the amœba ; while the farthest from the amoeba is perhaps seen in the corpuscles of bone.

Division of labour.

The greatest number of the amœba of the body have lost the power of moving from place to place, but rooted to one spot, have acquired special functions. The amœba or protoplasm of bone, develops or secretes from the nourishment brought to it, bone ; that of muscle, muscle ; that of cartilage, cartilage. The stationary masses of protoplasm are nourished by those that are moving, and thus receive not alone fluid but gaseous substances ; the red corpuscles of the blood each bring a tiny load of oxygen from the lungs, deliver the oxygen up to the tissues, go back to the lungs again to take another load, and so on for ever. This process is easily realised by anyone who has seen a beautiful experiment of Schutzenberger's. A tube of gold beater's skin is immersed in active growing yeast, and bright arterial blood, that is, blood with each of its red corpuscles containing, as in a little boat, a tiny load of oxygen, passed slowly through the tube ; the blood comes out at the other end dark and venous ; that is, it has delivered up to the living yeast cells its oxygen, just as in the body it delivers its oxygen up to the tissues.

The city of the body.

§ 3. Hence each human unit is in himself a small cosmos, a peripatetic city ; at the gates of sight, odour, feeling and hearing, stand sentinels ; along the fluid high-ways float with the stream oxygen-laden boats, discharge their cargoes, and return, and along the same channels flow the food of the inhabitants. In every day and night there are many births and many deaths. Each citizen has his appointed place and avocation ; those in the liver manufacture the bile and glycogen ; those in the brain store up as in a Fauré-battery the nervous force ; high up in the tower, beneath a thatch of hair, sit two rulers, the one a *Geist* or intelligence, the other a sleepless automaton ; the office of the higher is the direction of what are called voluntary acts ; the office of the lower is to see to the tick tick of life, the ebbing and flowing of the tides of secretion.

We have to study how this city, the city of the human *Bios*, has to be fed, the composition of the food, its distribution and assimilation.

CHAPTER II.

SUGAR STORES.—FAT STORES.

Discovery of glycogen.

§ 4. Claude Bernard made several years ago the important discovery that the blood coming from the liver was more rich in sugar than the blood going to the liver; and further, that the origin of this sugar was a starch-like substance which he isolated and extracted from the liver as a snow-white powder. He called it *glycogen** because it was readily transformed into sugar. If an animal is starved, its glycogen rapidly disappears, but if it is then given food rich in starch, the glycogen is rapidly renewed and is again found in the liver. This remarkable fact is explained by modern physiologists by supposing that the liver is a great store-room for sugar, that the blood must be maintained at a certain average composition, that many organs and tissues are constantly drawing on the blood for sugar, and that when the blood is thus deprived of its sugar, the deficiency is supplied from the great sugar store-house, the liver; when, on the other hand, we eat sweet things or starchy things in excess, instead of all this being thrown into the blood, it is treasured up for a time of need. Besides the great store-house of glycogen there are little private supplies, as it were, in the muscles themselves.

The liver a store-room for sugar.

Fat stores.

In the same way is garnered up "fat." It is not collected in one or two places, but, with the exception of certain parts which never become fat, is stored up very generally, especially beneath the skin and in the abdomen.

* Glycogen is a word derived from the Greek: glukus, sweet; gennao, to produce or engender.

CHAPTER III.

THE WORK TO BE DONE.

§ 5. The body never rests; in the long-continued deep sleep, occasionally met with, in which a person from some affection of the brain sleeps quietly for weeks, there is still work to be done, and unless suitable food be administered death will ensue. Such work is presided over by the automaton (p. 265), is independent of the will, and is called "internal work." It consists of the maintenance of the temperature of the body, of the maintenance of the heart's beat, of the respiratory wave, and of various minor reflex actions. Whereas "external work" consists in all voluntary acts whatever—standing, sitting, walking, running, thinking, talking, etc.

The never-resting organism.

External work.

§ 6. In my laboratory I have an incubator heated by gas, which I am enabled to keep at a constant temperature by means of a mercury governor. If the incubator gets hotter than required, the mercury rises and cuts off partly the supply of gas; if the incubator cools, the mercury falls; and a larger supply of gas—a larger flame—is the result. Night and day the incubator for many weeks is automatically kept within half a degree of the required heat; something like this goes on in the body, but the heat regulating automatism of the body is far superior to the heat regulating automatism of any artificial mechanism. In all climates, whether under the tropics or the poles, the temperature of the body remains at 98·8° F., or at the most one or two tenths above or below that temperature. Heat is lost to the body by evaporation from the skin, by the warming of the air we breathe, and a small quantity is also lost by all excretory matters leaving the body. Heat is given to the body by the chemical and vital changes going on. In cold

Heat equilibrium.

weather, there is greater metabolism* than in hot, and therefore a greater production of heat. It is in this increased metabolism in cold and diminished metabolism in hot, that the warm-blooded animals differ so much from the cold-blooded animals ; a frog has a temperature about that of the surrounding air, and in summer is hotter than in winter. By estimating the carbonic acid gas the frog exhales under different temperatures, it is possible to know whether the frog's metabolism is like ours, increased during cold weather, the result of the experiment is that it is diminished by cold, increased by heat ; in other words the frog behaves in this respect like a mass of dead organic matter, which decomposes quickly in hot weather, slowly in cold, while in our case it is quite the reverse.

§ 7. It is obvious that, since the food taken in and the metabolic changes in the tissues are very different at different times, and the temperature of the air is never maintained at the temperature of the body for any time, the mechanism must be very perfect to maintain the "heat equilibrium."

Regulators of heat.

The great regulator is the skin. If by exercise, or by external heat, the cutaneous vessels become dilated and filled with blood, there is a greater radiation of heat, and the perspiration is poured out, which by its evaporation cools the body ; on the other hand, cold, by constricting the vessels, causes a smaller flow through the skin, and a larger flow through the viscera, but besides the skin there is a nervous centre which regulates the production of heat, more or less heat being produced according to the wants of the body.

Heat-giving foods.

§ 8. The foods that give heat are the carbohydrates and the fatty, more especially the latter, hence in cold climates the large amount of fat used. The Esquimaux, the Tartars, the Fins, the Laps, the Patagonians, all from necessity devour enormous quantities of fat.

* Metabolism is a word derived from the Greek Meta-ballō ; its original meaning is "change" or "transposition ;" it is a convenient term by which to express "tissue change."

§ 9. The origin of muscular force has been hotly disputed. Liebig had a very strong opinion that meaty or nitrogenous substances went to feed the muscles; but this idea is no longer held, although at first sight it has so much in its favour. Everyone, for instance, knows that a highly nitrogenous diet is necessary for hard labour, that the labourer, if he can get it, eats plentifully of meat, and that the diets of training for athletic feats are also very "meaty." Origin of muscular force.

It is possible to examine living muscle itself, both at rest and in action, and to collect the products, gaseous and other, which are given forth; but when thus examined no nitrogenous body is set free, but on the contrary, carbonic acid gas, the same gas as in the burning of a candle or the burning of coal. We also find that a man in exercise and the same man in repose exhales very different amounts of carbonic acid gas. Thus one at work was found to consume in 24 hours 954 grms. of oxygen and to produce 1284 grms. of carbonic acid, but when at rest 708 grms. of oxygen and 911 grms. of carbonic acid; this man's nitrogen was not increased. This then teaches us, (1) that muscle during its action does not exhale any body containing an appreciable amount of nitrogen; (2) that it does exhale carbonic acid, just as if it breathed; (3) that in the excretions there is no increase of nitrogen beyond that consumed.

But although these are facts, yet for all that, strong exercise requires nitrogenous food. What is the reason? No decided answer, no answer that can be absolutely demonstrated by experiment, can be given; but there is probability in the view that the nitrogenous foods break up into urea, and a body nitrogen-free (in great part in the intestinal canal). The nitrogen-free body goes to form fat, which in turn is used up as a muscular fuel, and the carbon is excreted in the form of carbonic acid, just as a candle burning transforms the whole of the candle fat into carbonic acid and water; another part of the nitrogenous food possibly goes to renew the red blood corpuscles, which in strong exercise have much to do, conveying oxygen to the air-thirsty, eager, labouring tissues. We have then seen that The breaking up of the meaty substances.

the fats and carbohydrates are the remote sources of animal heat; that the nitrogenous foods are indirectly the support of the muscular system; but there is a third element to be supported—the highest of all—the nervous tissue. The nervous tissue is a most complicated structure; it contains very much water, it is built up of albumenous matter, and contains another element of which we have not spoken before, viz. phosphorus. If it were true that muscle made muscle, that fat made fat, then to stimulate our nervous system, to exalt our brains, we should live on the marrow of bones, the cerebral matter of animals, and the roe of fishes, for all these are substances rich in organic phosphorus; but if it is not clear in what way the muscles derive their energy, it is still less clear to what principle or food is to be referred the nervous force. All that we know is, that which keeps the bodily functions in the highest health is also good for the brain; the interdependence between bodily and nervous energy is so great that one can never suffer without the other more or less participating.

Food of the nervous tissues

CHAPTER IV.

A MATHEMATICAL FORM OF EXPRESSION FOR VARIOUS KINDS OF LABOUR.

§ 10. For comparing the values of foods as force producers, it is necessary to reduce all work to one common standard, in other words to reduce or convert the various kinds of labour, such as walking, climbing, pulling, rowing, carrying weights, wielding hammers and axes, into the same sort of work. This standard work is always referred to lifting a known weight. In order to fully understand this, you have only to suppose a hundredweight attached to a cord going over a pulley; now it is obvious, that neglecting friction, since there are 20 cwt. in a ton, if you lift by pulling at the string the weight exactly 1 foot off the ground and let it fall again, and do this 20 times in the day, the day's work will be accurately expressed by saying that you have lifted 1 ton 1 foot high; and the standard used in this country for expressing work is so many tons or pounds lifted 1 foot high. The mechanical equivalent of work.

The internal work, that is, the work done by the heart and generally automatic labour, is estimated at so high a figure as 260 foot-tons; the external work varies much; a country postman, 150 lbs. in weight, walking his daily round of 20 miles, would do work equal to 353·4 foot-tons; ordinary day labourers, such as we see in the roads, probably average 350 foot-tons. In the case of a pedlar cited by Parkes, who carried 28 lbs. on his back and walked 20 miles daily, the work was 419½ foot-tons. Internal work. External work.

In Weston's feat of 50 miles a day, I have calculated his daily work to be no less than 793 foot-tons, but this large number was exceeded in a former feat in which he walked 317½ miles in 5 days, which would give approximately 1010 foot-tons daily.

A very hard day's work for most men is 400 foot-tons At the other end of the scale stand the sedentary occupations, e.g., needlewomen; the external work of such may fall as low as 17 or 18 foot-tons.

The mechanical equivalent of heat.

§ 11. If the concept is difficult to those to whom these calculations are new, of expressing all manner of action as so much weight raised a certain height, the concept of expressing the latent power of various foods in the same way is still harder to grasp. I hope, nevertheless, to make the principle clear. Primitive man obtains fire by rubbing two sticks together, in other words he transmutes the force of motion into the force of heat; what the primitive man does for his necessities the scientific man has done for the advancement of knowledge. Joule and others have measured accurately the amount of friction necessary to raise a certain weight of water 1 degree of temperature; 1 lb. of water is raised 1° F. by an amount of force sufficient to raise 772 lbs. to the height of 1 foot, and this is called "*the mechanical equivalent of heat.*"*

The carbon and the hydrogen taken into the body are more or less burnt up, the one to carbonic acid gas, and the other to water. In this process they develop heat, and this heat can from the data just given be easily expressed in terms of the "mechanical equivalent of heat." The heat produced in this way by the union of oxygen is capable of experimental determination; in particular, Prof. Frankland a few years ago made some very valuable experiments and determined the energy developed by a known weight of a number of foods when burnt in oxygen.

Potential energy of food.

			Foot-tons.
An ounce of cabbage,		equalled	16
" "	carrots,	"	20
" "	milk,	"	24
" "	lean beef	"	55
" "	ground oatmeal	"	152
" "	butter	"	281

* Expressed in terms of the metrical system, this means that "a unit of heat, that is, the heat capable of raising 1 grm. of water 1° C., is equivalent to a force which would lift 423·55 grms. the height of 1 metre."

Very similar numbers have been obtained by calculation, that is, from the known amounts of carbon and hydrogen in the food. Just the same as in a steam engine the theoretical amount of steam is never obtained from a given weight of coal, so in the body this theoretical amount of force is never realised; the reason being that part of the carbon and hydrogen passes away unconsumed. But by carefully estimating these unburnt residues and subtracting them from the food, a knowledge of the available energy may be obtained. Unless this is done, a charcoal biscuit would on purely chemical grounds have a higher value ascribed to it than the same weight of an ordinary biscuit—besides, it is to be remembered that not alone must the food be digested but its energy applied at the proper place, so that the problem of determining the potential energy of a food is very complex and demands a number of exact experiments.

DIVISION II.

FOOD EQUIVALENTS.

CHAPTER V.

DIVISION OF FOODS.

Ultimate office of food.

§ 12. In the first chapter, the little protoplasmic masses, the tiny lives whose aggregate makes tissue, tendon, nerve, skin and muscle, have been described, and it has been explained that the ultimate object of all food is their nourishment. It necessarily then follows that any substance whatever that nourishes one of these micro-lives is a food. Since the tissues of the body can only be reached by circulating fluids, food must be first converted into a state suitable for absorption, so as to be conveyed by the circulation to wherever it is required; bread and butter, potatoes and meat, all have to be comminuted by the mill of the teeth, moistened by the saliva, fermented and dissolved by various juices, and reduced to the level of a common fluid: for it is obvious that such minute channels as the finest blood and lymph vessels can only convey fluids or particles of excessive minuteness.

§ 13. Foods are scientifically divided into—

Divisions of foods

1. Water.
2. Meaty or albumenous substances.
3. Starches or Carbohydrates.
4. Fats.
5. Mineral matters.
6. Accessory foods.

All of which have their representatives in the body itself.

A human being is so "watery" that the corpse of a man weighing 150 lbs., and carefully dried, would come out a shrivelled mass of about 50 lbs. in weight; the meaty substances are represented by muscle, the starchy by glycogen found in the liver, and by a sugar [*inosite*] found in the muscles; fat is present, padding angular parts and giving a roundness to the frame; mineral matters abound, especially in the bones and teeth.

Human body contains 66·6 per cent. of water.

The New Zealand native had a ferocious way of gouging out his sharp-sighted enemy's eye and swallowing it; this because he thought that such an act would give him clear sight which had resided in that eye; a very similar popular view is held by many people with reference to food; they think that if you want muscle, you must eat muscle, that fat makes fat, and that mineral matters make bone; but in these popular notions there are many errors—errors which I hope will be made clear in the subsequent pages.

The composition of the human body is somewhat as follows:—

Composition of the body.

ADULT MAN.

Bones	16 per cent.
Muscles	42 " "
Organs in the chest and abdomen .	9 " "
Fat and skin	25 " "
Brain	2 " "

Therefore supposing a person weighed 150 lbs. (ten stone ten pounds) 63 lbs. would be muscle, 37½ lbs. would be skin and fat, 24 lbs. would be bone, and 3 lbs. would be brain.

More than half the weight of the body is bone and muscle.

§ 14. Important information as to the office of food is afforded by two states—starvation and hybernation. When an animal is starved, the glycogen in the liver and the fat are the first to disappear, the abdominal organs then waste, but the muscles do not so much diminish, while the brain and spinal cord keep the same weight as

Hybernation and starvation

The master tissues.

before. Thus muscular and nervous tissues are the *master tissues* of the body, the others are their servants.

In hybernation the same phenomena are seen: on waking from the winter sleep the fat and glycogen have been used up, and the first thing the animal does is to renew both by food.

CHAPTER VI.

WATER.

§ 15. It is hardly to be realised that water essentially consists of the combination and condensation of two gases, hydrogen and oxygen in the proportion of two volumes of hydrogen and one volume of oxygen, represented by the chemical symbol H_2O; but few scientific facts are so well established. The composition of water.

In our food and tissues there is much water, part of it is in such a loose state of combination that it is usually described as *free*, but part is in a more intimate union. This will perhaps be better understood if I take an example from the mineral kingdom, say some crystals of common alum; if we sprinkle some water upon these crystals, and place them in a dish on the top of an oven which is kept at the heat of the boiling-point of water, the crystals rapidly become in popular language dry; but they still contain water—a water which bears a very definite and constant weight to the weight of the crystals, a water which to be driven off completely requires a higher heat than the water that was sprinkled upon them; and when it is at last driven off, the crystals lose their shape and crumble to a powder—so in all food that we eat, and in the body itself water is in two different states, in the one state merely soaking and imbuing the tissues or the basis of fluids, and in another state altogether, forming an intimate part and only to be got rid of by altering essentially, almost destroying, the structure.

§ 16. The amount of water in food is very large. A beef-steak contains 75 per cent. of water. In buying a pound, only one fourth of that pound is dry solid meat. Cabbages contain 85 to 90 per cent. of their weight of water, and succulent fruits sometimes more than 90 per cent. Of Amount of water in foods.

substances most commonly eaten, rusks or biscuits are the driest, and water-melons the most watery of foods.

Purposes which water serves.

§ 17. When water is taken into the system it assists without doubt in the building up of new tissues, in the repair of old. According to this view it is not merely a dilutent of fluids, it does not simply play an inactive part like a lubricant of machinery, but is in the truest sense a food. There are plenty of experiments—both involuntary experiments, as among shipwrecked people, and experiments made for the purpose of experiment—showing that so long as water is taken, the deprivation of all other food can be supported for a very long time. When deprived of food and water, it is the latter want we feel most and soonest.

To quench thirst water must be absorbed.

The sensation of thirst is felt in the mouth and throat; but it has been abundantly shown that, however much water the throat is laved with, unless the water is actually swallowed, thirst continues: e.g. in a case recorded by Dr. Gardiner, a man had a wound in the throat so placed that all liquids escaped through it; the man drank huge quantities of water, but without any alleviation; he was in the position of Tantalus, and suffered much—nevertheless, sailors shipwrecked and in extreme thirst have found some little relief by dipping or rather soaking themselves in the sea, so that it would seem that the skin is capable of absorbing some small quantity.

Amount of water required daily.

§ 18. The amount of water taken as water or in the shape of liquids—such as tea, coffee, soup, beer, and the like—varies much according to climate, exercise and custom; in our own climate, it may be put at two-and-a-half pints daily, as a sufficient quantity—the water naturally in food may amount to about two pints, making a daily total of four-and-a-half pints.

CHAPTER VII.

CARBOHYDRATES.

§ 19. The type of the carbohydrates is sugar or starch, and the composition of both sugar and starch is simply that of a union of carbon and water—hence its name, carbohydrate. That sugar or starches do contain charcoal and water, may be shown by simply burning a little sugar in a spoon ; the blackening shows the charcoal or carbon ; a dish filled with water to keep it cool, held over the burning sugar, will show a moisture of the bottom, which at all events proves that either water was originally present or was produced in the act of burning ; if the heat is continued nothing will remain in the spoon, the water has gone off as water, and the carbon has united with the oxygen of the air to form a colourless gas (carbonic acid gas) ; and as there are no mineral constituents in either pure sugar or pure starch, no ash or saline residue remains. The chemical formula for starch is $C_6 H_{10} O_5$ or six atoms of carbon united intimately with five atoms of water ($H_2 O$) ; the chemical formula for cane-sugar is $C_{12} H_{22} O_{11}$ or twelve atoms of carbon united with eleven atoms of water. It then follows that the percentage composition of starch and sugar is the same, that is, they each contain the same weight in 100 parts of carbon, hydrogen and oxygen, thus : Sugar and starches.

			Per cent.
Carbon		. . . . . .	44·45
Hydrogen	6·06	Water . . .	55·55
Oxygen	49·49		

§ 20. The four chief carbohydrates taken in food are ordinary cane-sugar, glucose, sugar of milk, and starches, such as wheat starch in bread, oat starch in oatmeal, rice starch in rice, &c. Though these have practically all the same centesimal composition, and may be presumed to be The four chief carbo-hydrates, to a great extent mutally replaceable, and to subserve the same functions in the body ; yet cane-sugar and starch are by no means alike, either in form, taste, or even in chemical reactions. It is, however, no surprising thing for substances to be identical in the percentages of their ultimate carbon, hydrogen, and oxygen, and yet to be very different things. The carbohydrates are transformed in the mouth, in the stomach, and in the intestines to some other body, the exact nature of which is not known.* When a small quantity of starch or sugar is given daily, the results of careful analyses made of the total carbon going into the body, and total carbon going out as refuse products, have shown that under such circumstances, a condition of *carbon equilibrium* is established—that is, the exact amount of carbon going into the body also leaves the body ; none of it is garnered away. On the other hand, if a plentiful supply of carbohydrates is given, the store-house of the liver becomes rich in glycogen, and at the same time there is an increase of fat. In this case careful analyses show that the amounts of carbon going into the body exceed the carbon going out of the body. There is therefore no carbon equilibrium, the body increases in weight ; the store-houses become full.

Digestion of carbo-hydrates.

Carbon equilibrium.

* Dr. Pavy's researches have clearly demonstrated that in animals there is a ferment in the stomach and intestines which acts on carbo-hydrates in a peculiar way.

CHAPTER VIII.

FATS.

§ 21. All the common fats we eat, such as butter, lard, dripping, and the fats of various meats, are absolutely neutral, that is, there is no free acid; on the other hand, vegetable fats, or oils, are seldom perfectly neutral, but contain usually some free fatty acid. The neutral fats are rather complicated bodies, splitting up under the action of superheated steam, or of a strong alkali like potash, into one or more fatty acids, and into glycerin. **Composition of fat.**

The fat, when it reaches the first part of the intestine, becomes emulsified by the action of the juice of the pancreas or sweetbread, and other juices, and is absorbed into the circulation as fat. It is believed to be partly burnt up, as it were, in the muscles, and if in moderate excess of the actual requirements, it is like glycogen stored up ready for emergencies.

§ 22. Fat is not formed entirely from fat. Lawes and Gilbert gave a pig, with other food, one hundred parts of fat, but the fat produced in the pig was four hundred and seventy-two parts, or almost five times as much as was given. The general view is now that fat is formed in part from fat, in part from carbohydrates, and in part from meaty substances. **Formation of fat.**

That the carbohydrates can produce fatty matters is well shown by the experiments of Erlenmeyer and Plantan-Reichenbau who fed bees on pure sugar and water, but they still produced wax.

CHAPTER IX.

THE NITROGENOUS, ALBUMENOUS OR MEATY SUBSTANCES.

Composition of albumen.

§ 23. The albumenous foods are so called because their type is the white or albumen of the egg. The albumen of the egg, besides containing carbon, oxygen, hydrogen, and a little sulphur, also contains nitrogen. Nitrogen itself is a gas, without odour or taste ; it is, in fact, the main constituent of the atmosphere, diluting oxygen. Each person from the beginning to the end of existence is immersed in a great gaseous ocean of nitrogen ; but however indifferent it may be in the gaseous state, when it enters into chemical combination with carbon and hydrogen it makes at once the most potent foods and poisons known. All the important functions of the body are carried on by nitrogenous fluids or solids. The muscles abound with nitrogen ; the brain, the nervous system, the blood, all the fluids of the body, and all the cells contain nitrogen, not as an accidental but as a leading character. Nitrogen is so intimately associated with life, that wherever it is found in combination it would seem to be a sign of either present or past life.

Life cannot be maintained on pure starch, sugar or fat for a long time ; on the other hand, a purely meat diet can maintain life indefinitely.

Urea.

§ 24. The nitrogen of the food appears to leave the body in the form of a substance called urea, which is dissolved in the urine ; some of the nitrogen, it is true, leaves the body by other channels, and under other forms, but the main channel is through the kidneys. It would be only natural to suppose that, with so many parts of the body nitrogenous, there would be much nitrogen to be continually replaced ; that in violent exercise, for instance, or intense brain-work, the nitrogenous molecules of the muscle or brain would be broken down in proportion to the work done, and have to be replaced by nitrogen from outside. Curiously enough, we have no proof of this, all the evidence goes to show that the excretion of nitrogen has very little relation to the work done, but very great relation to the amount of nitrogen taken into the system as food. It is true that there is a certain daily excretion of nitrogen as urea, an excretion bearing a definite relation to body-weight; but nevertheless, a number of careful experiments have shown very conclusively that nearly all the nitrogen taken as food leaves the body as urea, and that the nitrogen rises and falls whether hard work is done or not according to the nature of the food.

Intake and outgo of nitrogen.

§ 25. A nitrogenous diet increases the red corpuscles of the blood, those bodies which I have before likened to little oxygen-laden boats, and it also increases very largely the metabolic changes of the body. Perhaps this is dependent on the increased oxygen-carrying power; however this may be, the success of the so-called Banting system depends in some degree upon the great stimulus that an excessive meat diet gives to the tissue changes.

A meat diet increases tissue change.

CHAPTER X.

ACCESSORY FOODS—LUXURIES.

The accessories of food.

§ 26. Certain foods, the use of which we hardly know, have been thrown into a single class, and called "accessory foods." It is, under the circumstances, of course a most miscellaneous collection, and a higher knowledge of the functions of food will, it is hoped, differentiate the members; it includes such substances as tea, coffee, alcoholic drinks, pepper, and spices. We probably could do very well without them, but yet they seem in some way useful; they are the luxuries of diet. Such substances have been compared by those who have likened the human body to an engine, to the lubricating oil of machinery, making everything smooth and easy, stopping creaking and jarring. I have, however, been careful neither to liken the body to an engine, nor to copy Pettenkofer in likening it to a mill, for these conceptions, besides being faulty in themselves, consider the human body too much as a simple entity, whereas, I rather insist upon the more scientifically correct view that the human body is a collection of living units and life the sum-total of myriads of micro-lives.

Many of the so-called "accessory foods" are probably used in some way by the nervous system. This is specially the case with tea or coffee; a cup of strong coffee often removes the sense of muscular and mental weariness like a charm. We shall perhaps be able to divide the "accessory food" class hereafter into two, viz., the one a "nutrient alkaloidal" class, the other a "peptic" or digestive class.

Alkaloidal and peptic foods.

In milk, in extract of meat, in tea, in coffee, there are either true alkaloids, or bodies which stand between the albumenoids and alkaloids, which from the constancy of their presence are probably in some way subservient to nutrition; these I may provisionally call "nutrient alkaloidals." On the other hand pepper, small quantities of alcohol, malt extract, and the like, would belong to my "peptic" class, for they assist digestion.

CHAPTER XI.

MINERAL MATTER.

§ 27. In the pipe bowl of the earth, a slow oxidation by means of the air goes on for ever; beast and bird, king and peasant are burnt up, nothing remains but an ash. The phosphates of lime, magnesia, the chlorides of potassium and sodium, a little iron, silica, fluorine and a few other similar substances, may be mechanically dissipated, but preserve their form, when brain and nerve, muscle and all else that has built up the fabric of life has been totally changed to gaseous or fluid elements. It would seem that certain proportions of these mineral substances are necessary both for the development of growth, and for the maintenance of health; the chicken in the egg has some power of assimilating its outside case of lime, the case gets thinner and thinner, and goes to form the inner skeleton. There is an experiment on record in which pigeons were fed on wheat deprived of all mineral matter; after three months the bones became extremely thin and fragile, and parts of the breast bone disappeared, as though the *master-tissues* must have their lime and magnesia from any source, and not getting it from the outer world, feed upon the inner. Nature's cremation.

§ 28. The only mineral matter that man craves for is salt, all the rest is taken in sufficient quantities with the daily food; a few substances such as sugar, rice, arrowroot and starch, are either ash-free, or contain so small a quantity as to be unimportant sources, whereas meat, fruits, and vegetables, abound in "ash." The craving for salt.

The common bending of the legs and spine in rickety children, is usually ascribed to a deficiency of phosphates of lime in the food; but this is erroneous; it is rather due to want of power of those parts of the body to assimilate the proper mineral substances submitted to them. The explanation of the desire for common salt, is to be found in the fact that it is essential to all the fluids of the body—the blood, the lymph and the chyle. Rickets.

CHAPTER XII.

DIGESTIBILITY OF FOOD, OR INCOME AND OUTPUT.

Digestion and its imperfections.

§ 29. Digestion is in no animal perfect; if it were so that which passes away would be a residuum wholly without nutriment, but this is so far from being the case, that the dung of the higher animals is a food to countless insects and to many species of birds. As the stoker of a steam-engine has to supply an excess of coal over and above that required theoretically to start the mechanism and to maintain it in motion, so have we all to eat an excess of food over and above that which, if the digestive organs were perfect extractors of the food, would nourish the body.

The various degrees of digestibility of foods have been found out in the following ways:

1. By experiments in the laboratory; the chemist submitting different foods to the action of the juice of the pancreas, of the stomach, &c., at a regulated heat for a regulated time.

2. By experiments on the human body, in those rare cases in which a fistula or opening leading into the stomach has been caused by disease; or, in healthy people, watching the stages of gastric digestion by the removal of the products by the stomach pump.

3. By experiments on animals in which an artificial opening into the stomach has been made.

4. By analysis of the "income and output," i.e., of the food going into the body, and of the food residues (excreta) which pass out of the body.

Of all these methods the last is by many degrees the most certain, for no unnatural condition or element is introduced; besides which, a food residue, which has passed the length of the whole canal, may with more confidence have its value subtracted from the food, than a food residue which has only been submitted to the action of a small portion of the canal.

§ 30. The most indigestible things are vegetable substances abounding in woody fibre, the most digestible are substances like sugar, extremely soluble—the "hips and haws" that children pick from the hedges, and "sweets" are thus examples of the two extreme terms of a list of substances arranged in order of their digestibility.

Digestible and indigestible foods.

The following list of substances is arranged according to the results obtained by various experimenters,* those foods

	Parts digested of 100 parts of the perfectly dried solid.	Amount of solid food residue passing away from the body by the alimentary canal.
Sugar	100·00	
Rice	96·00	4·00
Wheaten Bread	95·00	5·00
Roast Meat	94·80	5·20
Hard boiled Eggs	94·75	5·25
Milk and Cheese (in the proportion of 2·4 : 1)	94·00	6·00
Cornflour	93·30	6·70
Milk and Cheese (in the proportion of 2 : 1)	93·20	6·80
Milk, 830 parts of fluid = 100 of solids	91·00	9·00
Potatoes	90·60	9·40
Rye Bread	88·9	11·1
Milk and Cheese (equal parts of dry solids)	88·7	11·3
Black Bread	83·0	17·0
Carrots, Celery, Cabbage	76·0	24·0
Peas, Beans, &c.	52·4	47·6
Gelatin	50 0	50·0

giving the least amount of waste products occupying the top of the list, those giving the most being placed at the bottom—that is, arranged according to their power of being digested; but it is not to be inferred necessarily that

* In particular, the experiments of Rubner, 'Zeitschrift f. Biologie, 1879,' S. 118; of G. Meyer, 'Zeitschrift f. Biologie, 1871,' 1; of A. Strümpell, 'Centrbl. f. Medicin. Wiss. 1876,' S. 47; and of H. Weiske, 'Zeitschrift f. Biol., 1870,' S. 456.

foods occupying the lower portion of the list will cause those unpleasant symptoms known as "indigestion" or dyspepsia, a condition induced by various causes and which may arise from all kinds of food—but the word "digestion" is used here rather in a physiological sense, that is, *digestible foods* of which small solid residues leave the body, *indigestible foods* of which the solid residues are large; hence let it be quite understood that these latter may, in a healthy person cause no inconvenience whatever, but if such foods are to serve as a basis of nourishment larger quantities will have to be consumed than of the more digestible foods.

Relative digestibility of rice, bread, and potatoes.

§ 31. Sugar cannot be made the basis of diet, but rice can, so that taking complex foods, rice heads the list. Of the three great foods on which, with very little addition, millions of human beings live—viz., rice, bread, and potatoes—rice is nearly all assimilated, fine wheaten bread being almost equal to rice, while with potatoes, there is nearly 10 per cent. of waste, or substances which pass away without being utilised. So that in point of economy, and considering the relative price of the three, rice stands first, especially in the lands of its culture.

Digestibility of meat.

With the exception of sugar, rice, and fine white bread, all meats, and meaty substances, whether veal, mutton, bacon, or beef, are far easier digested than vegetables; the small absorption of carrots, turnips, cabbages, peas and beans, is due to the amount of cellulose or woody fibre they contain.

Gelatin.

§ 32. Although gelatin in its chemical composition is so nearly allied to the albumenous or meaty class of foods, it will not support life alone; nor will it even replace meat; 50 per cent. of it leaves the body without having ministered to its nourishment; the remaining 50 is supposed to be split up into a urea moiety and a fat moiety; it does not seem capable, like meat, of directly assisting protoplasmic growth, but if given as a part of a mixed diet, it is found that it is in a way a food, for the strength can then be supported on, as it were, a lower nitrogenous level.

DIVISION III.

FLESH AND MILK.

CHAPTER XIII.

MEAT.

§ 33. WHAT meat people eat and what they reject is decided almost entirely by prejudice and custom. There is no consistency in eating rabbits and not rats; enjoying a reptile like the turtle and shuddering at frogs; but appetite is never governed by reason, and therefore no consistency is to be expected.

The English a meat-eating nation.

The English nation probably eats more meat than any of the European peoples; it has been estimated by Schiefferstecker and Mayer that the daily consumption per head of meat in Königsberg may be put at 3·2 ozs., in Munich 6·2 ozs., in Paris 6½ ozs., in London 9·6 ozs.; but surely the latter amount is too high.

General composition of flesh.

§ 34. Ordinary meat consists of fat, water, nitrogenous substances, non-nitrogenous substances, and mineral matters. However carefully the fat is removed from meat, some fat may be extracted by the chemist; flesh from which the fat has been mechanically removed as far as possible has the following general composition:—

Water	76·0 per cent.
Nitrogenous substances . . .	21·5 " "
Fat	1·5 " "
Mineral matter	1·0 " "

Fat replaces water.

The water in meat varies much according to the condition of the animal, and even in different parts of the same animal; a piece from the neckbone of an ox, yielding 6 per cent. of fat, contained 73½ per cent. of water; while a piece from the shoulder, containing a little over five times the amount (34 per cent.), only yielded 50½ per cent. of water. So that the housewife in buying fat meat gets more for her money in the way of solid substance than in buying lean meat.

Crystalline extractives of meat.

The nitrogenous substances in meat are partly in the flesh-juice and partly in the muscular fibre. In the flesh-juice are to be found albumen, and minute quantities of a number of bodies of very definite composition known as kreatin, kreatinin, sarkin, xanthin, urea, uric acid and others. All these can be obtained by chemical art in the crystalline condition. The connecting web binding the muscular fibres into bundles is also nitrogenous, and some of it may, by long boiling, be converted into gelatin.

Fat of meat.

The fat of ordinary meat is perfectly neutral ; it consists of varying mixtures of olein, palmitin, and stearin ; these again consist of glycerine united with oleic, palmitic, and stearic acids respectively. Olein is fluid, palmitin and stearin are solid ; a fat like beef fat, somewhat fluid, contains more olein than a solid fat like that of mutton.

Muscle-sugar.

In meat there is also to be found inosite or muscle-sugar in small quantities.

The mineral matters are composed of the phosphates of potash, soda and lime, with small quantities of iron, common salt and magnesia. Of these the salts of potash are much in excess of the other constituents.

Meat is always a little acid, and broth made from meat is likewise acid ; the acidity is due to the acid phosphate of potash and to sarko-lactic acid. The following table gives the average quantity of the various constituents of meat, which has been freed as far as practicable from fat.

	Water	75·0 to 77·0 per cent.
Nitrogenous Constituents	Connective tissue	2·0 to 5·0 ,, ,,
	Muscular fibre	13·0 to 18·0 ,, ,,
	Albumen	·6 to 4·0 ,, ,,
	Kreatin	·07 to ·34 ,, ,,
	Sarkin	·01 to ·03 ,, ,,
	Kreatinin	
	Xanthin	
	Inosic acid	
	Urea	·01 to ·03 ,, ,,
	Uric acid	

Nitrogen-free Organic Matters	Fat	·5 to 2·5 per cent.
	Lactic acid	
	Butyric acid	
	Acetic acid	
	Formic acid	
	Inosite	
	Glycogen.	·3 to ·5 " "
Mineral Matters	Potash	·40 to ·50 " "
	Soda	·02 to ·08 " "
	Lime	·01 to ·07 " "
	Magnesia	·02 to ·05 " "
	Iron oxyde	·003 to ·01 " "
	Phosphoric acid. . . .	·40 to ·50 " "
	Sulphuric acid	·003 to ·04 " "
	Chlorine	·01 to ·07 " "

§ 35. When meat is macerated in cold water, the albumen, the crystalline nitrogenous substances, the nitrogen-free matters, and nearly all the salts, pass into solution; on boiling the watery extract, albumen is precipitated.

The constituents soluble in water are about 6 to 8 per cent. of the flesh or meat. "Meat extract" in its various forms consists of the soluble portions of the meat extracted by water, then evaporated down to a pasty mass. Meat extract.

§ 36. There is a very considerable and appreciable difference in the taste of veal, pork, beef, lamb, &c.; these differences are partly dependent upon minute odorous matters and very largely on the proportions of fat, water, albumenous matters, and the greater or less difficulty in gelatinising the gelatin-yielding tissues. Messrs. Lawes and Gilbert made some elaborate researches on the composition of animals, not taking for analysis special portions, but finely dividing the whole carcase and thus obtaining a fair sample. I will select a few of their analyses as examples of the variations of the main constituents in different animals. Differences in the flesh of various animals.

From the following table it is clear that if fat-free muscle is alone considered, we buy more in an equal weight of veal than in beef, and that in an equal weight of fat beef there is more muscle than in lean mutton; and if we subtract the water, considering the water as of no value, then the following will be the order of merit—fat pork, fat mutton, fat beef, fat lamb, lean mutton, and fat veal; fat pork containing least water, and fat veal most.

PERCENTAGE COMPOSITION OF THE ENTIRE CARCASE OF ANIMALS, THE BONES HAVING BEEN FIRST REMOVED.

	Fat veal.	Fat lamb.	Lean mutton.	Fat mutton.	Fat beef.	Fat pork.
Water	67·0	53·9	62·0	45·1	51·5	38·5
Albumenous matters	15·8	9·7	11·1	9·9	13·1	8·6
Fat	16·3	35·8	25·4	44·5	34·7	52·6
Mineral matters	0·9	·5	1·5	·5	·7	4·3

There is a fraudulent practice prevalent among butchers of injecting their meat with water; it is done by means of a fine tube, and it is wonderful how much the weight of certain joints, especially pork, may in this way be increased, without any very evident alteration in the appearance of the joint.

Lastly, if the amount of fat be considered, it is exactly the inverse of the water, and it may be said generally that the tendency of fattening is to replace water with fat.

Digestibility of meat.

§ 37. The amount of digestibility of meat varies much. Many years ago some careful experiments were made by Dr. Beaumont on a Canadian, who had a fistula or wound leading into his stomach; through this opening different foods could be introduced and withdrawn at pleasure. The following are the various periods of time necessary tc dissolve up the "meats" mentioned.

	Time in hours and minutes for the meat to be dissolved. h. m.
Boiled pigs' feet (soused)	1 0
Boiled tripe	1 0
Broiled venison	1 30
Boiled turkey	2 25
Roasted goose	2 30
Roasted sucking pig	2 30
Broiled lamb	2 30
Fricasseed chicken	2 45
Boiled beef	2 45
Roasted beef	3 0

	Time in hours and minutes for the meat to be dissolved. h. m.
Boiled mutton	3 0
Roasted mutton	3 15
Fried beef	4 0
Boiled fowls	4 0
Roasted fowls	4 0
Roasted ducks	4 0
Roasted pork	5 15

Beaumont's experiments.

In this list pigs' feet, tripe and venison, stand at the top of the list, the time required for their disappearance being much less than the remainder. Roast pork in the Canadian's stomach was not fully digested until more than five hours had elapsed. The digestion of various people differs much, so that the time in the table represents this particular Canadian's power of digesting meat, and it does not necessarily follow that every person will be five hours in assimilating roast pork; but the order in which the meats disappear is probably constant with all people.

Jessen's experiments.

There have been some experiments lately by E. Jessen ('Bied. Centr. 1883,' 602–604), in which 100 parts by weight of meat, both in the uncooked and cooked condition, were introduced into the stomach of a healthy man; from time to time a portion of the contents of the stomach were withdrawn by a stomach-pump and examined. The results were as follows:—

	Time in hours required for digestion.
Raw beef	2
Half boiled	2½
Well boiled	3
Half roasted	3
Well roasted	4
Raw mutton	2
Raw veal	2½
Raw pork	3

It is evident from these facts that raw meat is much quicker assimilated than cooked meat.

Effect of cooking meat.

§ 38. The application of heat coagulates the albumenous matters in the meat, rendering them denser and harder, and hence not so easily permeated by the digestive fluids. If we could overcome our prejudices in favour of cooked meat and eat raw, the advantages would be more than counterbalanced by the danger of contracting parasitic and other diseases. Animals are affected with parasites like trichinæ, which, unless killed by cooking, cause a painful and even fatal malady.

Poisonous meat.

Meat is sometimes a poison; the flesh of a healthy animal decomposes and develops a peculiar substance which causes all the symptoms of an irritant poison. Such cases are rather frequent in Germany, as the result of eating sausages. Meat again sometimes plays the part of an infection-carrier; an animal dies of some zymotic disease, and the carcase is put in the market by an unscrupulous butcher; the Welbeck and Nottingham outbreaks, in which altogether nearly ninety people suffered severely, and five died, are examples of this, and were ascribed to eating pork. The pig died possibly from the disease Dr. Klein has called pneumo-enteritis.*

Relation of bone to meat.

§ 39. The relation of bone to meat is one of those practical matters which an intelligent and economical housewife should consider. The butcher calculates, and his calculation is fairly correct, the average weight of the leg bone in a leg of mutton of eight pounds is one pound; the price of a leg of mutton is now about 11½*d.* per lb., and therefore the meat, for we do not eat the bone, is really 13*d.* Similarly the shoulder of seven pounds will generally have a pound of bone, price 10½*d.*, but really 14*d.* per lb. In a sirloin of beef weighing 40 pounds, five of the 40 is bone, and though the apparent price is 10½*d.* its real price is 1*s.* In this way it may similarly be shown that the wing rib of beef, sold at 1*s.* per pound, is really an excessively dear joint, a quarter of it being bone, and the actual price no less than 16*d.* per pound.

It is then often more economical to purchase steak or

* For an account of the sausage poison, and of the Nottingham and Welbeck cases, see the Author's work on 'Poisons,' pp. 474, 475, 477, *et seq.*

portions of the carcase free from bone, the increase of price being more apparent than real.

One pennyworth of meat.

If the bone is deducted from all joints, we shall not be far wrong in putting the general price of all butchers' meat (joints) at 1*s.*, one pennyworth of good beef will then be equal to less than 300 grains of water-free solid nutriment thus :—

ONE PENNYWORTH OF GOOD FAT BEEF.

	Grains.
Water	300
Albumenous matters	76
Fat	204
Salts	4
	584, or $1\frac{3}{10}$ oz.

CHAPTER XIV.

FISH.

Two classes of fish, the fat and the lean.

§ 40. The various kinds of edible fish considered as foods may be divided into two classes, fat fish and lean fish. Examples of fat fish are salmon, mackerel, eels and herrings ; examples of lean fish are whiting, cod, haddock, sole, plaice, and flounders. The main difference in their chemical composition is the amount of fat they contain ; if we dissolve out the fat from the salmon by means of a solvent like ether, and operate upon codfish in the same way, the product thus made fat-free is in each case a white flaky, fibrinous substance, in every respect identical ; but the ether solution from the salmon and cod respectively, is in appearance and contents very different.

Composition of salmon.

§ 41. *Fat Fish.*—I made some analyses of cooked and uncooked salmon last year, and will give the general results.

ANALYSES OF SALMON.

	Uncooked. Parts per 100.	Boiled. Parts per 100.
Water	71·50	65·28
Fibrin and albumen	18·75	25·90
Colouring and extractive matter soluble in alcohol	2·95	2·11
Fat	6·22	5·90
Ash	·58	·81
	100·00	100·00

The salmon oil always contains some free acid, and is very difficult to obtain free from the pink colouring matter, which latter seems to be of a remarkably complex composition.

The salmon I purchased at a time when the price had sunk to 13*d.* per lb.; hence a pennyworth was equal to— A pennyworth of salmon.

	Grains.
Water	385
Fibrin and albumen	101
Extractive matters	16
Fat	33
Mineral matter	3
	538, or $1\frac{1}{5}$ oz.

Salmon then at 13*d.* per lb. does not compare favourably with beef at 1*s.* (See p. 295.) As another example of the fat fish I will give two analyses of mackerel, one in the fresh condition, another in the salted condition. Composition of mackerel.

	Fresh mackerel in 100 parts (Payen).	Salted mackerel in 100 parts (Aug. Almén).
Water	68·27	48·43
Albumenous and fibrinous matters	23·42	20·82
Fat	6·76	14·10
Extractive matters		·38
Salts	1·55	16.27
	100·00	100.00

The price of mackerel varies much at different times of the year, and according to the season, but its average is about 2*d.* per lb.*

One pennyworth at this price compares favourably with butchers' meat, for half a pound would give the following:— One pennyworth of mackerel.

	ozs. and tenths of ozs.
Water	5·5
Albumenous and extractive matters	1·9
Fat	·5
Salts	.1
	8·0 ozs.

* Not that it is sold by the pound, but so much a fish, from 2*d.* to 8*d.*

Composition of codfish.

§ 42. *Lean Fish,* or those which have little fat. No better example of this class can be found than codfish ; this fish in the fresh state contains in 100 parts—

Water	77·50
Albumenous matters	18·50
Fat	3.00
Salts	1·00
	100·00

One pennyworth of cod.

The average price of cod sold retail is about 3*d.* per lb. ; it is sometimes as low as 2*d.* in London, and rises as high, as 8*d.* ; one penny would then generally purchase $5\frac{1}{3}$ ozs. which would have the following composition :—

	ozs.
Water	4·13
Albumenous matters	·98
Fat	·16
Salts	·05
	5.32

Here again in respect of economy codfish is far superior to butchers' meat; for the same money more nutriment can be bought, and what is true of cod is also true of all the cheaper white fish—directly the price of any white fish sinks to 2*d.* or 3*d.* a lb., the advantage over the joints of the butcher is evident. There is no more practical way of cheapening food for the hungry classes than by encouraging the fishing industries ; facilitating the transit of fish from the coasts inland, establishing markets, and lastly teaching the people how to cook their fish properly.

CHAPTER XV.

TINNED FOODS.

§ 43. A very large industry has sprung up of late years, in the preservation of foods by enclosing them in metal boxes, having first destroyed any putrefactive germs by heat, then hermetically sealing. In this way excluded from the air and from all that air carries, meats and fruits may be sheltered from decay, and the produce of American prairies and tropical forests conveyed to our tables with all their juices and virtues intact. Tinned meats.

A sample of tinned corned beef analysed by Mr. Wigner gave the following results:—

Water	64·09
Albumenoids	24·44
Fat	6·71
Saline matters	4·76

When it is considered that tinned meat has no bone, that it contains less water, and more fat and albumenoids than fresh meat, it is as an article of nourishment cheaper than ordinary butchers' meat.

§ 44. In nearly every sample of meat and fish preserved in this way, a careful analysis will detect a trace of tin caused by the feebly acid juice of the flesh attacking the tin, but the amount is so small that it can have no injurious effect. Tin in most tinned meats.

Apricots, tomatoes, pineapples, cranberries, &c., are also preserved in the same way; and practically the preserved are identical with fresh fruits, save certain delicate and evanescent flavours, which are weakened or lost. In 1883, I examined 23 samples of tinned fruits with the special object of ascertaining the amount of metallic contamination. Each pound tin contained amounts of the dissolved metal from $1\frac{1}{4}$ up to 11 grains. The fruits containing 9, 10 and Tinned fruits always contain more or less dissolved metal.

11 grains per lb. of tin were cheap brands of apricots. This then is a great disadvantage, for although two or three grains of a soluble salt of tin in fruit may have no perceptible effect, a larger quantity may cause indigestion, and irritation of the bowels, especially in children, the class most fond of fruit.

At the same time it is only just to observe that some purveyors, by carefully selecting their tins, seeing that they are free from all scratches, and employing fruit with only a moderate acidity, have succeeded in the preservation of fruit, in which the tin contamination is very slight.

CHAPTER XVI.

MILK.*

§ 45. The natural food of all young mammals—whether human-mammal or beast-mammal—is milk. Milk, although a fluid that is for the most part water, yet contains matters which are assimilated readily by the new-born, and on which the young increase in weight, grow, and become fat. Milk from the earliest times, even when its composition was most imperfectly known, has been considered the type of foods. Before the 17th century it was thought to consist of water, cheesy matter, and fat; but in 1619 Bartoletus, in a curious treatise, first mentions what he called the "*Manna*" of milk, and what we call "milk-sugar." This discovery was not known beyond Italy for more than a century. The first to observe the microscopic characters of milk was Leeuwenhoek, who in the early part of the 18th century described it as a fluid containing many globules. Some which he judged to be of a buttery nature rose to the top of the liquid; others again sank to the bottom—these he considered to be of another composition.

Milk the food of the young mammal.

Discovery of milk-sugar.

Microscopical characters of milk.

§ 46. The number of substances which have been found constantly in milk has so much increased during this century, that in my work on Foods (p. 214) I have enumerated, reckoning the fat and the ash as single substances, no less than fifteen constituents. For our purpose, however, we may consider milk to be composed of water, casein, milk-sugar, milk-fat (butter), and mineral substances (ash).

Complexity of milk.

§ 47. The following is the average composition of the milks which are in common use as foods:—

General composition of milk.

* For the composition of buttermilk, cream, cheese, &c., see the tables at the end of this Handbook, pp. 349–354.

—	Cow's milk.	Ass's milk.	Human milk.	Goat's milk.
Water	86·87	91·17	88·00	87·54
Casein and albumen	4·65	1·79	2·97	3·62
Milk-fat	3·50	1·02	2·90	4·20
Milk-sugar	4·28	5·60	5·97	4·08
Ash	·70	·42	·16	·56

These different constituents are partly in solution, partly in suspension. The substances in solution are albumen, a portion of the casein, milk-sugar, and a portion of the mineral constituents; the remainder of the casein in the form of very fine particles, each particle holding in close union a little mineral matter, and the fat in the form of little globules, are in suspension. The little globules are in number in direct relation to the richness in fat; milk containing 2½ per cent. will contain about 190 million of globules in a millimetre, while milk containing 3 per cent. will have about 270 millions of globules in the same quantity.

Distribution of the components of milk, some in solution, others in suspension.

Specific gravity of milk.

§ 48. If a bottle holding by weight exactly 1000 grains of water, be filled with milk, that bulk of milk will then weigh, if of average good quality, 1032 grains; if the milk is excessively rich in fat it may only weigh 1028, or on the other hand if it is watered the weight may in like manner be decreased. An investigation of this sort is called taking the "*specific gravity.*" In practice it is only occasionally done in this manner. Generally a little float called a lactometer is placed in the milk; as soon as it has displaced a bulk of milk equal to its own weight, there is equilibrium, and the mark on the scale to which it has sunk is read off, giving the gravity. It is then easily understood that the gravity is the result of three things—the amount of fat in a milk which tends to lower the gravity, fat being lighter than water—the amount of water which also tends to lower the gravity to its own standard—and the amount of milk-sugar and the other matters which tend to raise the gravity.

§ 49. All the constituents of a perfect diet are in milk.

The carbohydrates have their representatives in milk-sugar; the meaty or nitrogenous substances have their representatives in casein with albumen; there are also fat, mineral constituents and water. This being so, it might be supposed that milk would be a suitable food for every age and condition of life, and that an adult ought to thrive if fed on a diet wholly composed of milk solids; but this is not the case. As an adjunct to other foods it is useful to the full-grown, but it is essentially a diet for an infant, not for a man. The waste floating down the intestinal canal of an infant fed on milk is about 6 per cent. Rübner, in an experimental feeding of four men with milk, found that from 8 to 10 per cent. of the milk solids passed away without having been assimilated.

All the constituents of a perfect diet represented in milk.

Milk a food for children, not for adults.

§ 50. I have attempted to calculate the relative value of the water-free solids in a quart of milk, on the following principles.

The first thing is to translate a measure of milk, e.g., a quart into weight. The weight will vary as the "specific gravity." A quart of milk of the specific gravity corresponding to the composition given at p. 302, will weigh 18080 grains or 41·3 ozs. avoirdupois containing—

	ozs.
Milk solids, minus fat	4·0
Milk-fat	1·4
Water	35·9
	41·3

There are varying prices for milk, but to the London public we may consider it to average 4*d.* per quart; the market price of milk-fat when made into butter can be shown to be 3·36*d.* for 1000 grains; it hence follows that the 1·4 oz. of milk-fat will have a value of $2\frac{1}{10}$*d.* and the fat free solids must be equal to $1\frac{9}{10}$*d.*

Price of milk and value of its constituents.

Hence if this reasoning be correct, 1000 grains of fat-free solids equal 1·09*d.*

1000 grains of milk-fat equal 3·36*d.*, and further for 1*d.* we get in good milk about an ounce of fat-free solids and about $\frac{3}{10}$ths of an ounce of milk-fat, which $\frac{3}{10}$ths of an ounce should correspond to an ounce of cream.

Milk then, in London, even if it were a suitable diet for the adult would be a very dear one.

Adulteration of milk.

§ 51. The scope of this little treatise does not take in adulteration, but it may be useful, on account of the prevalence of the fraud, to explain the principles on which it is detected, and on which the amount of adulteration is calculated.

Analysis of milk.

The analyst takes a carefully weighed or measured quantity of the milk and places it in a little dish the weight of which is known ; the dish with its contents is then submitted to a steam-heat which dries the milk up, that is, expels the water ; when dry the weight is again taken, and the loss reckoned as water, the residue being technically called the *total milk solids* ; these solids are soaked in ether, which dissolves out the fat, and the solids now fat-free after expelling any trace of ether by a short exposure to a gentle heat, are again weighed ; the loss is the "fat," the remaining substances on the dish being technically called *the solids not fat* ; these are now burnt and a little grey ash is left, this is the mineral matter and returned as such, or it is called the "ash." The most important factor for determining watering of milk is the "solids not fat," which in milk derived from a healthy cow have not been observed to fall below 9 per cent. ; hence this number is adopted by the Society of Analysts as a standard. A milk with the solids falling below 9 per cent. would in the ordinary way be returned as adulterated except the amount of fat in the milk was so great as to bring the milk up to the quality of a fair milk. The amount of adulteration is ascertained by a rule of three sum. For example, if the analyst found 8 per cent. of solids not fat in a milk, he would multiply 8 by 100 and divide by 9, which gives 88·8 as the amount of real milk in the 100 ; he might then certify that the milk was adulterated to the extent of *at least* 11·2 per cent. It must be perfectly understood that no analyst ever pretends to

How the water in milk is detected.

certify the exact amount of adulteration, for the composition of milk varies within certain limits ; all that he can do is to work by a standard and certify to that standard.

From my own analyses year by year, I have calculated that even in St. Marylebone—a parish in which the Sale of Food and Drugs Act is in systematic operation—there is yet a loss to the inhabitants of at least £10,000 a year from the adulteration of milk.

Money loss by the prevalence of adulteration.

CHAPTER XVII.

BUTTER.

The process of butter-making.

§ 52. The little globules of fat floating in milk are quite isolated one from another, and it has long been a disputed point whether some thin membrane does not surround each globule ; that is, each little round sphere that we see by the microscope is supposed to possess, egg-like, an excessively thin shell, which has to be broken before two globules of fat unite. The number of scientific papers both for and against this view is considerable, but the point to us is immaterial ; the fact remains that if milk is allowed to rest quiet, some considerable portion of the fat rises in the shape of cream,* but that however rich and dense the cream may be, it can never be made into butter without considerable agitation. Another condition necessary to ensure the formation of butter is that the cream must be feebly acid.

Butter-fat is never pure fat.

§ 53. However carefully the lumps of butter-fat are separated from the liquid in which they float, and however strongly they are pressed, as might be expected, some of the other constituents remain. We find all butter to retain mechanically water, casein, and with the casein a little mineral matter ; the water of the butter also contains a little lactic acid derived from the milk-sugar, and traces of other constituents. Salt is added to butter to preserve it ; the quantity of the salt added makes the difference between salt and fresh butter ; fresh butter contains but a little salt ; salt butter much salt.

Difference between salt and fresh butter.

If a small quantity of butter is melted in a graduated

* The old-fashioned way of allowing the cream to rise is in large establishments almost universally superseded by a method of separating the cream by centrifugal machines. These machines may be seen in operation at the model dairies in the exhibition.

tube, the water separates and the butter-fat rises to the top, the curd (casein) sinking to the bottom. In this way a rough proximate analysis may be made. The chemist operates in a different way, and pretty much on the same lines as in the analysis of milk (see page 324), drying up the water, dissolving out the fat by solvents, lastly destroying all that will burn by fire, and by a cremation in miniature arriving at the amount of "ash."

How the composition of butter is known.

§ 54. Last year I investigated the butter supply of the parish of St. Marylebone, and ascertained the usual composition of pure butter, sold during the March quarter of that year at 16*d.* per lb., to be as follows :—

—	Per cent.	Ozs. and tenths of an oz. in a lb.
Butter-fat (sp. gr. ·9121) . .	84·3	13·5
Salt	1·3	·2
Curd	2·3	·4
Water	12·1	1·9
	100·0	16·0

The mean composition of butter sold at 18*d.* was as follows :—

—	Per cent.	Ozs. and tenths of an oz. in a lb.
Butter-fat (sp. gr. ·9118) . .	84·2	13·5
Salt	1·0	·2
Curd	2·4	·4
Water	12·4	1·9
	100·0	16·0

Since, when we buy butter our sole object is to buy the fat; the water, curd and salt is of no value, and considered in this way the actual price of the butter-fat in the 16*d.* butter was 18¾*d.* per lb., while in the 18*d.* butter it was 21¼*d.* The difference of price in these two classes of butter was neither supported by analysis nor by taste, and generally

Price and real value of butter.

X 2

speaking the price of butter is governed by no settled principle.

Composition of butter-fat.

§ 55. The butter-fat looks a simple single substance, but this is not the case. It is a mixture of at least seven fats, each of the seven again being composed of a fatty acid united with glycerin; besides this the butter is coloured by a small quantity of a colouring matter of complex composition. The amounts in 100 parts of butter-fat are as follows:—

Glycerides:			
Olein .	42·21,	equal to oleic acid . . .	40·40
Stearin, Palmitin	50·00,	equal to stearic and palmitic acids	47·50
Butyrin.	7·69,	butyric acid	6·72
Caproin, Caprylin, Rutin	.10		

Separation of fatty acids and glycerin.

By dissolving the butter-fat in a solution of potash in spirit, and heating, the olein, stearin, &c., are broken up into their respective fatty acids and glycerin, the fatty acid at once combining with the potash to form "a soap;" but on adding a strong mineral acid to the soap, the fatty acids are set free, and on driving off the spirit the acids may then be separated into two classes, one class soluble in water, and the other insoluble; the soluble acids being butyric acids with small quantities of caproic, caprylic and rutic, while the oleic, stearic and palmitic acids are insoluble in water. It is in the relatively large amounts of glycerides yielding soluble fatty acids, from five to seven per cent., that butter differs from animal fats and from artificial butter or oleomargarin. For instance, the fat of butterine has the following average composition:—

Two classes of fatty acids, one soluble, the other insoluble.

Palmitin	22.3
Stearin	46·9
Olein	30·4
Butyrin, &c.	·4

Hence one of the most important processes in the analysis of butter-fat is the careful determination of the relative proportion of the soluble and insoluble fatty acids.

Of all fats butter-fat seems to be the most easily assimilated: persons who are unable to eat a sufficient quantity of other animal fats, can always eat and enjoy butter. Nevertheless it is entirely an open question whether there is any difference of nutritive value between equal weights of carbon in butter-fat, beef-fat or mutton-fat.

Easy digestibility of butter-fat.

DIVISION IV.

CHIEF SOURCES OF THE CARBOHYDRATES.

CHAPTER XVIII.

BREAD—FLOUR.

Definition of bread.

§ 56. BREAD is a term applied to any form of flour made into a paste with water, permeated by the gases of fermentation, and baked. Thus we may have bread made from wheat, from rye, or from any other cereal.

Structure of the wheat grain.

If a grain of wheat be taken, divided in half, and then an extremely thin transparent section cut, the following structures will be seen (see Fig. 1).* First, on the outside some

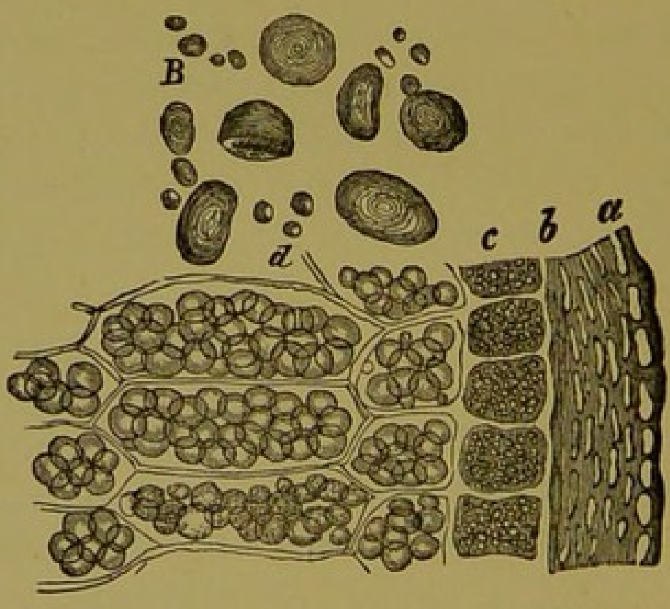


FIG. 1.—SECTION OF A GRAIN OF WHEAT.

thick walled cells (*a*) closely applied to others flatter and more compressed (*b*); these together make the bran and cuticle. Within these again are some larger and darker, almost square spaces, filled with a granular substance (*c*),

* This figure is from the Author's work on 'Foods, their Composition and Analysis.'

these are called the gluten cells, while the bulk of the wheat grain is made up of (*d*) the starch cells, which are largish spaces, crammed and packed with starch granules. The object of grinding the wheat grain to flour is not alone to divide it finely, but to get rid of the layers *a* and *b*. The differences between the different varieties of flour are chiefly dependent upon the fineness of the flour, the completeness with which the bran and cuticle have been separated, the purity and healthiness of the wheat, and also the kind of wheat used.

Composition of wheat.

§ 57. The composition of wheat is very complex; the meaty or nitrogenous substances are represented by gluten and vegetable albumen; and the carbohydrates by fat and starch.

The "whole meal" from which nothing has been separated contains the following:—

		In 100 parts.
Water		14·0
Nitrogenous substances, part of which is gluten, but a large proportion of which cannot serve for nutrition		21·8
Carbohydrates	Fat 1·2, Starch 59·7	60·9
Woody fibre (cellulose)		1·7
Mineral matters		1·6

Composition of flour.

The white flour from which the bran has been separated has the following composition:—

		In 100 parts.
Water		16·5
Gluten and other nitrogenous bodies		8·59
Nitrogenous substances not of the nature of albumen		3·41
Carbohydrates	Fat 1·2, Starch 69·6	70·8
Mineral matters		·7

The gluten may be readily separated from the starchy matter by making flour up into a paste, and then washing the mass for a long time with a thin stream of water, until the water flowing away is no longer milky. It is thus obtained as a yellowish grey elastic, adhesive mass, drying up into a horny, brittle substance; it is of very complicated composition.*

Changes taking place in bread-making.

§ 58. The changes which take place in the process of bread-making are as follows. On making the flour into a paste and the addition of yeast, if the dough is placed in a warm place, fermentation commences just as in the brewing of beer, the starch to a certain extent is converted into sugar, the sugar is decomposed into alcohol and carbonic acid gas; the latter would if evolved in a fluid escape, but the tenacious gluten holds it imprisoned, and the little cavities in light bread are the remnants of centres of considerable activity, each marking the site of a group of yeast-cells, which, during fermentation, were budding, growing, multiplying, changing starch into sugar, and sugar into gas and alcohol, the gas expanding the dough into, as it were, bubbles.

Tracing the chemical changes, the nitrogenous matters partly become less soluble, and in the crust they are to some extent destroyed.

The carbohydrates, on the other hand, become more soluble, for the starch granules are either broken up or quite changed, some part being converted into sugar and some into dextrin; the sugar may be further decomposed in two ways, viz. into alcohol, and into lactic acid. The alcohol nearly all escapes, but a portion of it remains and a portion is oxidised into acetic acid. With the growth of chemical knowledge, it began to be clearly understood that the object of fermentation was simply to ferment the dough with gas, to make it in structure like a sponge;

Artificial aëration of bread.

processes were then suggested by which carbonic acid gas was developed *in situ*, not as a result of the breath, as it were, of living cells, but evolved from purely mineral substances. Liebig proposed the addition in suitable proportions of biphosphate of lime, bicarbonate of soda, and chloride of potassium, to the flour; on adding water to make a dough, and warming, a gentle continuous evolution of gas

* See the Author's work on 'Foods, their Composition and Analysis, p. 150.

takes place, very similar in its regularity to that of ordinary fermentation, and in this way a good light bread may be made. The different "baking powders" are all mixtures of substances which, on the addition of water, enter into chemical reaction and evolve carbonic acid gas. A very scientific method of making bread was some years ago patented by Dr. Dauglish. Instead of the addition of any solid substance to the flour, the water used for making the bread is saturated with carbonic acid gas. The mixing and manufacture is all done by machinery; hence this process has the merit of great purity and cleanliness.

§ 59. Bread made in dirty places, or in itself damaged, may have various acids developed, especially butyric, and then smells peculiarly offensive. The acid reaction of bread.

All bread is, however, acid in a feeble degree, and if it is soaked in water, and the water tested with blue litmus, the litmus will be reddened.

The mean amount of alcohol in fresh bread is ·313 per cent.; that is, a pound loaf would yield, if very carefully distilled, about twenty-two grains (considerably less than a teaspoonful). As the bread gets staler, the quantity decreases. Alcohol in bread.

The changes taking place when bread becomes "stale" are but little understood, but certainly the seat of change is the gluten, and not the carbohydrate. The bread feels dryer and harder, and is no longer doughy. On re-baking, the bread becomes apparently new again; but this rejuvenescence, as it were, cannot be repeated often. At each re-baking there is a loss of water, and when 30 per cent. of water has been lost, re-baking fails to cause any change. Stale bread.

§ 60. Bread of fine wheaten flour is, according to various well-arranged experiments, more digestible than meat, that is, it leaves less residue; on the other hand, rye bread and brown bread are much inferior in digestibility. Digestibility of bread.

Bread made of whole meal will show to analysis a much higher content of nitrogenous substances, but the nitrogen is that of the bran and cuticle, and is in a form not to be Whole-meal bread.

assimilated. Hence we find that whereas with wheaten bread only five per cent. passes away to waste, the bread in which the bran and cuticle are more or less retained, gives double the amount of waste.

The general composition of fine bread and coarse bread is as follows :—

—		Fine bread.		Coarse bread.	
Water			38·51		41·02
Nitrogenous substances			6·82		6·23
Fat			·77		·22
Carbohydrates	Sugar	2·37	52·34	2·13	50·82
	Starch, Dextrin	49·97		48·69	
Woody fibre			·38		·62
Mineral matters			1·18		1·09

Alum in bread.

§ 61. There is little adulteration of bread save with alum. The long and formidable list of substances supposed to be used by fraudulent bakers, such as sulphate of copper, peas, beans, &c., are drawn from rare instances, or from times of famine, or are based upon theory rather than observation. Bakers' bread in this country, taking it as a whole, is of fair purity, and is wholesome. Where the customer is cheated is mainly in the weight ; here there are really serious and continuous frauds. Notwithstanding Inspectors of Weights and Measures, such frauds are practically unchecked, and only limited by the prudential conscience of the baker.

Detection of alum in bread.

I devised some two years ago a very ready method of detecting alum in bread by a simple test, and one which takes no skill in its application. The materials required for the test are a solution or tincture of logwood to which a sufficient quantity of carbonate of ammonia has been added to render it strongly alkaline, and some slips of gelatin ; a slice of the bread is then crumbled into a glass, and covered with pure water, a slip of gelatin is added, and the whole allowed to stand over night. In the morning the swollen and softened slip of gelatin is removed and stained with the ammoniacal logwood ; if no alum is present, the gelatin will be of a dark pink or red colour, but if the bread contain alum, the gelatin will be coloured various shades of blue from a barely perceptible purple up to quite a decided blue, according to the quantity of alum present.

CHAPTER XIX.

OATMEAL—BARLEY MEAL—RYE MEAL

The oat an almost perfect food.

§ 62. The oat is the special cereal of the northern latitudes; Liebig called it the "*hunger plant*," because of its power of sending roots to a great depth, thus extracting nourishment from earth which was on the surface exhausted.

The oat possesses all the constituents necessary for the maintenance of high bodily vigour, and is one of those complex foods that, especially with the addition of a little fat, is capable of supporting life for an indefinite period. In the border forays of the 12th and 13th centuries the provision carried by the Scotch was simply a bag of oatmeal.

The general composition of oatmeal is as follows:—

COMPOSITION OF OATMEAL IN 100 PARTS.

Water			12·92
Nitrogenous matters analogous to gluten			9·78
Nitrogenous matters which do not serve for the purposes of nutrition			1·95
Fat			6·04
Carbohydrates	Sugar	2·22	
	Dextrin and Gum	2·04	55·43
	Starch	51·17	
Woody fibre			10·83
Mineral matter			3·05
			100·00

§ 63. In structure the general arrangement of the different layers and substances of the oat is similar to that of wheat. (See Fig. 2.)

There is first (*a*) the outer layer corresponding to the bran of wheat, then a thin membrane (*b*), next the gluten cells (*c*), and finally the starchy matter (*d*). The starch grains in the unground oat cohere into oval or rounded masses; these are represented more highly magnified at *B*. The oat has a much higher content of fat than any other common cereal (except maize); the fat or oil is not a perfectly neutral oil, but contains some free fatty acid.

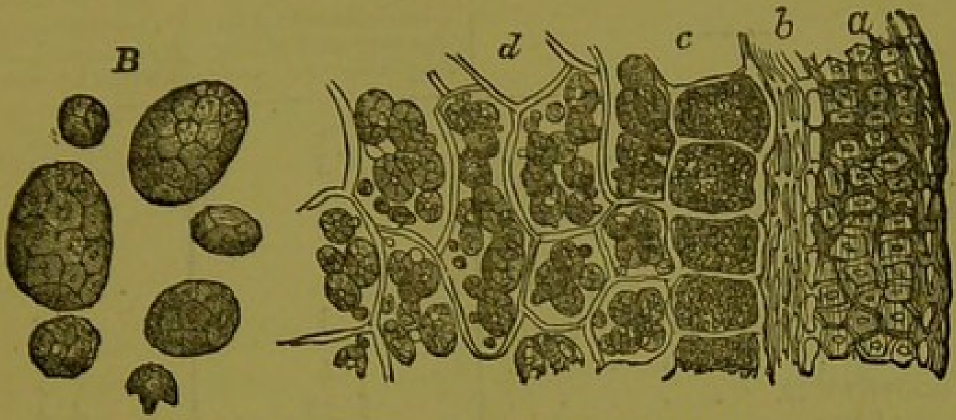


FIG. 2.—SECTION OF THE OAT GRAIN.

Weight for weight, oatmeal has been stated to be more nutritious than wheat meal or flour, but in reality there is not much difference between them, when a proper distinction is drawn between the nitrogenous matters available for the purposes of nutriment, and substances which contain nitrogen, but which pass away through the alimentary canal without serving any useful purpose.

Flour and oatmeal compared both as to price and nutrient value.

§ 64. Oatmeal is cheaper than the better kind of flour known as *best whites*, but about the same price as the common flour, that is when bought retail; both average 2*d*. per lb., hence 1*d*. will buy the following amounts of principles in flour and oatmeal; the figures represent ounces and tenths of ounces.*

——	Flour.	Oatmeal.
	ozs.	ozs.
Albumenoids	·7	·8
Fat	·1	·5
Carbohydrates	5·5	4·4
	6·3	5·7

* I have omitted the mineral matter, water, and non-assimilable nitrogenous matter, and added the real nutritive substances up as above.

From this table it will be evident that a pennyworth of flour buys 6·3 ozs. of nourishing material while a pennyworth of oatmeal buys 5·7 ozs.*

——	Constituents in ½ lb. (3500 grains) of flour bought for one penny.	Constituents in ½ lb. (3500 grains) of oatmeal bought for one penny.
	ozs.	ozs.
Water	1·3	1·0
Gluten and other nitrogenous substances which may be digested	·7	·8
Nitrogenous substances which will not be digested . .	·3	·2
Fat	·1	·5
Carbohydrates	5·55	4·4
Woody fibre		·9
Mineral matter	·05	·2
	½lb. or 8·00	½ lb. 8·00

On the other hand, the comparatively large proportion of fat in the oat renders it a better balanced food than flour; a person could live with more comfort on oatmeal alone than on flour alone. Oatmeal cannot be made into light bread, it is therefore when baked converted into cakes. Its most popular form is that of porridge, in which the ground meal is well softened by boiling, and made more palatable by a little salt and milk. The decorticated oatmeal, when crushed, goes by the name of groats, and is used for making gruel. It is a curious fact that at the latter end of the 17th century, gruel was a favourite drink asked for by the public in the London taverns.

In England, porridge, gruel, and "black puddings" are the only common forms into which oatmeal is made; but in Scotland, in Norway, and Sweden, there are a great variety of oatmeal cakes and dishes.

Components of barley.

§ 65. *Barley.*—Barley ground into meal and made into a close bread, was so late as the time of Charles I. used very extensively in England, and to a great extent took the

* I have omitted the mineral matter, water, and non-assimilable nitrogenous matter, and added the real nutritive substances up as above.

place of wheaten bread; its percentage composition is as follows:—

Water	15·06
Digestible nitrogenous substances	9·79
Indigestible " "	1·96
Fat	1·71
Carbohydrates	70·90
Woody fibre	·11
Mineral matter	·47
	100·00

Barley meal is about 1*d.* per pound, and subtracting all matters not available for nourishment, it would seem that for this small sum, about 13 ounces of dry barley meal nutriment, or twice the amount of food in flour, and four times that of oatmeal, can be bought.

Therefore barley meal is an extremely cheap food; perhaps the cheapest. Barley meal cannot be made into light bread, for its gluten is deficient, but when mixed with flour, the combination answers very well, and it can be then manufactured into palatable, somewhat close bread.

Pearl barley and Scotch barley, so much used to give consistence to broth, are simply the grain deprived of its outer covering and then rounded by attrition.

Components of rye meal.

§ 66. *Rye meal*, once an article of common diet in this country, and the basis of the dark sour breads of Northern Europe and Holland, is of very nearly the same composition chemically as barley meal.

The rye becomes attacked with a peculiar fungus, which has powerful medicinal properties; when rye thus affected is made up into bread, it causes a very extraordinary disease known as

Ergotism.

§ 67. *Ergotism*; in this disease mortification of the limbs may take place.* The general disuse of rye bread in England has practically extinguished the disease; but cases on the Continent still occur.

* The various epidemics of ergotism, the varieties of the disease, and the unique Waltisham case, in which, out of a family of eight, seven lost one or more limbs, are fully detailed in the Author's work on Poisons, p. 430, *et seq.*

CHAPTER XX.

MAIZE OR INDIAN CORN.

Structure of maize.

§ 68. Indian corn or maize (*Zea Mayo*) is a native of tropical America, but is cultivated in the south of Europe and in Africa. A section of the seed as seen under the microscope is represented in Fig. 3; *a* is the cellular layer of

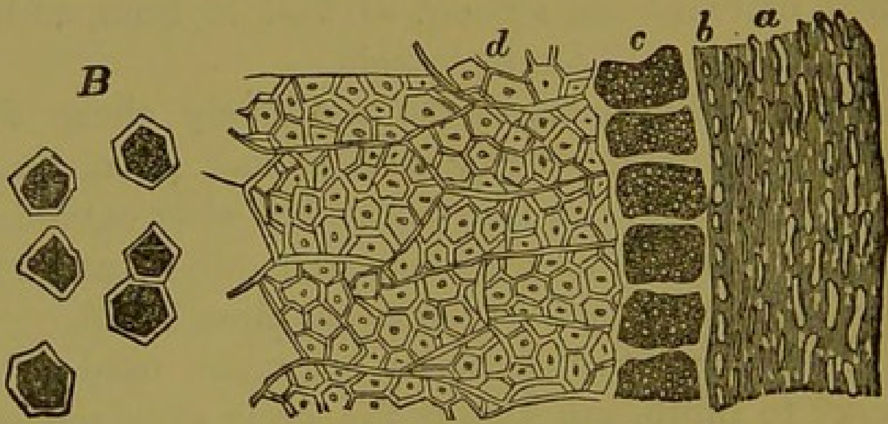


FIG. 3.—SECTION OF INDIAN CORN.

the outer husk, *b* the inner; *c* is the gluten cells, and *d* the curiously shaped starch cells. In many parts of the world maize is the almost exclusive food; in Mexico, where it grows wild, and the Northern States of America, the natives pretty well live upon it.

It cannot be made into light bread.

Indian meal is not capable of being made into a light bread; its proper use is in the form of cakes or puddings or a porridge.

In Ireland it has been much consumed since the potato famine of 1846.

The preparations of Indian meal, like "Polson's patent flour," have been purified from the bitter principle, and are of course much more expensive and palatable than the simply ground meal. The composition of Indian meal is as follows:—

COMPOSITION OF MAIZE IN 100 PARTS.

Water	17·10
Nutritive nitrogenous matters	10·91
Non-nutritive nitrogenous matters	1·89
Oil or fat	7·00†
Carbohydrates { Dextrin and Sugar 1·5 / Starch 59·0 }	60·50
Cellulose	1·50
Mineral matter (ash)	1·10
	100·00

The oil or fat which may be extracted from maize is not built up like the animal fats, differing from them in containing free fatty acids; in this respect it agrees with the oily matters derived from the oat and from rye. *The oil.*

§ 69. The finely ground meal may be bought for 1*d.* per lb.; hence calculated in the usual way, one pennyworth would contain the following amounts of real nutriment:— *The money value of maize.*

	ozs.
Nutritive nitrogenous matters	1·7
Fat	1·1
Carbohydrates	9·7
	12½

3 lbs. of the meal would give a diet equal to

	ozs.
Nutritive nitrogenous substances	5·1
Fat	3·3
Carbohydrates	28·8
	37·2

This would be equivalent to 7921 grains of carbon and 351 grains of nitrogen, just about the amount which would keep up the strength of an active labourer in full work.

Unfortunately its bitter taste is a bar to the food becoming so popular as to entirely supplant the dearer cereals. *The bitter taste of maize.*

A disease in Italy has been ascribed to the long-continued use of maize as a food, but it is not certain whether it is not rather due to a fungus attacking the maize, than to the use of pure maize.

* The maize oil or fat in some samples sinks as low as 3 per cent., in others it may rise to 9 per cent.

CHAPTER XXI.

RICE.

Composition of rice.

§ 70. More than a hundred million people in India, China, Egypt, Arabia, and in portions of South America, derive their main food from rice. Amongst ourselves rice is but an adjunct to other foods; the labourer, the artisan, and even the middle class take it only at intervals, and it certainly does not as a rule form part of the daily diet. Rice is obtained from the *Oryza sativa.* Its composition is as follows:—

Water	14·41
Nitrogenous substances	6·94
Fat	·51
Starch	77·61
Woody fibre	·08
Ash	·45
	100·00

Money value of rice.

§ 71. Ground rice is sold at 2*d.* per lb.; hence, throwing out the water, the woody fibre, and the mineral matter, we buy half a pound of rice for one penny, and the pennyworth contains—

	ozs.
Nitrogenous substances	·55
Fat	·04
Starch	6·21
	6·8

That is, 6⅘ ozs. or nearly 7 ozs. It is thus cheaper than wheat flour, but the great deficiency of rice in fat renders it alone a very unsuitable diet for a temperate or a cold climate. The fat or oil which may be obtained from rice is, like the oils from the cereals, generally acid, from a small quantity of free fatty acid.

CHAPTER XXII.

THE POTATO.

§ 72. The composition of the uncooked potato according to the mean of 70 analyses is as follows :— Composition.

	per cent.
Water	75·77
Nutritive nitrogenous substances	·84
Non-nutritive nitrogenous substances	·95
Fatty matter	·16
Starch	20·56
Woody fibre	·75
Ash	·97
	100·00

The average retail price of potatoes being in London about 7 lbs. for *6d.* a single lb. would cost 1*d.*, and would contain the following amounts of real nutriment :— Money value.

	grains.
Nutritive nitrogenous substances	58·8
Fat	1·6
Starch	1439·2
	1499·6

That is, about 3⅖ ozs.; hence in buying potatoes in London you get a little more for your money in the way of nourishment than in the purchase of oatmeal, but less than in the purchase of flour. But in the country, the cottager, growing his own potatoes, will raise seven pounds for a penny; under these circumstances it becomes the cheapest vegetable diet obtainable.

§ 73. The potato is mainly composed of starch, but there are other constituents in minute quantity classed under the head of the non-nutritive nitrogenous substances, such as asparagin, an alkaloid called solanine and amido-acids. Details of the composition of potatoes.

There are also organic acids such as citric (the acid of the lemon) and succinic acids.

Solanine.

The alkaloid solanine* is very poisonous; it abounds in the plant itself. There are small quantities to be found in potato-peelings but scarcely any in the starchy interior of the potato. Solanine is readily destroyed by a dry heat, so that a baked potato will contain none; similarly boiling potatoes in their "skins" probably extracts the alkaloid.

Antiscorbutic properties of the potato.

In the year 1781, in Sir Gilbert Blane's work entitled 'Diseases of the Fleet,' occurs the first definite statement of the antiscorbutic properties of the potato; properties the existence of which have now from long and varied experience received ample confirmation. Whether these properties are due to the small quantities of citric and organic acids, or to some other constituent, is not at present fully known.

The potato disease.

§ 74. The disease known as the potato disease is caused by a fungus or mould, the history of which has only of late years been fully mastered. This mould has three methods† of reproduction, the most certain of which is by the development of what are called *oospores*, little dark-brown reticulated bodies which are so constructed that they are able to resist the frosts of winter and are very difficult to destroy.

§ 75. If potatoes are supplemented with a little fat, or still better with fat meat such as bacon, they will support life and maintain health for an indefinite time. Such a diet in places where, as in Ireland, both the potatoes are grown and the pig fed by the consumer, is perhaps the cheapest diet possible.

Cheap diet for a labourer.

Half a pound of bacon and 5 lbs. of potatoes would be a daily diet on which a labourer could do hard work and live in good health. It would contain the following water-free constituents :—

* See the Author's work on Poisons, p. 368, *et seq.*

† Fully described and figured in the Author's work on Foods, p. 183.

	ozs.	Nitrogen grains.	carbon. grains.
Albumenoids	8·8 =	607	2050
Fat	3·0 =		1037
Carbohydrates	16·4 =		3184
Salts (mineral matter)	1·0		
		607	6271

The money value of such a diet in London would be perhaps about 9*d.* a day.

Cooking potatoes.

Potatoes require some little care in cooking. In a well cooked potato the starch granules are all swollen, distorted, and for the most part ruptured, but in a badly cooked potato this action on the starch granules is only partial, and the potato, instead of having a mealy appearance, is sodden and heavy.

When the potato was first introduced into England, its popularity as a diet was slow until people had learned the proper method of cooking it.

DIVISION V.

LEGUMINOUS VEGETABLES—SUCCULENT VEGETABLES AND FRUITS.

CHAPTER XXIII.

LEGUMINOUS VEGETABLES.—PEAS—BEANS—LENTILS.

§ 76. THE ordinary peas, beans, and lentils are members of a well-marked order of plants, distinguished by having flowers with some resemblance to a butterfly, and hence called papilionaceous. No botanical order exists in which there are so many foods and poisons, but the poisons predominate, for as a rule leguminous plants are noxious.

Legumin—vegetable meat.

Those that are edible are distinguished from other members of the vegetable kingdom by containing a nitrogenous principle which has been named Legumin. It is composed of carbon, hydrogen, nitrogen and sulphur, and is of very complex composition ; it may be likened to animal fibrin, or if the expression be permitted it might be called "vegetable meat." The following table gives the relative proportions of the chief constituents in beans, peas and lentils.

COMPOSITION OF BEANS, PEAS, AND LENTILS, IN PARTS PER 100 AND OZS. PER LB.

—	Peas.		Broad Beans.		Kidney Beans.		Lentils.	
	per cent.	per lb.	per cent.	per lb.	per cent.	per lb.	per cent.	per lb.
		ozs.		ozs.		ozs.		ozs.
Water . . .	14·31	2·3	14.84	2·4	13·60	2·2	12·51	2·0
Nutritive nitrogenous substances	19·98	3·2	21·30	3·4	20·81	3·3	22·31	3·6
Non - nutritive nitrogenous substances	2·65	·4	2·36	·4	2.31	·4	2·50	·4
Fat. . . .	1·72	·3	1·63	·2	2·28	·3	1·85	·3
Carbohydrates	53·24	8·5	49·25	7·9	53·63	8·6	54·78	8·7
Woody fibre .	5·45	·9	7·47	1·2	3·84	·6	3·58	·6
Ash . . .	2·65	·4	3·15	·5	3 53	·6	2·47	·4
	100·00	16·0	100·00	16·0	100·0	16·0	100·00	16·0

It will then be seen that in the dried state the nutritive value of the various legumes are not widely different.

§ 77. The price of split peas averages 1½*d.* a lb. In the pound there are 12 ozs. of nutriment; hence it follows that one pennyworth of peas contains no less than half a pound of nitrogenous and starchy substances capable of being assimilated. **The price of peas.**

§ 78. To utilise the leguminous foods to the best advantage they require to be finely ground into meal and to be thoroughly cooked. An experiment of A. Strümpell bears on this. Leguminous meal was made into cakes, with suitable mixtures of eggs, butter and milk, and eaten, and compared with the result of eating the same substance, without grinding but first soaking in water and then boiling. In the first case 91·8 per cent. of the nitrogen was absorbed, but in the second only 59·8, so that more than half of the "vegetable meat" was wasted. **Legumes must be skilfully prepared and cooked.**

The leguminous seeds, however skilfully prepared, are not palatable alone, they require the addition of certain other things, especially of fat, and it will be noticed on referring to the table that peas and beans are weak in fat; hence the union of bacon with beans, and butter with peas, is founded upon a rational instinct. **Peas and beans, &c., require the addition of animal fats.**

The composition of green peas and beans will be found in the tables at the end of the volume. As might be expected, they are more watery, more palatable, and easier cooked and digested than when dried.

§ 79. They are also capable of being preserved in sealed tins or bottles. It has been the practice to boil the peas previous to their being preserved in copper vessels, and thus impart a fine green colour; in this way some considerable metallic contamination of the vegetable has resulted. There is a patented process by which chlorophyll, the innocent and beautiful green of the plant world, can be separated and applied to heighten the hue of preserved vegetables, and it is to be hoped this method will supplant the coppering process, which may be deleterious. **Preserved peas, and their contamination by metals.**

I have also found tin and lead in preserved peas; the latter in a very beautiful French brand.

German pea-tablets.

§ 80. In Germany there is a condensed food made up of dried and powdered meat incorporated with pea meal by strong pressure. It deserves notice, as one of the most successful examples of a condensed food. The form of the food is that of tablets; its general analysis is as follows:—

	Per cent.
Water	12·09
Nitrogenous matters	31·18
Fat	3·08
Carbohydrates	47·50
Ash	6·15

Of such a food about 2 lbs. daily would support a man in hard work.

Poisonous decomposition of peas.

Peas when preserved in tins hermetically sealed, occasionally undergo some very peculiar decomposition and become poisonous; it would seem that a poison is developed from some change in the legumin analogous to the formation of the cadaveric alkaloids.

CHAPTER XXIV.

SUCCULENT FRUITS AND VEGETABLES.

§ 81. The succulent fruits and vegetables contain so much water that certain animals, such as the rabbit, supplied with "green stuff," never require other water than that taken in the juices of the fresh herb. **The large amount of water in vegetables and fruits.**

The importance of cabbages, carrots, turnips, of apples, pears, raspberries and strawberries, is far more than their nutritive value; for without the addition of these substances, even while eating fresh meat, we are liable to decline in health and suffer from eruptions, while if we eat salt meat for any time, and consume neither potatoes, nor vegetables, nor fruits, then that terrible disease scurvy is imminent.

Prevention of scurvy.

The reason why fresh fruits and vegetables prevent and cure scurvy is at present not known with certainty, although so much has been written about it. The supposition is that the organic acids present in vegetables and abounding in fruits, such as malic acid, citric acid, and tartaric acid, are the agencies which produce this beneficial result.

The composition in general terms of most of the succulent fruits and vegetables are to be found in the tables at the end of the volume.

DIVISION VI.

ALKALOID HOLDING DRINKS.

CHAPTER XXV.

TEA, COFFEE, COCOA, AND CHOCOLATE.

The universal craving for the theine holding plants.

§ 82. THERE are certain leaves and berries which, when infused in hot water, impart whatever virtues they possess to the liquid and make a drink—a drink which no tribe of men, once tasting, ever forget. The precious plants grow and thrive, in limited spots of the warmer portions of the earth, from whence their products are exported to every clime, to be consumed by races of every colour.

§ 83. However different in appearance and taste tea, coffee and cocoa may be, there is considerable agreement in their chemical composition and physiological effects; for three special active matters—a crystalline alkaloid, an astringent substance, and a volatile oil—are present in all.

But little nourishment in tea and coffee, but cocoa more of a food.

There is very little nourishment in the ordinary quantities of tea, and coffee, but these drinks give in some obscure way energy to brain and nerve—a stimulus distinguished from that of alcohol, in being not alone different in kind but also in not being followed by a depression.

In cocoa there is more nutriment, and it may be considered as a drink or a food, or as a combination.

Excessive use of tea injurious to some people.

§ 84. There is a moderate and an immoderate use of all things. Certain people acquire a habit of drinking enormous quantities of tea or coffee; the majority, like smokers of tobacco, are not perceptibly affected by this habit; but a few fall into a dyspeptic nervous state, evidently due to excessive tea-drinking.

Tea and coffee suit "bread and butter meals" rather than meals in which meat is the chief dish; this is thought to be due to the very insoluble compound which the astringent matters in the tea form with albumen. Tea better with "starchy" food than "meaty."

§ 85. Tea is the dried leaf of different species of *Thea*, a section of the genus *Camellia*; the botanical varieties are not numerous. The tea plants in China, *Thea Bohea*, *T. viridis*, *T. vinensis*, are but varieties of one plant; but the *Thea Assamica*, indigenous in Assam, is possibly a distinct species. Varieties of tea.

Formerly all our tea was obtained from China. Pepys, a little after its introduction into England, alluded to it as "the Chinese drink," but India year by year cultivates more tea, and it seems likely that she will to a great extent supplant China in the export trade of tea, as far as this country is concerned. In 1871, India's share in feeding us with tea was 11 per cent. of the whole; China's share 89; but in 1881, India's exported tea had grown to 30, China's tea exports had decreased to 70 per cent. of the whole.

The commercial varieties of tea imported into this country are extremely numerous, but seldom does any one of them reach the consumer unmixed; for the wholesale tea merchants carefully improve their teas by "blending." The most common sorts are:—Gunpowder, Hyson, Congou, Caper and Indian tea. Of these, the Gunpowder and Hyson are dried at a higher temperature than the others, and contain therefore less moisture. The Caper may be generally told by the leaves being rolled up into little lumps with starch or gum; as a class they are much adulterated, and in fact can hardly be called genuine tea. Besides these, there are a number of special teas, some of a very high price, and imported in a state of great purity; but such teas are used almost entirely for mixing or blending; they are known under the names of Moyone and Moyone gunpowder, Oolong, Mannuna Kaisou, scented Pekoes, Indian Souchong, Varieties of tea.

Assam, Java, &c. The names by which teas of commerce are most familiar to the public are simply "green" and "black," which differ merely in accordance with the method of preparation followed. Green tea is prepared from young leaves, which are roasted over a wood fire within an hour or two after being gathered; the black tea leaves, on the other hand, are allowed to lie in heaps, for ten or twelve hours after they have been plucked, during which time they undergo a sort of fermentation; the leaves then pass through certain processes and are slowly dried over charcoal fires.

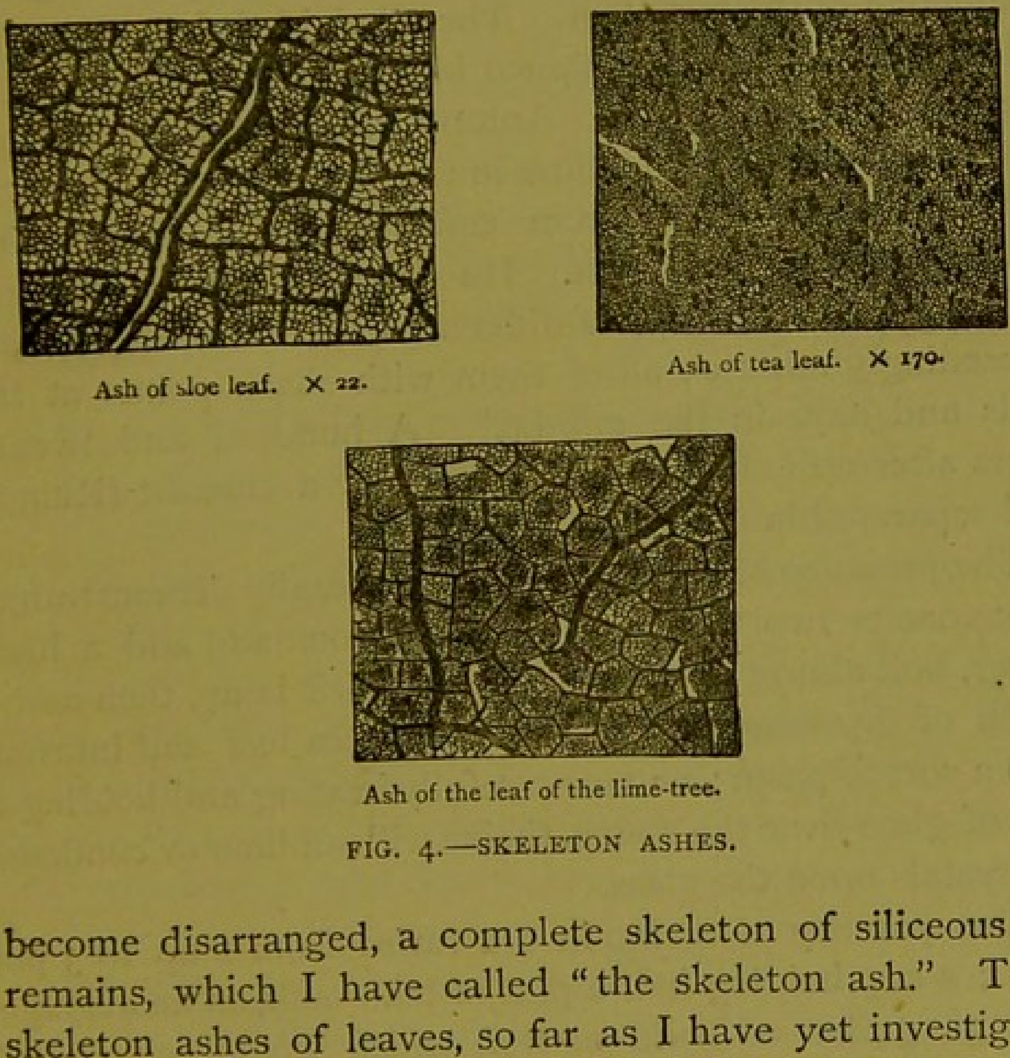
Black and green tea.

The tea leaf.

§ 86. The tea leaf has a peculiar shape and microscopical structure; in the dried state of our ordinary tea the leaves are rolled up and crumpled, but when soaked and softened in warm water, their form is readily distinguishable. In order to examine the microscopical structure, slices so thin as to be transparent must be cut by a razor and examined by the microscope; this requires very considerable skill in manipulation, but a few years ago I devised methods which are much easier and require but little practice. One of these methods is to make the leaf transparent by a chemical means. A portion of a leaf is enclosed between two of the thin circles of glass used by all microscopists, and a weight having been placed upon the upper glass, the portion of leaf thus enclosed is heated with a strongly akaline solution of permanganate of potash. The action begins at once, and the substance under examination must be examined from time to time to see that the oxidation does not proceed too far; alkaline permanganate attacks the colouring matters, the contents of the cells first, and afterwards the cell membranes. The object of this treatment is to make the leaf transparent, and yet to preserve its structure. Tea leaves are very opaque, and it is impossible without some mechanical or chemical treatment to render them transparent. When from the appearance of the leaf fragment the oxidation is considered sufficient, it is removed, washed in water, and treated with a little strong hydrochloric acid,

Method of making a tea leaf transparent.

which at once dissolves the manganese oxide which has been precipitated on the leaf, and leaves the latter as a translucent white membrane, in which the details of structure can be readily made—tea leaf in this way being quite different in appearance from other leaves. The second method of great value is to place a fragment of leaf between two circles of glass, weight the upper one with a silver coin, and burn the leaf thus prepared on a bit of sheet platinum. Since it is impossible for the ash to curl up and The skeleton ash.



Ash of sloe leaf. × 22.

Ash of tea leaf. × 170.

Ash of the leaf of the lime-tree.

FIG. 4.—SKELETON ASHES.

become disarranged, a complete skeleton of siliceous ash remains, which I have called "the skeleton ash." These skeleton ashes of leaves, so far as I have yet investigated show such decided differences the one from the other, that a great number of leaves may with a little practice be recognised by this method alone. Fig. 4 are examples of skeleton ashes.*

* The method of obtaining a "skeleton ash" is also extremely useful in detecting the adulteration of tobacco with foreign leaf.

Chemical composition of tea.

§ 87. The chemical composition of tea, if we have regard to every substance which can be extracted from it, is of great complexity. In my larger work on Foods I have enumerated no less than sixteen components, viz.—essential oil, theine, boheic acid, quercetin, tannin, quercetrinic acid, gallic acid, oxalic acid, gum, chlorophyll, resin, wax, albumen, woody and colouring matters, and ash.

Theine or caffeine.

It must however be remembered that many of these, such as wax, colouring matters, albumen, woody fibre, gum and resin, are common constituents of plants, and in no way are distinctive of the tea plant. The alkaloid theine, otherwise called caffeine, can be obtained in beautiful silky crystals of the whiteness of snow. Antony van Leeuwenhoek first discovered theine some time in the latter part of the 17th century, separating it from coffee beans by evaporating down the watery extract. He described the crystals as "oblong saline particles of different sizes, but most of them exceedingly minute; all of them with sharp points at the ends and dark in the middle." A hundred and twenty years afterwards it was rediscovered by a chemist (Runge) and separated in quantity from coffee.

Method of showing theine.

The presence of theine in tea is very easily demonstrated. Place one or two tea leaves in a teaspoon and add a little water, boil almost to dryness over a spirit lamp, then add a pinch of dry magnesia, and make the tea leaf and infusion into a sort of paste; on now carefully heating and holding a slip of glass over the spoon, theine will sublime or condense in crystals upon the glass.

Amount of theine in tea.

The quantity of theine in tea varies from 1 up to 3 per cent.; a cup holding half a pint of tea would, on an average, give 38 grains of solid matter, which would include 7½ grains of tannin and 2½ grains of theine, with a fraction of a grain of essential oil.

The average composition of mixed tea, such as sold for 2*s*. 8*d*. per lb., is as follows.

——	Per cent.	In a pound, ozs. and tenths of an oz.
Water	11·49	1·8
Nitrogenous substances other than theine	21·22	3·4
Theine	1·35	0·2
Essential oil	0·67	0·1
Fat, chlorophyll and wax	3·62	0·6
Gum and Dextrin	7·13	1·1
Tannin	12·36	2·0
Other nitrogen-free matters	16·75	2·7
Woody fibre	20·30	3·3
Mineral matters* (ash)	5·11	0·8
	100·00	16·0

The table clearly shows that in a pound of tea, we only purchase 9 ozs. of active substances, hence even tea at 2*s.* a pound is a very dear article; a pennyworth of two shilling tea will only buy 162 grains of the components of the tea. Value of tea.

§ 88. *Coffee.* The coffee berry is the seed dried and deprived of its integument of the *Caffea arabica.* Nat. Ord. Cinchonaceæ; thin sections of the berry have a very marked and distinctive microscopical appearance, and show a very complex structure.

The berry before use is always roasted. The use of coffee seems somewhat on the decline in England, the chief reason being the difficulty in ever purchasing a really good cup of coffee at an hotel or restaurant; and the few cooks in private houses who know how to prepare it properly. The whole secret of good coffee is to *grind* the *freshly roasted* berry, and use the ground coffee at once. The aroma is very delicate and fugitive, all attempts at full preservation seem to be failures. The use of coffee on the decline.

The changes in the berry produced by roasting are the volatilisation of a small portion of the theine (caffeine), a partial change of the sugar into caramel, a general breaking Changes produced by roasting.

* The mineral matter of tea contains much potash and reacts alkaline; it is partly on account of this that tea leaves are found so useful in cleansing bottles, &c.

up of the oil and albumen cells, with the extrication of gas and water, and the development of a very powerful and volatile aromatic substance.

The general composition of coffee is as follows:

——	Parts per cent.	In a pound, ozs., and tenths of an oz.
Water . . .	1·81	0·3
Nitrogenous substances other than theine	12·20	1·9
Theine (caffein)	0·97	0·2
Fat	12·03	1·9
Gum and sugar	1·01	0·2
Caffeo-tannic acid	22·60	3·6
Cellulose	44·57	7·1
Mineral matters (ash)	4·81	0·8
	100·00	16·0

Price of coffee as compared with tea.

Thus in a lb. of coffee, we do not purchase more than $8\frac{3}{4}$ ozs. of useful matter, a little less than in a lb. of tea. Although coffee ranges only from 1*s.* to 1*s.* 6*d.* a lb. it is dearer than tea, for the simple reason that so much more of the ground berries is required.

Chicory as an addition to Coffee.

§ 89. Chicory is a harmless root; with no particular physiological action, it is added to coffee because by its use a weak infusion of coffee has the appearance of a strong infusion. For the same reason it is a favourite ingredient in coffee extracts; the consumer sees a dark brown liquid, which tastes a little bitter, and imagines he is taking a good cup of coffee, whereas in reality he may be imbibing rather chicory infusion flavoured with coffee, than coffee flavoured with chicory. Of all substances used as food, none have been adulterated with such a variety as coffee; the berry in this country has been dealt with unfairly from first to last, great companies have been started to substitute for it worthless ingredients; it has been coloured with sugar, fraudulently mixed with chicory, and all sorts of torrefied roots, and lastly, its proper method of use has never been popularised. Adulteration of coffee.

§ 90. *Cocoa and Chocolate.* The cocoa of commerce is made from the roasted seeds of the *Theobroma cacao*, a tree belonging to the natural order Byttneriaceæ, whole forests of which exist in Demerara. Cocoa is at present cultivated in Central America, Brazil, Peru, Caraccas, Venezuela, Ecuador, Grenada, Essequibo, Guayaquil, Suriinam, some of the West Indian Islands, parts of the East Indies, the Philippine Islands, the Mauritius, Madagascar, and Bourbon.

The various names by which the cocoas of commerce are known, are those of the locality from which the cocoa has been derived.

The cocoa seeds intended for the manufacture of chocolate are submitted to a kind of fermentation (technically called the sweating process), during which they lose a certain disagreeable flavour, and develop an aromatic odour.

The commercial varieties of cocoa are very numerous. *Cocoa nibs* are simply the bruised, roasted seeds deprived of their coverings, and *flake cocoa* is composed of the nibs ground in a particular form of mill. The *soluble cocoas* are cocoas variously diluted with sugar and starches, for example, *Epps's cocoa* was proved in a legal action to be composed of 40 per cent. of cocoa, the rest starch and sugar. *Granulated cocoa*, *Homœopathic cocoa*, and *Maravilla cocoa* are all dilutions with sugar, and either arrowroot, sago or other starch. Commercial varieties of cocoa.

There are other preparations, like cocoa essence and cocoatine, which consist of pure cocoa deprived of its fat.

§ 91. *Chocolate* is made by grinding the nibs in a mill, the rollers of which are heated by steam; this softens the cocoa butter, and the pasty mass is mixed with sugar, and Chocolate: its mode of preparation.

flavoured with vanilla or other flavouring matters. The composition of cocoa and chocolate is as follows :

—	Pure Cocoa.	Chocolate.
Water	5·66	1·55
Cocoa butter	46·00	15·25
Theobromine	1·24	·41
Albumen, fibrin, and gluten	15·10	4·65
Starch	12·51	11·03
Sugar	..	63·81
Gum	7·20	*
Colouring matter	3·14	*
Woody fibre	5·90	1·15
Ash	3·25	2·15
	100·00	100·00

Theobromine and cocoa butter.

§ 92. The peculiar constituents of cocoa are two: viz. Theobromine and cocoa butter. Theobromine is an alkaloid analogous to theine; cocoa butter is a yellow concrete oil, of the consistence of tallow; it has a brown colour and agreeable taste; it never becomes rancid, however long it is kept.

When the large amount of starchy matter, fat, albumen, &c. is considered, cocoa and chocolate are seen to be as much a food as a drink. In 1 lb. of cocoa there are no less than 14 ozs. of useful matter; and at the average price of 15½*d.* per lb., for one penny 398 grains or nearly 1 oz. more or less nutritious substances are bought.

* Included with the starch.

DIVISION VII.

THE PRINCIPLES OF DIET.

CHAPTER XXVI.

THE PRINCIPLES OF DIET.

§ 93. THERE are diets suited for every age, for every climate, for every species of work, physical or mental; there are diets by which diseases may be prevented and cured, there are diets suited to some constitutions, injurious to others; diets which make the skin glossy, the frame vigorous, and the spirits joyous; others which mar the face with wrinkles, speckle the body with eruptions, and make the form hollow and lean, and prematurely old. Good and evil powers of diet.

When, by successive researches, the science of diet is better understood, without doubt a school of physicians will arise, discarding all drugs, and treating maladies by cutting off certain foods, by surfeiting with others. If, indeed, at the present time there is not in the highest representatives of modern medicine, the nucleus of the future school of dietetics ready formed.

§ 94. It has already been explained that all food may be reduced to a few principles; that is, albumenous or nitrogenous matters, carbohydrates, fat, and mineral or saline matter. A person having for breakfast bacon, eggs, and toast, for dinner soup, vegetables, fish, meat and fruit, and for lunch a chop and bread, takes a variety of food which could not be compared with the simple rice diet of the Hindoo, were it not possible to reduce the elements to their equivalents, as albumenoids, carbohydrates, and the like. The components of food for the purpose of comparison, must be reduced to their equivalents.

The process by which any one can do this I will endeavour to explain. In order to express food in equivalents, only two things are required to be known ; one, the percentage composition of the food ; two, the weights of the food consumed.

How to express foods in equivalents.

In all scientific calculations the French weights are infinitely preferable ; but since to many of my readers, ounces and grains may be more familiar, I will use the latter.

The percentage composition of most common foods will be found in the tables, pages 349–354 ; how they may be employed may be shown from an example.

A person eats for dinner 2 ozs. of moderately fat beef, 4 ozs. of potatoes, 4 ozs. of cabbage, and 5 ozs. of bread—required the "*equivalents.*"

On referring to Table I. page 349, we see that 100 parts of moderately fat beef has a certain composition, and we have only to multiply the amounts given by $\frac{2}{100}$ that is ·02 to know the several amounts in 2 ozs. which will be, viz., water, 1·44, nitrogenous substances, ·43. Fat, ·10 ; ash (i.e., mineral substances), ·03. Similarly, the percentages of the components of the potato (Table V., page 353) have to be multiplied by $\frac{4}{100}$ or ·04, of the cabbage (Table V., page 353,) by $\frac{5}{100}$ or ·05 of bread (page 314) by ·04.

The whole 15 ozs. are then thus expressed in ounces and tenths.

—	Water.	Nitrogenous matters.	Carbo-Hydrates.	Fat.	Ash.
The 2 ozs. of beef is equal to . . .	1·44	·43	..	0·10	·03
The 4 ozs. of potatoes*	3·03	·07	·82	0·01	·04
The 4 ozs. of cabbage*	3·60	·07	·20	0·01	·05
The 5 ozs. of bread .	1·92	·34	·04	2·62	·06
	9·99	·91	1·06	2·74	·18

The totals added together make 14·88 ozs., ·12 ozs. being woody fibre, and therefore not included.

* The woody fibre need not be reckoned.

It is often convenient to make a still farther reduction, and express the food as so many grains of nitrogen and carbon.

This may be done by multiplying the nitrogenous matters as calculated out in ounces, by 69 for nitrogen, and 233 for carbon; multiplying the fat by 345·6 for carbon, and the carbohydrates (except milk or sugar) by 194·2 for carbon.

	Grains of Nitrogen.	Grains of Carbon.
Thus, ·91 ozs. of nitrogenous (albumenoids) matter . =	62·8	212·0
1·06 oz. of carbohydrates = . .		205·8
2·74 ozs. of fat = . . .		946·9
	62·8	1364·7

§ 95. The researches of a great number of physiologists and chemists have now laid down the true principles of diet in relation to physical work. The standard diet for ordinary labour, after reckoning out the water, is as follows:— Standard diet.

	Ozs.	Grains.
Albumenoids . .	4·2 =	290 nitrogen
Fat	1·6	4184·4 carbon
Carbohydrates .	18·7 =	459·3 mineral substances
Salts . . .	1·05	

The diet of the English soldier consisting of 12 ozs. of meat ($\frac{1}{5}$ bone), 24 ozs. of bread, 16 ozs. of potatoes, 3 ozs. of other vegetables, 3¼ ozs. of milk, 1·3 ozs. of sugar, with salt, tea and coffee, is about equal to the standard diet, being equivalent to 266 grains of nitrogen and 4718 grains of carbon.

On such a diet 300 tons may be lifted one foot daily (see page 271), and health and strength be maintained.

§ 96. König has made a useful comparison of the cost of the different principles of a standard diet, according as it is derived from the animal or vegetable kingdom; he has taken as his basis the albumenoids in ordinary half-fat beef, as contrasted with the albumenoids in potatoes; similarly, he Cost of the food equivalents of animal and vegetable diets compared.

has taken the fat as lard; and he has reckoned out its equivalent in carbohydrates from the researches of Voit and Pettenkofer, who have shown that 100 of fat is equal to 175 of starch in its work in the economy. The comparison is, of course, based on the German prices, viz., meat, 7½*d.* per lb.; lard, 9½*d*; and potatoes about ½*d.* per lb. Our English retail prices in London differ somewhat from this; meat and potatoes being dearer. Nevertheless, the comparative difference, which may be very well shown on König's calculations, translating kilogrammes and marks into pounds and shillings, is as follows:—

	Animal food. per lb.	Vegetable food. per lb.
	s. d.	*s. d.*
Albumenoids	3 0	1 3
Fat	1 0	0 9
Carbohydrates	1 2¼	0 3

If labourers lived on meat alone, their wages would have to be very high; the commonest meat and meat fat to make up the standard diet would cost in this country something like 1*s.* 8*d.* daily, or not far off 12*s.* a week.

The poor man's diet must be a proper mixture of the expensive animal diet with the cheap vegetable diet: such as that given at page 341.

The embryo fed chiefly on albumen.

§ 97. *Diet in development.* It is a curious fact that the earliest food is not the starchy or carbohydrate, but the albumenous. The hen's egg, the changes in which have been so fully worked out by means of artificial incubation, is a good example of this. The body of the chicken is formed out of the yellow yelk, which is the little bird in an unarranged state. The white is almost pure albumen and water, around all is the shell, part of which is to be dissolved by the albumen and carried to the yelk to form the bones. During the whole period, the developing egg diminishes in weight from the loss of carbonic acid and water, the albumen becomes slowly assimilated into the substance of the chicken, and lastly, the shell is attacked and thinned. The chicken thus grows at the expense of its surrounding food, and when it at length frees itself from the shell, there is scarcely anything left for it to live upon, the little bird then seems to be built up entirely on albumen and salts; but if you make the attempt to feed adult birds with white of egg, and finely ground shells, they die of starvation; Tiedemann and Gmelin indeed tried the experiment with geese, but that same food which would have given to the young embryo all the sustenance required, starved and killed the adult. The embryo of mammals is no doubt nourished in a less simple way, and probably extracts carbohydrates, in the form of sugar, from the circulating blood stream, common to both parent and offspring. As soon as born the mammalian infant lives upon albumenous and sugary matters (see milk, p. 301), and after some time develops its digestive organs sufficiently to take a mixed diet; but in the earliest years the human infant is more of a carnivorous than an omnivorous animal.

The human infant at first easier digests flesh products than starch products.

§ 98. The nearer a young infant's diet approaches to milk the better, but older children can consume very large quantities of carbohydrates in the form of starches. Voit made an elaborate investigation on the diet used in the Orphan Asylum at Munich, in which the children of from 6–15 years of age are maintained in excellent health. An example of a day's ration is as follows:

Diet of young children above six years of age.

Breakfast: 9 ozs. of milk, 1·4 ozs. of bread.
Mid-day meal: a vegetable dish made of 1·8 ozs. of cabbage, 6 ozs. of flour, ·4 lard with onions, 6 ozs. of beef including bone, mashed potatoes made of 7 ozs. of potatoes, 5 ozs. of flour, 3 ozs. of lard and a couple of onions; also bread 2·8 ozs.
Afternoon: bread 2·8 ozs.
Evening meal: bread 2·8 ozs., beer, half-pint, 9·9 ozs. potatoes, cut in slices with ·4 ozs. of lard.

Taking the whole week through, the average daily equivalents are:

Albumenoids	2·7 ozs.
Fat	1·3 ozs.
Carbohydrates	8·7 ozs.

which is equal to 169½ grains of nitrogen and 4·451 grains of carbon. Hence, although growing children do not seem to require so much nitrogen as adults, they require quite as much or even more sugar, starch, and fat—the fondness of young people for sweetmeats, cakes, and pastry being based upon a physiological necessity.

Diet for body work.

§ 99. *Diet suitable for great physical efforts contrasted with that suitable for sedentary pursuits.* When there is excessive exertion the elements of the diet must be increased proportionate to the effort. Some addition to our knowledge of the quantity of food required, to keep the system in health, has recently been afforded us in observations upon Mr. Weston during the 6 days in which he concluded his pedestrian feat. The external work was walking 50 miles daily on a level track in the Victoria Hall, which I have calculated to be equal to lifting 793 tons one foot high.

Weston's diet.

Weston, while under observation at the Victoria Hall, would breakfast at 6·30, on 12 ozs. of porridge, 3 eggs (or if he did not have eggs he had nine or ten ozs. of fish), with from 2 to 5 ozs. of toast, bread and butter, or muffin, and from ½ a pint to a pint of coffee.

At eleven he lunched on from 6 to 8 ozs. of bread and butter, and a pint or more of coffee.

At half-past two p.m. he dined on about one pint of mutton broth, from 6 to 11 ozs. of either beef or mutton, as free from fat as possible, 4 ozs. of potatoes, 5 ozs. of cabbages, 4 to 5 ozs. of bread and butter or toast, and 12 ozs. of a tapioca pudding, taking soda water or ginger ale as a drink.

At 7 p.m. he had a small quantity of toast, and a pint or more of tea or coffee.

At 10.30 he had some toast, some figs, 2 ozs. of sponge cake, and from 8 to 20 ozs. of pudding, sometimes milk, sometimes soda-water.

I have reduced the daily diet to equivalents, as in the following table.

FOOD EQUIVALENTS OF THE DIET USED BY MR. WESTON WHILST WALKING 50 MILES DAILY ON THE LEVEL TRACK IN THE VICTORIA HALL.

—	Water. ozs.	Albumenoids. ozs.	Carbohydrates. ozs.	Fat. ozs.	Ash. ozs.
Monday	137·9	8·0	27·5	1·6	0·8
Tuesday	109·6	7·8	24·7	1·8	0·7
Wednesday	146·2	8·6	27·7	3·3	1·1
Thursday	130·4	8·7	32·0	1·6	0·7
Friday	145·0	8·5	30·6	3·1	0·7
Saturday	140·3	5·8	19·5	2·5	0·6
Total	809·4	47·4	162·0	13·9	4·6
Mean	134·9	7·9	27·0	2·3	0·7

This diet is equivalent to 545 grains of nitrogen and 7879 grains of carbon daily, or rather more than twice the amount of nitrogen, and about twice the amount of carbon which will support ordinary work. It will be instructive to compare with these large quantities of food, which in order to perform the task effectually were really necessary, the diet of people who live, whether from indolence or necessity, vegetative lives, with but little physical and less mental exertion. One of the best examples of the small amounts required to support life is that of the Trappist monks. Their diet is interesting, not alone because it is well authenticated, but because it is wholly vegetable. It indeed consists only of black bread and vegetables. There are three meals daily, and the average daily ration is 17½ ounces of bread, 17½ ounces of beer, two plates of vegetable soup, and one plate of greens. This reduced to equivalents would be 2·4 ounces of albumenates, 4 ounces of fat, and 16·5 ounces of carbohydrates, or 165 grains of nitrogen, and a little over 5000 grains of carbon—the carbon is therefore about or a little over that of the standard diet (page 341), the nitrogen is about ⅓ less.

Vegetable diet of the Trappist monks.

§ 100. Some years ago there was a sort of an experiment made on certain prisoners in Glasgow. Ten prisoners were under sentence of two months' imprisonment each. They were all employed at very light work, involving no great muscular exertion. At the commencement all were in good health; two were in indifferent health. At the end all were in good health, and the average gain of weight* per man was four pounds; one had gained as much as nine pounds, and one had lost somewhat in weight. The diet consisted of three meals a day, and the total quantity per man was 13 ounces of oatmeal, 3 pounds of boiled potatoes, and $1\frac{1}{2}$ ounces of buttermilk. It was equal in equivalents to 164 grains of nitrogen and 4·643 grains of carbon.

Diet of oatmeal, buttermilk, and potatoes.

This again shows that for light work the meaty class of substances may be much decreased.

Diet for brain work.

§ 101. *The diets for mental exertion.* This is a difficult subject, we know so little of the true food of the brain; what we do know is that morbid fancies are often but the emanations of a brain poisoned by impure blood; and that food, digestion, and morals have a more intimate connection than theologians are prepared to accept.

The brain must not be "filliped" up with brandy.

One of the first laws to which men working their brains must submit to is the greatest moderation in the use of alcoholic drinks. To take a glass of light ale with a meal for the sake of digestion is one thing, but to stimulate the flagging brain with brandy or wine is another, and is likely to produce early disease and premature exhaustion. When the brain is tired, it must be renovated by sleep and bodily exercise.

The brain, together with the nervous system, is chemically composed of a number of phosphorised fats set in an albumenous framework. It has never been proved that there is any real waste of the phosphorus compounds under prolonged mental exertion; nor is it precisely known whether there is any metabolism of these compounds; but judging by analogy just as the muscular

* Gain or loss of weight is in itself of no value as a criterion of health; the men showed however general signs of good health.

system requires organic nitrogen, the brain may require organic phosphorus. The diets most rich in organic phosphorus are fish diets and egg diets; and not a few eminent men, engaged in hard mental work, take fish under the idea that it is of greater assistance to them than an equal amount of nutriment in beef or mutton.

Does the nervous system require organic phosphorus.

Whether these theories have a proper basis or not, this one thing is certain, that any form of indigestion greatly interferes with mental effort, either causing somnolence, apathy, or irritability; so that those diets which the worker knows will best agree with him, are, *cæteris paribus*, best for his brain.

§ 102. *The reduction of fat by diet.* A method for the removal of unhealthy and inconvenient fat was some years ago brought prominently before the public by Mr. Banting—the Banting system in its essence was known to Hippocrates, Celsus, Galen, and to Æsculapius and his school and previous to Mr. Banting's little book, an exact and clear account of the proper principles of reducing fat was published by Brillat-Savarin, for in his famous '*Physiologie du Gout*,' 1843, after saying that the first cause of obesity is predisposition, he continues: "The second and principal cause is in the flours and starches, of which man makes the daily basis of his nourishment. The starch produces its effect most quickly when mixed with sugar."

How to get lean.

Brillat-Savarin.

The man who makes widely known a useful fact or invention is often as useful to the world as the discoverer, and Mr. Banting's little octavo pamphlet, called 'The Letter on Corpulence,' will always be rightly considered an important contribution to practical dietetics. Mr. Banting weighed 202 lbs., or over 14 stone. In a little more than 12 months he reduced it by 50 lbs., and became 10 st. 12 lbs. His diet was, for breakfast, beef, mutton, or kidneys, bacon, or cold meat of any kind, except pork or veal. He took tea or coffee, and one ounce of dry bread. The total amount of meat was between five and six ounces, which, with the bread, makes six or seven ounces. For dinner he took any fish except the fatter kinds, that is, salmon, eels or herrings.

Mr. Banting's diet.

Any meat and any vegetables, except potatoes, parsnip, beetroot, or carrot. He had some dry toast, some fruit out of a pudding, and poultry or game. He took a little wine, and altogether seems to have consumed eleven or twelve ounces of meat and vegetables, and one ounce of bread. For tea he had fruit, a rusk or two, and tea without milk or sugar. For supper he again had meat, taking about four ounces, and he finished the day with a glass of grog.

It is to be regretted that the foods and liquids he took day by day were not recorded with scientific exactness; but if I have read his pamphlet aright, he took altogether of meat something like 19·5 ozs., of starchy substances, 6 ozs., about equivalent to 338 grains of nitrogen, and 1617 grains of carbon. The food was extremely deficient in fat and carbo-hydrates, containing about $\frac{1}{6}$th of the quantity of fatty and starchy substances which ordinary people would use. The fat-forming substances being thus decreased, by cutting off the supply; the excess of nitrogenous food by its peculiar action (see page 283) increasing the oxidation, the metabolism of the body aided the dimunition of the various fat-stores of the body.

People inclined to be inconveniently fat may profitably use a partial or modified Banting system. An abstinence from sugar, the sparing use of bread, pastry and potatoes, and a plentiful supply of lean meat, combined with exercise, ought to be sufficient to restrain the proportions of most people within due limits. On the other hand lean people who desire to get fat, must use a diet opposite to this; eat little lean meat, plenty of butter, potatoes, bread, and pastry: they must live in warm rooms, and take little exercise. These are, indeed, the principles upon which animals are fattened, but there are certain men who will always be lean and anxious-looking, such have peculiar irritable nervous organisations, and the metabolism of their tissues is very active.

How to get fat.

APPENDIX.

TABLE I.

PERCENTAGE COMPOSITION OF VARIOUS ANIMAL FLESH OR MEAT.

—		Water.	Nitrogenous substances.	Fat.	Nitrogen-free extractive matter.	Ash.
Bacon fat, salted and dried		13·9	9·0	74·1		3·0
Beef (fat)	minimum	32·49	10·87	5·80		0·75
	maximum	73·50	19·94	56·11		1·53
	mean	54·76	16·93	27·23		1·08
Beef (moderately fat)	minimum	68·50	16·99	1·00		0·75
	maximum	78·00	25·03	9·86		2·02
	mean	72·25	21·39	5·19		1·17
Beaf (lean)	minimum	75·21	20·18	0·61		1·14
	maximum	78·16	22·17	3·46		1·20
	mean	76·71	20·61	1·50		1·18
Fowl		70·82	22·65	3·11	2·33	1·09
Hare		74·16	23·34	1·13	0·19	1·18
Kidney (sheep's)		78·60	16·56	3·33	0·21	1·30
Mutton	very fat	47·91	14·80	36·39	0·05	0·85
	moderately fat	74·79	18·11	5·77		1·33
Pigs' liver		72·37	18·65	5·66	1·81	1·51
Pork (fat)	minimum	40·27	12·55	28·03		0·47
	maximum	54·63	16·58	46·71		1·07
	mean	47·40	14·54	37·34		0·72
Pork (lean)	minimum	69·32	17·32	3·73		0·98
	maximum	76·14	24·47	11·77		1·64
	mean	72·18	19·91	6·81		1·10
Tripe		67·1	13·3	17·1		2·50
Veal	(fat)	72·31	18·88	7·41	0·07	1·33
	(lean)	78·82	19·86	0·82		0·50
Eggs (hen's)		73·67	12·55	0·35		1·12
Egg albumen (white)		86·49	12·67	0·25		0·59
Egg, yelk of (yellow)		50·79	16·24	31·75	0·13	1·09

TABLE II.

Percentage Composition of Fish.

—	Water.	Nitrogen-ous sub-stances.	Fat.	Nitrogen-free and extractive matter.	Ash.
Codfish	77·50	18·50	3·00		1·00
Eels	79·91	13·57	5·02	0·39	1·11
Gudgeon.	76·89	17·37	2·68		3·44
Herrings — fresh	80·71	10·11	7·11		2·07
Herrings — salted . . .	47·12	18·97	16·67		17·24
Herrings — smoked . . .	69·13	21·12	8·51		1·24
Lamprey.	51·21	20·18	25·59	1·61	1·41
Mackerel — fresh . . .	68·27	23·42	6·76		1·55
Mackerel — salted . . .	48·43	20·82	14·10	0·38	16·27
Oyster	89·69	4·95	0·37	2·62	2·37
Pike	77·37	19·86	0·79	1·60	0·38
Salmon	71·50	18·75	6·22	2·95	0·18
Sardine (preserved) . . .	51·77	22·30	2·21		23 72
Skate.	73·79	24·03	0·47		1·71
Sole	86·14	11·94	0·25	0·45	1·22
Sprat.	59·89	22·73	15·94	0·98	0·46
Whiting	82·95	15·09	0·38	0·50	1·08

TABLE III.

Percentage Composition of Milk, Cheese and other Dairy Products.

—	Water.	Casein and albumen.	Fat.	Milk-sugar.	Ash.
Milk	87·55	3·41	3·64	4·69	0·71
Skim milk	90·11	3·37	0·46	5·34	0·72
Cream	28·58	1·42	67·63	2·25	0·12
Devonshire cream	28·68	4·05	65·01	1·77 (Lactic acid ·32)	0·49
Buttermilk	90·62	3·78	1·25	3·38	0·65
Condensed milk (preserved with the addition of cane sugar)	24·42	10·33	9·02	Milk sugar 12·64 (Cane sugar) 41·66	1·93
Condensed milk (without any addition)	48·59	17·81	15·67	2·53	35·00
Butter	14·14	0·86	83·11	0·70	1·19
Butterine	12·01	0·74	82·03		5·22
Cheese.					
1. *Soft Cheeses.*					
Fromage de Brie	51·87	18·30	24·83		5·00
Camembert	51·30	19·00	21·50	3·50	4·70
Roquefort (fresh)	11·84	85·43	1·85	Lactic acid 0·88	11·84
2. *Hard Cheeses.*					
American cheese	22·59	37·20	35·41		4·80
Cheddar cheese	27·83	44·47	24·04		3·66
Dunlop cheese	38·46	25·87	31·86		3·81
Gloucester (single)	21·41	49·12	25·38		4·09
Stilton (fresh)	32·18	24·31	37·36	2·22	3·93
Gruyère	34·68	31·41	28·93	1·13	3·85
Gorgonzola	43·56	24·17	27·95		4·32
Parmesan	27·56	44·08	15·95	6·69	5·72
Skim cheese	48·02	32·65	8·41	6·80	4·12

TABLE IV.

Percentage Composition of various Flours and leguminous Meals.

—	Water.	Nitrogenous substances.	Fat.	Starch, &c.	Woody fibre.	Ash.
1. *Meal.*						
Barley meal . . .	15·06	11·75	1·71	70·90	0·11	0·47
Buckwheat meal . .	14·27	9·28	1·89	72·46	0·89	1·21
Maize						
Oatmeal	10·46	15·50	6·11	63·67	2·24	2·02
Rye meal	14·24	10·97	1·95	69·74	1·62	1·48
Wheaten flour (fine) .	14·86	8·91	1·11	74·18	0·33	0·61
,, (seconds)	12·18	11·27	1·22	73·65	0·84	0·84
2. *Starch.*						
Arrowroot . . .	16·52	0·88	82·41			0·19
Maize starch . . .	11·90	2·37	85·30			0·43
Sago	12·89	0·81	86·11			0·19
Tapioca	13·3	0·63	85·95			0·12
Wheat starch . . .	11·30	1·12	87·05			0·53
Macaroni (stars) . .	14·01	8·69	0·32	76·49		0·49
,, (pipe) . .	15·86	8·19	0·29	75·06		0·60
3. *Leguminous Seeds.*						
Beans (fresh and green)	86·10	4·67	0·30	6·60	1·69	0·64
,, (dried) . . .	14·84	23·66	1·63	49·25	7·47	3·15
Peas (green) . . .	80·49	5·75	0·50	10·86	1·60	0·80
,, (dried) . . .	14·31	22·63	1·72	53·24	5·45	2·65
,, (shelled) . . .	12·73	21·12	0·82	60·94	2·64	1·75
Pea meal (dried) . .	8·12	28·10	2·97	50·17	8·02	2·55
Kidney beans . . .	88·36	2·77	0·14	1·20 Sugar 6·82	1·14	0·57
Lentils.	12·51	24·81	1·85	54·78	3·58	2·47
Millet	11·26	11·29	3·56	67·33	4·25	2·31

TABLE V.

PERCENTAGE COMPOSITION OF SUCCULENT VEGETABLES.

—	Water.	Nitrogenous substances.	Fat.	Carbohydrates.		Woody fibre.	Ash.
				Sugar.	Nitrogen free extractive-matter.		
Asparagus	93·32	1·98	0·28	0·40	2·34	1·14	0·54
Beet, common	87·88	1·07	0·11	6·55	2·43	1·02	0·94
Beet, sugar	83·91	2·08	0·11	9·31	2·41	1·14	1·04
Cabbages	89·97	1·89	0·20	2·29	2·58	1·84	1·23
Carrots	87·05	1·04	0·21	6·74	2·60	1·46	0·90
Celery, leaves	81·57	4·64	0·79	1·26	7·87	1·41	2·46
Celery, stalks	89·57	0·88	0·34	0·62	5·94	1·24	1·41
Cauliflower	90·39	2·53	0·38	1·27	3·74	0·87	0·82
Chicory, dried and roasted	10·69	6·29	1·52	15·54	55·00	6·11	4·85
Chicory, fresh	75·69	1·01	0·49	3·44	17·62	0·97	0·78
Cucumber	95·60	1·02	0·09	0·95	1·33	0·62	0·39
Garlick (leaves and stalks)	90·82	2·10	0·44	0·81	3·74	1·27	0·82
Horse-radish	76·72	2·73	0·35		15·89	2·78	1·53
Lettuce	94·33	1·41	0·31		2·19	0·73	1·03
Onions (bulbs)	64·66	6·76	0·06		26·31	0·77	1·44
Parsley	85·05	3·66	0·22	0·75	6·69	1·45	1·68
Potatoes	75·77	1·79	0·16		20·56	0·75	0·97
Radishes	93·34	1·23	0·15	0·88	2·91	0·75	0·74
Savoys	87·09	3·31	0·71	1·29	4·73	1·23	1·64
Spinach	90·26	3·15	0·54	0·08	3·26	0·77	1·94
Turnips	85·01	2·95	0·22	0·40	8·45	1·76	1·21
Water-melon	95·21	1·06	0·60	0·27	1·16	1·07	0·63

TABLE VI.

Percentage Composition of Fruits.

—	Water.	Nitrogenous substances.	Free Acid.*	Sugar.	Nitrogenous-free substances, extractive matter, &c.	Cellulose and seeds.	Ash.
Almonds	5·39	24·18		fat 53·68	7·23	6·56	2·96
Apple	83·58	0·39	0·84	7·73	5·17	1·98	0·31
Apricot	81·22	0·49	1·16	4·69	6·35	5·27	0·82
Bilberry	78·36	0·78	1·66	5·02	0·87	12·29	1·02
Blackberry	86·41	0·51	1·19	4·44	1·76	5·21	0·48
Chestnut	51·48	5·48		fat 1·37	38·34	1·61	1·72
Cherry	80·26	0·62	0·91	10·24	1·17	6·07	0·73
† Cocoa nut, white solid part	5·32			fat 66·16		?	1·55
Currant	84·77	0·51	2·15	6·38	0·90	4·57	0·72
Damson	81·18	0·78	0·85	6·15	4·92	5·41	0·71
Figs (as sold)	31·20	4·01	1·21 also fatty matter 1·44	49·79	4·51	4·98	2·86
Filberts	3·77	15·62		fat 66·07	9·03	3·28	1·83
Gooseberries	85·74	0·47	1·42	7·03	1·40	3·52	0·42
Grapes	78·17	0·59	0·79	24·36	1·96	3·60	0·53
Mulberries	84·71	0·36	1·86	9·19	2·31	0·91	0·66
Oranges	89·01	0·73	2·44	4·59	0·95	1·79	0·49
Peach	80·03	0·65	0·92	4·48	7·17	6·06	0·69
Pears	83·03	0·36	0·20	8·26	3·54	4·30	0·31
Plums	84·86	0·40	1·50	3·56	4·68	4·34	0·66
Raisins	32·02	2·42		54·56 also fatty matter 0·59	7·48	1·72	1·21
Raspberries	86·21	0·53	1·38	3·95	1·54	5·90	0·49
Strawberries	87·66	1·07	0·93	6·28	0·48	2·77	0·81
Walnuts	4·68	16·37		fat 62·86	7·89	6·17	2·03

* The free acid which gives the sourness to fruits is different in different fruits. The chief free acid of the apple, pear, plum, apricot, peach and cherry is malic acid; that of the grape, tartaric acid; in oranges and lemons, citric acid; and in strawberries and raspberries, the acidity is due to a mixture of citric and malic acids.

† Cocoa-nut milk contains water 91·50, nitrogenous substances ·46, fat ·07, nitrogen-free extractive matters 6·78, ash 1·19 per cent.