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THE DIETETIC VALUE OF BREAD

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BY

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PREFACE

THE main portion of this work was originally contributed to the *Bakers' Record* as a series of articles.

In response to numerous requests these articles have been collected and revised for publication in the present form.

The object of the work is twofold: First, to lay before the general public an account of the various kinds of bread, by which their merits may be judged; and secondly, to afford technical information to students and others on the important subject of the true value of bread as a food.

The author believes that there is no work published which deals exclusively with the dietetic value of bread, and he hopes that the present volume may in some measure supply this want.

The analytical work has been of such an extensive nature that possibly errors have arisen. But every reasonable care has been taken, and the results checked as far as possible.

The author wishes to acknowledge his indebtedness to Professor G. B. Howes, of the Royal College of Science, for many hints and suggestions; to his friend T. Lyon, Esq., of Cheltenham Training College, for the painstaking way in which he read the proof sheets; and to his assistant Mr. D. J. Knightley, who has loyally worked with him in the laboratory. He is also greatly indebted to the MSS. of his colleague, C. H. Clarke, Esq., M.R.A.S. The author's hearty thanks are due to the baking trade for the very kind way in which it has co-operated with him in the production of this work, and he hopes that it may prove a worthy addition to the literature pertaining to the important subject of bread.

J. G.

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FOOD, DIET, AND DIGESTION

CHAPTER I

INTRODUCTORY

Of late years a widespread interest has been aroused in the laws of health. This is evident from the number of journals which are now devoted to the various subjects embraced under the term "Hygienic Science," as well as from the various societies which have for their principles hygienic laws. Nearly every weekly journal or paper has its column for items of hygienic importance, and the winter season always brings numerous lectures on fresh air, rational clothing, and food reform. It would seem at the present time that hygienists are directing their attention more particularly to *food reform*. There can be no doubt that the food we eat determines to a great extent the health of our bodies, and scientists are doing well in attacking the food question first. Food reformers, however, have been slow to recognise the importance of *educating the masses* up to the point of being able to understand *why* in certain cases a change of diet is necessary, and why certain foods are harmful. Until this be done comparatively little progress will be made, for the English people are essentially conservative in such matters, and refuse to make changes without knowing the why and wherefore.

No branch of food reform has received so much attention as that dealing with the "staff of life," and rightly too, for bread is the most important food we have. When we consider how much we depend on bread for the maintenance of the body, we are forced to the conclusion that it is of vital importance to get the kind of bread most suited to supply the wants of the economy. The poorer classes depend more on bread than the middle and upper classes. The two latter supplement the "staff of life" with a great variety of other foods; but not so with the former. The working man partakes of bread at nearly every meal, and relies on it to form his staple food. In the poor districts of London the children seldom get any other food. In some personal inquiries made by the writer, it was found that in many places the children only had other food beside bread *once* or *twice* a week. They had bread for breakfast, dinner, and tea. This was especially the case in the poorer districts, like Bethnal Green. In the better class parishes it was invariably found that the children had something different for dinner. The number of cases inquired into represented about 20,000 children, and the following table gives a rough analysis of the results. The number of meals is counted at 21 for the week, and only solid food is reckoned. No account was taken of beverages or butter.

TABLE I.—*Poor Districts*

Nothing	but bread	for 21	meals,	about	15	per cent.
,,	,,	20	,,	,,	15	,,
,,	,,	19	,,	,,	5	,,
,,	,,	18	,,	,,	20	,,
,,	,,	17	,,	,,	28	,,
,,	,,	16	,,	,,	5	,,
,,	,,	15	,,	,,	5	,,
,,	,,	14	,,	,,	5	,,

Table II.—*Better Class Districts*

Nothing but bread for	21	meals	about	0 per cent.
" "	20	"	"	
" "	19	"	"	
" "	18	"	"	2 "
" "	17	"	"	
" "	16	"	"	5 "
" "	15	"	"	
" "	14	"	"	75 "
Below	14	"	"	18 "

A study of these tables will show clearly that to a considerable number of children bread is practically the only food supplied, while to the remainder it forms the chief article of diet.

This being so, how imperative it is for us to inquire into the *real* value of bread as a food, and to ascertain the kind of bread best suited to nourish the body.

It is the writer's present intention to deal with bread from the physiological standpoint, in order to show its exact dietetic value, and the kind of bread which is most suitable to meet the requirements of the body. The first section will treat of the general principles relating to food stuffs and their practical application to the calculation of diets. Section II.

will be devoted to the study of white bread as a food. Section III. will deal with whole-meal bread. In Section IV. the exact physiological value of special breads will be stated. Section V. will treat of the diseases of bread. In Section VI. the value of bread as a curative agent in certain diseases will be indicated.

In carrying out this scheme a great deal of the chemistry of bread will be omitted, and only those details will be introduced which are absolutely necessary to the comprehension of the subject. The technique of bread-making will not find a place in the work. The results to be attained will be pointed out, but the best methods to be employed may be safely left to practical scientific bakers who spend a large proportion of their lives in the bake-house, and who will therefore be best able to devise methods by which bread of the highest dietetic value may be produced.

A journeyman cannot gain too much knowledge about the article he manufactures. The more he knows about its properties, value, and composition, the better able will he be to work intelligently.

Bread is so universal a food that every care should be bestowed on its manufacture, not only to secure purity, but to produce a loaf which shall be perfect in a physiological sense. Surely it is not too much to ask, seeing the importance of good bread to the health, that bakers should be conversant with the dietetic principles of food, and with the hygienic requisites of good bread.

Guided by a sound knowledge of these particulars, bakers will no doubt successfully produce bread possessing them, and will thus do more than all the theoretical food reformers in England to help the people back to perfect health.

CHAPTER II

THE WASTE AND WORK OF THE BODY

There is a popular saying that "a man's body changes once in seven years." When we examine this statement from a physiological standpoint, we find that there is a great deal of truth in it, for there is abundant evidence to prove that the body is constantly undergoing change. The nails grow, the hair changes, and even such hard tissue as bone undergoes absorption and a process of rebuilding. The various excretions of the body—sweat, urine, expired air—all prove that the organs are continually undergoing chemical change, or, in other words, that the body is wasting. During life repair goes on simultaneously with the decay, so that the body might be compared to a great building, in which single bricks were being taken out and replaced by new ones, the work being so dovetailed as never to destroy the form and symmetry of the whole. In the same way the tissue units of the body are being used up and as constantly replaced by new ones.

There are three periods in the life of an individual as regards the relation of loss and gain. From birth to the time of maturity, or later, the gain far exceeds the loss, and consequently the body increases in weight. But soon a period is reached when the gain and loss just balance one another, and the body neither increases nor decreases in weight. Presently this state of things ceases, and a time succeeds when the loss is in excess of the gain, and the body gradually loses weight.

By a study of the waste products, both as regards composition and amount, we gain most important knowledge as to the kind and amount of material required to make good the loss.

The products of bodily decomposition are got rid of by three leading channels, viz. the lungs, the skin, and the kidneys.

The loss by the lungs is represented chiefly by carbon-dioxide (CO_2), but water is also exhaled as well as other organic matter of an undefined nature.

In 24 hours nearly 32 ounces of CO_2 and $10\frac{1}{2}$ ounces of water are given off in the breath. Part of the water is not derived from the body, as it exists in the air breathed in. The expired CO_2 represents nearly 3 ounces of solid carbon.

The skin excretes the substance known as sweat, which chiefly consists of water and salts.

The following is an analysis of sweat by Schottin—

Water	98·2
Epithelium	·3
Extractives	1·0
Common salt	·2
Other salts	·3
Fat	Traces.

The quantity of sweat excreted is variable, depending on a number of circumstances, such as the work done, the condition of the nerve centres, the state of the weather, etc. On an average about 1000 grammes, equal to about 35 ounces, are got rid of in this way, containing $\frac{3}{5}$ of an ounce of solids.

The waste by the kidneys mainly consists of water and *nitrogenous* matter. The urine, which is the secretion of the kidneys, has the following composition in 100 parts—

Water	96·00
Urea (containing nitrogen)	2·30
Uric acid (containing nitrogen)	·05
Common salt	1·10
Phosphoric acid	·20
Earthy phosphates	·08
Other bodies	·27
	100·00

It will be seen that the most important constituents of urine are water, urea, common salt, and phosphoric acid.

In 24 hours 1500 grammes are excreted (52 ounces), containing $1\frac{1}{5}$ ounce of urea, about $\frac{3}{5}$ of an ounce of common salt, and 8 grains of phosphoric acid.

Waste is thrown off from the alimentary canal mainly in the form of indigestible portions of the food, but we may conveniently neglect this when considering the waste products of bodily activity. The chief products of the waste of the body are thus seen to be carbon-dioxide, water, urea, and salts.

Now all these bodies (except the salts) are highly oxidised, that is to say, they are the products of the slow combustion of carbon, hydrogen, and nitrogenous substances. We are thus led to the conclusion that the "waste" of the body is simply one result of a series of chemical changes which take place within the tissues, as an accompaniment of their living activity or *metabolism*, and which are believed to be essentially of an oxidative character. Careful experiments have shown that the energy which the waste of the body represents in a healthy man would be supplied by the oxidation of

4600	grains of	carbon,
300	,,	nitrogen,
200	,,	hydrogen.

It must be carefully pointed out that there are two sources of waste in the muscles—the tissue units and the substances which are oxidised in the muscles.

This will be clearly understood by comparing the muscle to a gun. When a gun is fired, two things undergo waste in different degrees. The gun is wasted *slightly*, while the gunpowder is entirely consumed, and certain waste gases are produced which diffuse with the air. Similarly with the muscle. The tissue units, like the gun, only decay very slightly; but the circulating bodies in the immediate vicinity of the units are more or less entirely consumed, and the waste products excreted. The waste of the body may also be divided into nitrogenous and non-nitrogenous. The former is almost entirely represented by the very complex body urea $(NH_2)CO_2$, which is excreted with the urine.

That urea is a nitrogenous body may easily be proved by heating a little in a dry test tube and testing with red litmus paper. The litmus paper is turned blue, showing the presence of ammonia, a compound gas which is known to contain the element nitrogen.

The non-nitrogenous waste products are chiefly found as carbon-dioxide (CO_2), water (H_2O), and minute quantities of organic acids.

It is a very striking fact that the nitrogenous waste is very small when compared with non-nitrogenous waste, and this can only be explained by assuming that the nitrogenous compounds merely represent the slight wear and tear of the machine, while the non-nitrogenous may be regarded as the waste products of the fuel which is used. Another important fact connected with the waste of the body is that increased work only slightly augments the nitrogenous output, but largely increases the excretion of non-nitrogenous compounds. This was clearly proved by the experiments of Fick, to which reference in detail will be made in a future chapter. This would tend to support the theory that work may be largely the result of oxidation of the carbon and hydrogen in our food, the nitrogen acting as a repairer of the mechanism, and as an incentive to the combustion of the other bodies.

Finally, the waste products represent a large amount of energy which has been made manifest as heat and work.

Energy may be defined as the "capacity for doing work," and anything which has the power of performing work is said to possess energy. Inasmuch as work is done by bodies in motion, we may say that moving bodies possess *active* energy, while those bodies which are at rest, but capable of producing motion if placed in favourable circumstances, possess *potential* energy. A moving stream, a falling stone, a contracting muscle have active energy, while a coiled spring, confined steam, and coal possess potential energy.

The most perfect engine can only convert $\frac{1}{8}$ of the potential energy of heat into work, $\frac{7}{8}$ being lost as far as work is concerned, but in the body of man $\frac{1}{2}$ of the heat produced can be converted into actual work, while the remainder is used to maintain the normal temperature of the body.

CHAPTER III

FOOD AND ITS DUTIES

THE constitution of the body is such that it cannot assimilate as food simple compound bodies or elements, although the waste of the body may be represented by such compounds or elements. We cannot feed on the *nitrogen* contained in ammonia, the carbon of coal, or hydrogen as a gas. These elements must be supplied in some combined form suited to meet the requirements of the body, for the organs of digestion are totally incapable of assimilating such elementary substances. It is entirely different with plants. They are adapted to take in CO_2 from the air, and mineral matter from the soil in the form of comparatively simple compounds, and to elaborate from them many complex substances which serve as food for man. The wheat plant, for example, chiefly lives on carbon-dioxide, water, ammonia, potash, magnesia, and silica. From these simple compounds, which are totally unsuited for human food, the plant elaborates starch, gluten, sugar, and other substances, which are capable of performing in our bodies the functions required of food. Similarly the grass plant, living on allied elements or simple compounds, elaborates more complex compounds, upon which the ox and sheep live, and we, in turn, utilise the beef and mutton as food.

The food of man must be of a very complex composition, capable of being broken down by metabolism into simpler compounds. It is probable that no synthetical construction of food from elements takes place within the body, for there is every reason to conclude that the elaboration of fat and other substances within the body is brought about by changes taking place in ready-formed material of complex composition, such as albumin, protoplasm, or carbohydrates.

A great French physiologist has said that plants are "synthetical" feeders, while animals are "analytical" feeders, and this statement very tersely expresses the great difference between the modes of feeding in plants and animals, as generally understood.

Before we can ascertain whether a substance is a food or not, it is necessary to know something of the duties which a food performs in the body.

One of the first functions of food is to supply material for oxidation (*slow combustion*) in the tissues, in order to generate and maintain the heat of the body. The temperature of the body in health is always maintained at 98° F., summer and winter, and the necessary heat is produced in all the vascular tissues (*not exclusively in the lungs*) by the oxidation of the tissue units, and the bodies in their immediate vicinity.

Closely connected with the production of heat is the liberation of energy which enables us to do work.

Any organic substance to be classed as a food must contain potential energy, that is to say, energy which is locked up, and only waiting for favourable conditions to become active. The *muscles* are the leading organs which set free the potential energy of our food, and by their contractions we are enabled to perform work. The muscles may be compared to machines which liberate the stored-up force in the foods we eat. The energy for performing work, then, comes from food, and, as we shall point out in a future chapter, it is quite possible to calculate approximately the amount of work which a person can do on a given diet.

The various tissues of the body are constantly undergoing oxidation, and are therefore slowly wasting.

This waste must be made good, and the tissues reconstructed as fast as they are disintegrated. This duty devolves on the substances we use as food, and is a most important function. This only applies, however, to *existing* tissues; but we know that in growing animals *new* tissues are laid down. Fresh muscle fibres are developed, the bones increase in length, the brain grows larger, and the cells of the body are constantly undergoing "cell division," adding to the bulk of the organs of which they form the units. Materials for these constructions must be supplied over and above the amount required to renew the existing tissues, and the food we take efficiently performs this function.

All these duties of food may be described as general, but there are special duties which food performs at certain periods. The embryo requires nourishment, and more food must be taken during pregnancy in order to supply the requisite amount.

Lastly, the duty of supplying the materials to form the milk which sustains the infant falls upon food. When this fact is remembered, it will be seen how important it is that proper food should be partaken of at this period. Another important fact in connection with food should be stated, viz., that all the organic foods, and some of the inorganic foods, undergo a number of changes in the body, and it may be stated generally that if an organic substance passes through the body unchanged it is not a true food. These changes may be divided into—

(1) Those which take place in the digestive system; and
(2) Those of an oxidative character which take place in the tissues (muscles, etc.)

These changes will be fully dealt with in future chapters, and therefore may be passed over for the present. It is essential that it should be pointed out that although the various duties of food have been represented as being distinct, they are in reality performed more or less by all parts of the food eaten. In a meal, for instance, we cannot say that any particular part of the food *exclusively* supplies the force for performing work, or the materials for combustion. We must rather look upon the food as a whole replenishing the blood, and the blood supplying the tissues with the materials which they require. But for convenience we may summarise the duties of food as follows—

(1) To maintain the heat of the body.
(2) To supply the force for performing work.
(3) To renew wasting tissues.
(4) To supply materials to build up new tissues.
(5) To nourish the embryo.
(6) To supply the materials for the elaboration of milk.

We are now in the position to define a "food," and may say that "a food is a substance which is capable of performing any or all of the above functions."

Strictly speaking, no substance is entitled to be designated a food unless it is capable of fulfilling at least one of the duties enumerated in the above list, and in the examination of any food we must carefully ascertain how far it performs in a satisfactory manner any or all of these duties.

CHAPTER IV

GENERAL CLASSIFICATION OF FOODS—PROXIMATE PRINCIPLES AND THEIR USES

Food may be broadly divided into (1) Organic, (2) Inorganic.

The *organic foods* have generally either formed part of a living plant or animal at some time or other, or have been derived by artificial or other means from such animal or plant products. They all contain the element *carbon*, and with few exceptions have never yet been built up from their elements in the laboratory of the chemist. But it would be premature to limit in these days of scientific marvels the achievements of any science, and it is within the region of possibility that in the future many of our food stuffs may be manufactured from their elements, and thus render man independent of the coming time when the natural food supply of the world will be inadequate to sustain the human race.

The *inorganic foods* are those substances which do not contain the element carbon (exception, carbonates, which contain CO_2), and which are contained in all the foods we eat. They include the substances water and common salt, which are taken in separately from the other foods.

Physiologists find it convenient to divide the organic foods into—

(1) Nitrogenous.
(2) Non-nitrogenous.

This classification depends on the presence or absence of the element nitrogen, as the names imply.

The nitrogenous foods are further divided into

(*a*) Proteids.
(*b*) Gelatinoids.

The non-nitrogenous foods are also divided into—

(*a*) Fats and oils.
(*b*) Carbo-hydrates, or amyloids.

The inorganic foods are usually divided into—

(*a*) Water.
(*b*) Salts.

The following table gives this broad classification in a convenient form—

FOOD.

Organic
- (1) Nitrogenous—
  - (*a*) Proteids.
  - (*b*) Gelatinoids.
- (2) Non-Nitrogenous—
  - (*a*) Fats and oils.
  - (*b*) Carbo-hydrates.

Inorganic
- (1) Water.
- (2) Salts.

Proteids are those foods which are capable of renewing the wasting tissues, and include such bodies as albumin and casein. They are composed of the elements carbon, hydrogen, oxygen, and nitrogen, with sulphur and phosphorous in peculiar combination with the other constituents of the molecule.

Their chief function is, undoubtedly, to build up the wasting nitrogenous tissues; but they may, possibly, perform other functions in the economy.

It appears from recent experiments that proteids may be transformed into fat, or even into glycogen, and it is probable that the change is accompanied with a destructive metabolism of part of the proteid into the waste nitrogenous body urea. Where these downward oxidative changes and reconstructive actions take place is a matter of speculation, but the evidence appears to indicate the liver as one of the organs concerned.

It has also been proved by Lawes and Gilbert that proteid material directly increases the oxidative changes taking place within the body, and has, therefore, a stimulating effect on the metabolic organs.

No animal can live without proteid material, and some authorities explain this by assuming that the proteids are the bodies which initiate the other oxidations of the body, and are necessary for their continuance. The term "flesh formers," which was applied by Liebig to the proteids, is misleading, inasmuch as they perform other functions in the body. It is true that they repair the slight wear and tear of the muscles, but it is *not essential that the proteids should actually form part of the muscle* before they undergo oxidation.

If proteids are withdrawn from the diet the animal dies of "nitrogen starvation."

Gelatinoids are also composed of carbon, hydrogen, oxygen, and nitrogen, but they are unable to renew the wasting tissues. That is to say, they cannot alone reconstitute protoplasm. The experiments of the French Gelatin Commission proved that animals fed on fat, starch, and gelatin died of "nitrogen starvation," just the same as animals fed on fat and starch alone; but it was found that if gelatin were given, an animal could subsist on a smaller quantity of proteid than if no gelatin had been given. This would indicate that the gelatinoids shelter from oxidation the more important proteid constituents of the body, and are thus of some value as food if taken with proteid material.

Fats and Oils are primarily concerned in the production and maintenance of animal heat. Their composition shows that they are highly oxidisable compounds, consisting as they do of carbon, hydrogen, and oxygen, the two former elements preponderating.

This will be readily understood from the following formulæ of some of the common oils derived from fat—

Stearin $C_{57}H_{110}O_6$.
Palmitin $C_{51}H_{98}O_6$.
Olein $C_{57}H_{104}O_6 + 3H_2O$.

It is probable that part of the fat oxidised in the body not only produces heat, but supplies some of the force for performing work. Fats and oils have the highest heat-producing powers of any foods; hence we find that the colder the country the larger the proportion of fat which finds a place in the diet. But fat has other important duties to perform in the body. It is stored up in the cavities and depressions between muscles, whereby it gives a roundness and grace to the figure. Besides this, it greatly facilitates the movements of parts one on the other by reducing friction, and minimises the effect of jars by its elasticity. The layer of adipose tissue which is found beneath the skin, owing to its non-conducting powers, checks the loss of heat. Most important are the effects of fat or oil on the intestinal tract. It has been ascertained that a certain amount of fat or oil is essential to the healthy action of the bowels, and often severe constipation is produced by a deficiency of it. Not only does it favour peristaltic contraction, but by lubricating the intestinal walls it may facilitate the absorption of other foods.

The following experiment clearly supports the view that the presence of fat in the intestinal tract facilitates the absorption of food.

A gentleman undertook to live for three weeks on fine whole-meal bread and water, and for three succeeding weeks on whole-meal bread and *butter* plus water.

The appended tables[1] give the average weight in ounces per diem ingested and excreted in the fæces during each period—

[1] The tables in this work are given in English weights for the benefit of the general reader. If it be desired to convert them into French measures (grams, etc.), the data given in the Appendix will render it an easy task.

First Period.

	Ingested.	Excreted.
Proteids and Peptones .	5·31	1·23
Carbo-hydrates . .	21·61	1·31
Fat	·61	·21
Fibre	·91	·91
Mineral matter . .	·73	·36
	29·17	4·02

Bread and water only allowed.

Second Period.

	Ingested.	Excreted.
Proteids and Peptones .	5·48	·55
Carbo-hydrates . .	21·73	1·23
Fat	2·73	·23
Fibre	·92	·92
Mineral matter . .	71	·41
	31·57	3·34

Besides whole-meal bread and water, 2 ounces of pure butter were allowed.

The same kind of bread was used throughout.

In the first period the waste averaged 13·7 per cent.

In the second period the waste averaged 10·0 per cent.

There was thus an absorption of 3·7 per cent more food in the latter period than in the first period. This increased absorption the author believes was due to the action of the milk fat on the villus coat of the intestines.

The influence of the fat on the absorption of peptones must be very considerable, seeing that the proteid waste was reduced by 50 per cent.

Carbo - Hydrates are compounds consisting of carbon-hydrogen and oxygen, but they differ very much from the fats, inasmuch as they contain a smaller percentage of carbon, and the hydrogen and oxygen always exist in the proportion to form water. They may be regarded, as their name plainly indicates, as carbon combined with water.

A few examples will make the constitution of these bodies clear.

Starch, which is a carbo-hydrate, may be considered to have the simple formula of $C_6H_{10}O_5$. Now this may be written $C_6(H_2O)_5$; that is to say, six *atoms* of carbon combined with five *molecules* of H_2O (water). Similarly, maltose may be written $C_{12}(H_2O)_{11}$, and any carbo-hydrate may be split up in the same way. Like the fats and oils, the carbo-hydrates are concerned in the production of animal heat, but they do not possess such great heat-giving powers. This is easily explained when we consider that the amount of carbon is comparatively small, and that there is no hydrogen available for oxidation by the inter-molecular oxygen of the tissues, owing to the fact that the hydrogen is already "fixed" by the oxygen which forms part of the carbo-hydrate molecule.

The carbo-hydrates also largely supply the materials for muscular energy.

Drs. Fick and Wislicenus, of Zurich, and Drs. Parkes and Pavy, of England, have conclusively shown that the urea excreted is no measure of work done. They found that muscular exertion increased the excretion of CO_2, and that the urea did not increase to such an extent as would have been the case, supposing that all the energy had been derived from the metabolism of the muscle itself. These facts would lead to the conclusion that in the muscle non-nitrogenous bodies like fat and carbo-hydrates are oxidised to supply the necessary force for the contraction of the muscle.

There is a certain amount of evidence to show that excess of carbo-hydrate material may be converted into fat,—but how and where in the body has not yet been ascertained.

It is impossible for an animal to live on fats and carbo-hydrates alone, for under such conditions the body loses weight, the digestive organs cease to do their work, and the animal soon dies from a want of nitrogen.

Water is mainly concerned in the solution of the food, and the conveyance of the soluble matter by means of the blood to the various tissues. It also dissolves effete matters and conveys them from the body. The evaporation of water from the skin is the chief means of equalising the temperature of the body.

Salts.—Little is known about the functions of the various salts found in our foods. The fact that an animal falls into ill-health when deprived of mineral matter shows conclusively that its presence is closely connected with the nutrition of the body. The most important mineral bodies are common salt, and salts of potash, iron, lime, and magnesia.

The *rôle* of *common salt* has not yet been ascertained. Some authorities maintain that it plays an important part in *osmosis,* while others suggest that part may help to form the hydrochloric acid of the stomach. Whatever its functions may be, it is the most important salt, for it is found in every fluid and organ of the body.

The *potassium salts* greatly predominate in the corpuscles of the blood and in muscles. Kemmerich found that a dog deprived of potash soon became feeble and emaciated, but could offer no satisfactory explanation why it did so. Some physiologists state that the potash salts act as normal stimulants to the heart, increasing the force of its beat.

Iron is found in the red corpuscles, and is supposed to be intimately connected with their oxygen-carrying power.

Lime is found chiefly in the bones and teeth, and it is probable that the lime salts in our foods are used to replace those which are absorbed and excreted.

Phosphates no doubt replace the amount which is excreted from the brain and nerves, as well as that which is removed from bone by absorption.

Phosphate of lime is largely concerned in cell growth and tissue metamorphose.

There is one important point which must not be overlooked, viz., that the body can only readily assimilate the salts when they form *part of the actual food,* or have been derived from actual foods. It appears that salts direct from the mineral kingdom do not enter the tissues so readily, nor do they perform the functions required of them so efficiently as the salts which are present in the foods.

CHAPTER V

FOOD STUFFS

THE term "Food Stuffs" is applied to the *special* proximate principles which are found in the various foods. There are many varieties of proteids, for instance, each one of which is called a food stuff, and is known by a special name. The same is true of the carbo-hydrates, fats, and salts. The following table gives the names of the more important food stuffs in a convenient form—

FOOD STUFFS.

I.—Proteids.

	Food Stuff. Whence Obtained.	
Animal.	Albumin—Lean meat, milk.	These all contain nitrogen.
	Syntonin—Lean meat.	
	Myosin—Lean meat.	
	Fibrin—Lean meat.	
	Casein—Milk, cheese.	
Vegetable.	Legumin—Peas, beans, lentils.	
	Gluten—Wheat, oats, rye.	
	V. Albumin—Wheat, oats, rye.	

2.—Gelatinoids.

Animal.	Gelatin—By boiling bones and hoofs.	All contain nitrogen.
	Keratin—By boiling horns.	
	Chondrin—By boiling cartilage.	

3.—Carbo-hydrates.

Animal.	Lactose—Milk.
	Glycogen—Liver and muscles.
	Inosite—Heart.
Vegetable.	Starch—In nearly all plants and cereals, potato, sago, tapioca, arrowroot, white bread, rice.
	Dextrose—Fruits and sweet vegetables.
	Maltose—Cereals, bread.
	Sucrose—Sugar-cane.
	Dextrin—Cereals.

4.—Fats and Oils.

Animal and Vegetable.	Palmitin—Mostly present in vegetable oils and fats; also in animal fats. Stearin—Rarer in vegetables; largely present in mutton fat. Olein—Forms the liquid fats.

5.—Mineral Matter.

Animal and Vegetable.	Potash. Soda. Lime. Iron. Magnesia. Sulphuric acid. Hydrochloric acid. Phosphoric acid.	In all foods.

We are immediately concerned with the food stuffs present in *bread*, or which result from its digestion. They are starch, dextrose, maltose, dextrin, gluten, albumin, fat, and the various salts.

Starch is very widely distributed through the vegetable kingdom, occurring in all green plants. It is found in the form of small bodies, called "starch grains," which are stored up in various parts of the plants. It is largely present in tubers, seeds, and in some stems. The starch grains are usually found enclosed in small cells, the walls of which are formed of a substance termed cellulose.

Starch grains vary exceedingly as to shape and size, according to the plant from which they are taken. The starch grains are formed within the chlorophyll bodies of plants. They first appear as exceedingly minute bodies of a spherical form. As

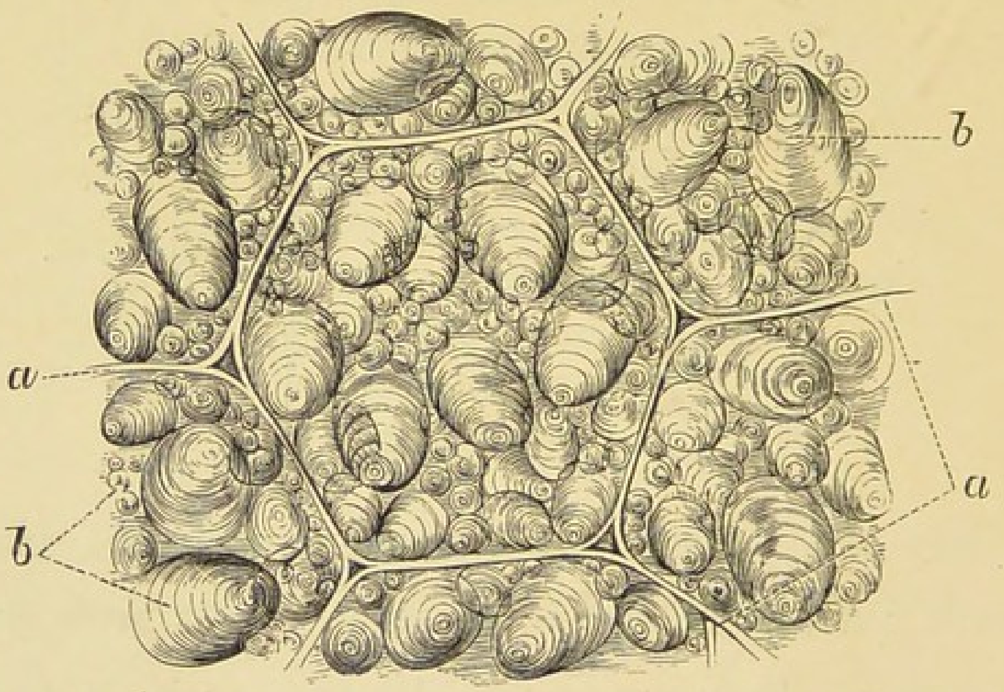

Fig. 1.—Section of Potato showing Starch Granules *in situ.* *a*, walls of cellulose cells ; *b*, starch grains.

they grow they assume a more characteristic shape, peculiar to the plant to which they belong. Under the microscope they appear to be made up of a number of layers, surrounding a portion termed the *hilum*.

The formation of starch can only take place in the presence of light. During darkness the fully-formed starch becomes soluble, and circulates to the parts of the plant where it is to be stored for the purpose of future use.

Some starch grains, when examined under polarised light, have the appearance of being composed of a "skeleton" surrounded by another substance, and chemical analysis would seem to point to the

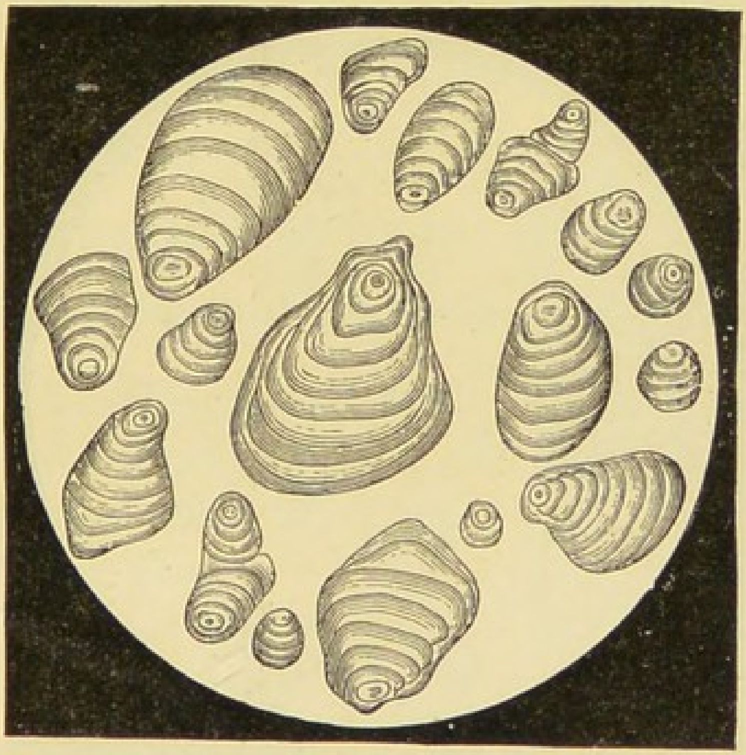

Fig. 2.—STARCH GRANULES FROM THE POTATO, SHOWING THE HILUM AND LAYERS. (Multiplied 300 diameters.)

conclusion that the starch grain is really composed of two distinct bodies. It is thought by some that the grain is made up of two substances termed *granulose* and *farinose*, the latter corresponding to the "cross" or "skeleton" which appears under polarised light. But more recent researches by

Naegeli and A. Meyer point to the conclusion that the starch grain is composed of—

(1) Dextrin.
(2) Amylodextrin.
(3) True starch.

It appears that *farinose* or starch cellulose has no existence in fact.

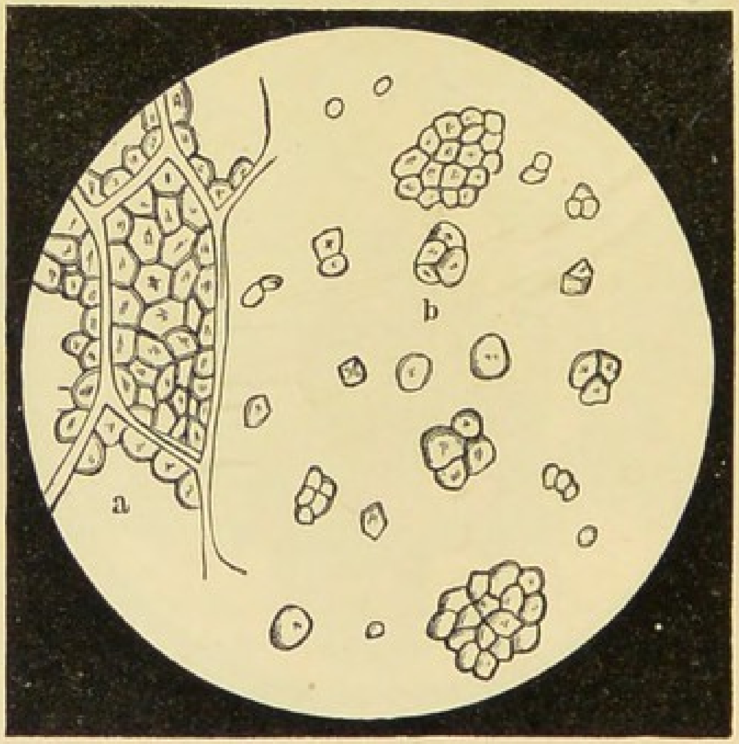

Fig. 3.—Starch Granules from Rice. *a*, part of grain showing the grains *in situ*; *b*, isolated grains. (Multiplied 300 diameters.)

The chemical elements present in starch are carbon, hydrogen, and oxygen, and it is isomeric with many other bodies. Its formula may be written $C_6H_{10}O_5$. The characteristic test for starch is a solution of iodine in potassic iodide, which gives an indigo-blue coloration when added to it.

Wheat Starch may be obtained for examination by cutting through the grain and gently scraping the central portion over a glass slip. It appears as two distinct kinds of grains—

(1) Small spherical or angular grains.
(2) Large lenticular grains.

The former are very minute, averaging about $\frac{1}{5000}$ of a inch in diameter. The larger grains average about $\frac{1}{900}$ to $\frac{1}{1000}$ of an inch in diameter. The following table gives the results recently obtained in some common wheats—

Treadwell wheat—largest		$\frac{1}{860}$	of an inch.
Wicks wheat	"	$\frac{1}{890}$	"
Russian wheat	"	$\frac{1}{1150}$	"
Vienna flour	"	$\frac{1}{865}$	"
Egyptian wheat	"	$\frac{1}{990}$	"
Schaffer wheat	"	$\frac{1}{1000}$	"
Treadwell wheat—smallest		$\frac{1}{6100}$	of an inch.
Russian wheat	"	$\frac{1}{4000}$	"
Vienna flour	"	$\frac{1}{5160}$	"
Egyptian wheat	"	$\frac{1}{6000}$	"
Schaffer wheat	"	$\frac{1}{4680}$	,

The hilum is usually central, and the concentric layers are not easily seen. Notwithstanding the assertions of many botanists that the "cross" may be distinctly seen in wheat starch grains, the writer has never been able to detect its presence satisfactorily. The only appearance which he has seen resembling in any way the well-defined "cross" of the potato starch granule is a shadow which floats over the whole grain.

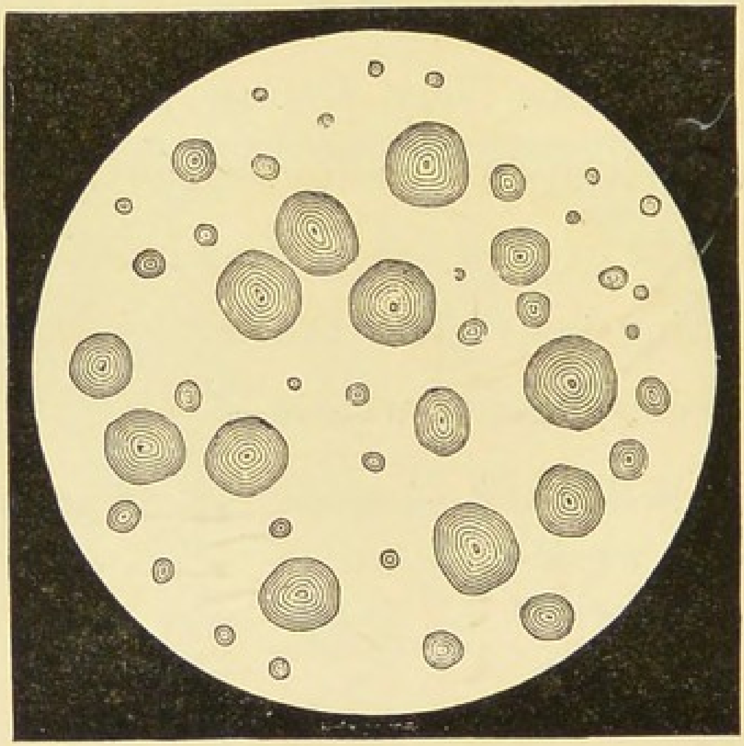

Fig. 4.—Starch Granules from Wheat. (Multiplied 300 diameters.)

Starch is insoluble in cold water, but it may be converted into soluble dextrin by heating to about 150° C., or by acting on it with a ferment. Starch may also be converted into sugar by heating with dilute sulphuric acid, or by subjecting it to the influence of any of the amylolytic ferments, such as diastase or ptyalin.

Recently, two kinds of starch have been isolated from flour, to which the names a.-amylan and b.-amylan have been given.

Rye Starch grains are larger than those of wheat, and very seldom show the laminated appearance. Usually a star-shaped nucleus is visible. The grains vary in size from $\frac{1}{730}$ of an inch to $\frac{1}{5700}$ of an inch in diameter.

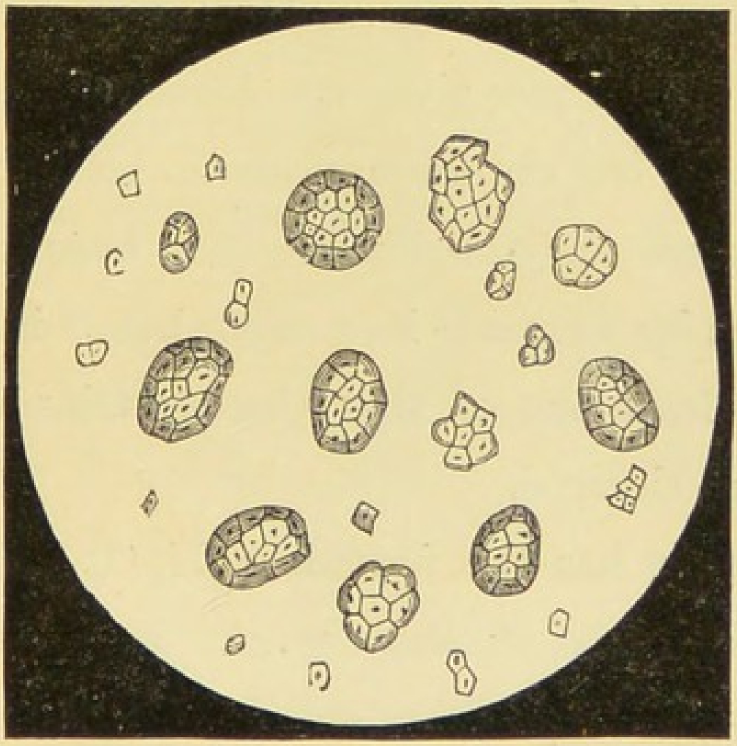

Fig. 5.—Starch Granules from Rye. (Multiplied 300 diameters.)

Dextrin ($C_6H_{10}O_5$) is isomeric with starch; that is to say, it has the same chemical composition, but differs in its reactions and physical properties. Iodine solution gives, with dextrin, a port-wine colour, which disappears on heating, and does not return on cooling.

It is soluble in water, but precipitated by alcohol, and is changed into sugar by the action of dilute acids and ferments.

Many varieties of dextrin are known to exist, formed by the action of acids or ferments on ordinary starch or dextrin.

The two most important are described by Brücke, and named respectively *erythrodextrin* and *achroodextrin*. The former gives the characteristic reaction with iodine, but the latter gives no colour with the test reagent. Erythrodextrin, it is stated, may be converted by ferments into sugar, but it is believed that at least one of the achroodextrins does not become so changed.

Dextrose has the formula $C_6H_{12}O_6$. It is also known as *glucose* or *grape sugar*. Pure dextrose is colourless, and crystallises out into hexagonal prisms. It is soluble in water, but may be precipitated by ammonic hydrate and acetate of lead.

The characteristic test for dextrose depends upon its reducing power. The best solution is Fehling's or Pavy's, which, on being added to a hot solution of dextrose, yields a bright red precipitate of cuprous oxide.

A characteristic property of dextrose is the power of undergoing fermentation when subjected to the action of yeast, and certain forms of bacteria. The change produced may be represented as follows—

$$C_6H_{12}O_6 \text{ breaks up into } 2C_2H_5HO + 2CO_2\,;$$

that is to say, under the action of yeast a sugary solution will split up into alcohol with the liberation of CO_2 (carbon-dioxide). Other bodies are produced in minute quantities—viz., glycerin, alcohols of the acetic series, and succinic acid.

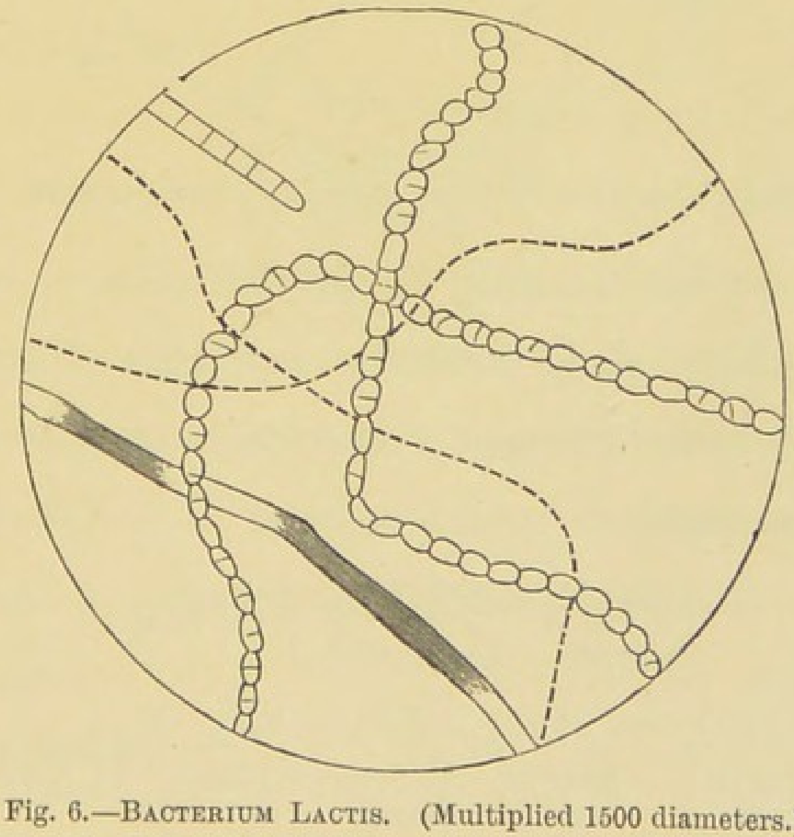

Fig. 6.—Bacterium Lactis. (Multiplied 1500 diameters.)

The dextrose may also be converted into lactic acid by action of the *bacterium lactis.*

Under the influence of another specific ferment (*bacillus subtilis*, or, as some bacteriologists affirm, the *bacillus amylobacter*) a different fermentation

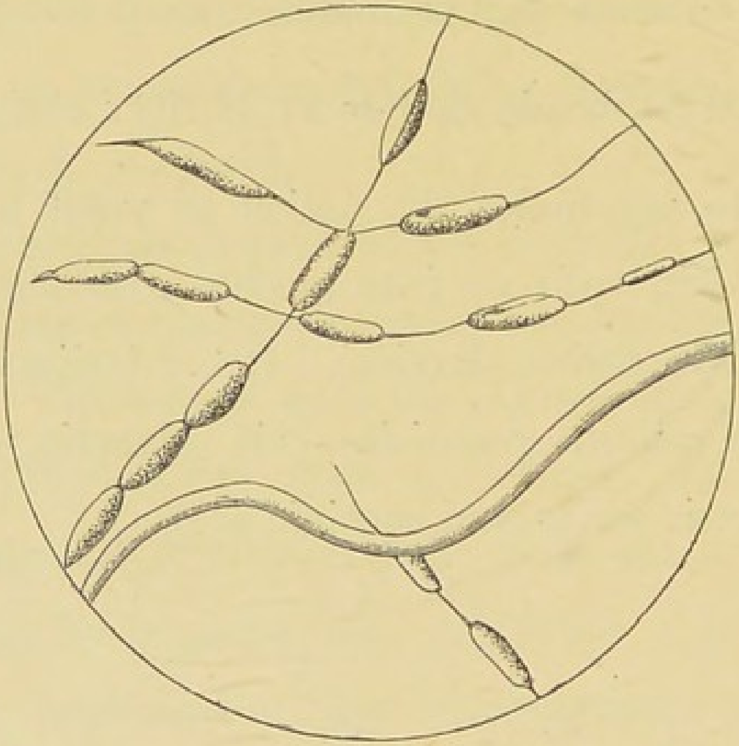

Fig. 7.—Bacillus Subtilis. (Multiplied 3500 diameters).

may be set up, resulting in the formation of butyric acid (a fatty acid) with the evolution of carbonic acid and free hydrogen. The stages may be represented as under—

$$\underset{\text{Dextrose.}}{C_6H_{12}O_6} = \underset{\text{Lactic acid.}}{2C_3H_6O_3} \quad \Big\} \textit{1st Stage.}$$

$$\underset{\text{Lactic acid.}}{2C_3H_6O_3} = \underset{\text{Butyric acid.}}{C_4H_8O_2} + \underset{\text{Carbon-dioxide.}}{2CO_2} + \underset{\text{Hydgn. gas.}}{2H_2} \quad \Big\} \textit{2d Stage.}$$

Maltose ($C_{12}H_{22}O_{11}$) was first noticed by Dubrunfaut, and afterwards described by O'Sullivan. It crystallises in acicular crystals, but does not reduce Fehling's solution so readily as dextrose. It is capable of undergoing the alcoholic fermentation. It is produced by the action of malt diastase on starch, and probably during the digestion of starch in the mouth.

Gluten is a nitrogenous body present in nearly all cereals. It may be obtained from flour by washing in a muslin bag. The starch is removed by the running water, and the gluten remains behind in the bag. This crude substance is a mixture of three or four distinct bodies, to which the following names have been given—

(*a*) Gluten casein.
(*b*) Gluten fibrin.
(*c*) Mucedin.
(*d*) Gliadin.

It is very tenacious and sticky, and may be drawn out into strings. It is this property which renders it so valuable in bread-making. A combustion of the mixed glutens gave the following result—

Carbon	52·8
Hydrogen	6·9
Nitrogen	16·8
Oxygen	21·7
Sulphur	1·8
	100·0

Gluten is quite insoluble in water, but may be converted into a soluble form known as *peptone* by the action of certain ferments.

The **Albumin** of flour differs from gluten in its physical properties, being soluble in water. It does not materially differ in composition from gluten. On being heated, the albumin is so changed that it becomes insoluble.

It has been already stated that food has *potential* energy which is set free by the body: it remains now to point out the comparative amount of energy derivable from the various food stuffs which we have been considering. It must be clearly understood that the figures do not convey accurately the amount of energy which the human body derives from the various food stuffs, for it is by no means certain that the metabolism of the body is identical with simple oxidation outside it. But it gives us the comparative value of the bodies experimented on.

1 oz. of dry gluten	yields	174	foot-tons.
1 oz. of dry starch	„	135	„ „
1 oz. of dry maltose	„	122	„ „
1 oz. of dry fat	„	378	„ „

(*Frankland*).

The table indicates that, by complete oxidation of

1 oz. of dry gluten, enough heat would be produced to raise 174 tons one foot from the ground; similarly with starch, etc.

CHAPTER VI

THE DIGESTION OF FOOD

MOST of the foods we eat are *insoluble*, that is to say, they will not pass through a moist animal membrane. Nothing can enter the blood stream unless it be in such a condition as to easily pass through the thin walls of the capillaries. Such being the case, we can easily understand that primarily the energies of the digestive system are directed to the task of rendering insoluble substances soluble. Starch, albumin, gluten, casein, etc., cannot be absorbed by the blood unless they undergo such changes as will enable them to penetrate the delicate envelopes of the small blood vessels. The parts of the body which are specially concerned in rendering the said bodies soluble are known as the organs of digestion, and the whole group of these organs is termed the digestive system. The changes in the food are brought about by certain fluids containing special ferments. These are called the digestive juices.

The digestive system may be regarded as a long tube with certain dilatations, into which the digestive juices are poured. The food is forced along this tube by the contraction of involuntary muscle fibres. They will respond to chemical and mechanical stimuli, so that certain drugs and hard particles increase the "peristaltic contraction," as it is called, and so hurry the food along. The natural stimuli to these muscles include—

(1) The bile.
(2) The food itself.
(3) The nervous impulses transmitted by the nerve plexuses related to the canal.
(4) The blood supply.

The nervous arrangements have been most thoroughly worked out in the case of the intestines. It appears that there are special nerve centres residing in the walls of the bowel which generate the nervous impulses, causing the muscles to contract. It may be easily understood, in such a case, how hard bodies such as the skins of fruits, nuts, or bran, increase the activity of the bowels, for they act as mechanical stimuli to the ganglionic nerve centres, if not to the muscles directly.

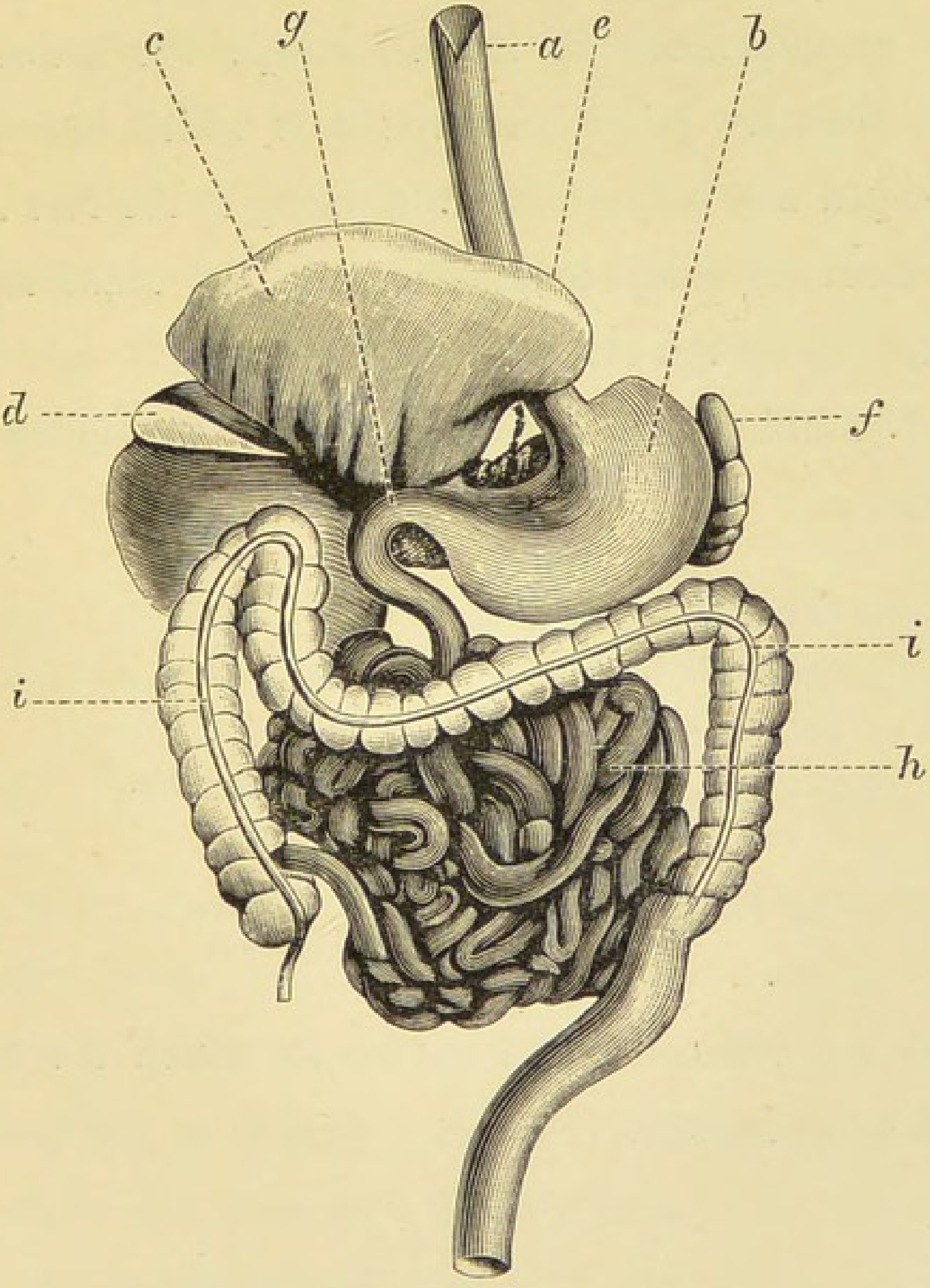

Fig. 8.—THE DIGESTIVE SYSTEM. *a*, gullet; *b*, stomach; *c*, liver; *d*, gall bladder; *e*, pancreas; *f*, spleen; *g*, duodenum; *h*, small intestines; *i*, colon.

As the food passes along the alimentary canal it mixes with the fluids from various glands, and the insoluble substances are converted into soluble bodies. The latter are absorbed by the minute blood-vessels. It will be clear that if the food passes along *too rapidly* much of it will escape the action of the digestive juices, and that part which has been changed will be partially lost, owing to the fact that it does not tarry long enough in the canal to be taken up by the blood.

The alimentary canal consists of the following parts—

(1) Mouth.
(2) Gullet.
(3) Stomach.
(4) Small Intestines { (*a*) Duodenum. (*b*) Ileum.
(5) Large Intestines { (*a*) Colon. (*b*) Rectum.

And we will consider the changes which the food undergoes in each.

Digestion in the Mouth.

When food is introduced into the mouth it is reduced by the teeth to a very fine state of division. This reduction is facilitated by the spittle or saliva mixing with the food as it is masticated. The chief use of saliva is a mechanical one, viz. to enable a bolus to be formed for the purpose of swallowing. Too much importance cannot be placed on this division of food in the mouth, for, as we shall see, the rapidity of digestion in the stomach and intestines depends largely on the *size of the food particles.* Saliva is secreted by three pairs of glands situated in the mouth. The names of the glands are—

(1) The parotid glands situated beneath the ears.
(2) The sub-maxillary glands, situated beneath the lower jaw bone.
(3) The sublingual, situated beneath the tongue.

The saliva from each pair of these glands has its own characteristics, but the secretions all blend in the mouth to form "mixed saliva." Mixed saliva is a transparent or slightly turbid fluid, consisting chiefly of water and mucus. It is alkaline in reaction. On being allowed to stand it deposits a slight sediment.

Frerichs gives the following analysis of human saliva—

COMPOSITION OF MIXED SALIVA.

Water	99·410
Mucin	·213
Ptyalin	·142
Carbonate of calcium, Alkaline chlorides, Phosphate of calcium, Phosphate of magnesium, Sulpho-cyanide of potassium	·229
Unaccounted for	0·006
	100·000

From the above table it will be seen that in 100 ounces of saliva there is only about half an ounce of solids.

Although the chief function of saliva is probably a mechanical one, yet it acts chemically on starch. The constitutent which does this is ptyalin, a peculiar nitrogenous body belonging to the class of unorganised ferments. We shall have occasion to speak very often of these ferments, so it will be as well to devote a few lines to the consideration of them.

Most of my readers are acquainted with the action of yeast in producing fermentation in sugary solutions. But this fermentation is brought about by an organised living structure, which breaks up certain constituents in the medium in which it floats, in order to obtain its food. The fermentation under consideration is quite of a different nature.

There are certain nitrogenous bodies known to physiologists which have the power of changing bodies without *undergoing any change themselves.* These ferments are known as *unorganised* ferments, and it is believed that they produce the changes in the bodies in contact with them, by causing the molecules to take up water and undergo deduplication. The ferments are for this reason often spoken of as "hydrolytic ferments."

Ptyalin belongs to the class of hydrolytic ferments, and has the power of converting starch into sugar.

The whole series of changes which take place when ptyalin is mixed with starch are not known with any degree of certainty, but it appears that the starch is first converted into dextrin, and finally into sugar.

It is probable that two or three varieties of dextrin are produced. It is generally stated that dextrose only is formed as a final product, but there are reasons for believing that maltose is chiefly produced, with a small quantity, if any, of dextrose.

This action of ptyalin is quite comparable to the action of diastase on starch during the germination of a seed.

Some authorities represent the change as follows—

$$\left.\begin{array}{lcl} \underset{\text{Starch.}}{C_6H_{10}O_5} + \text{Ptyalin} & = & \underset{\text{Dextrin.}}{C_6H_{10}O} \end{array}\right\} \text{1st Stage.}$$

$$\left.\begin{array}{lcl} \underset{\text{Dextrin.}}{C_6H_{10}O_5} + \underset{\text{Water.}}{H_2O} & = & \underset{\text{Sugar.}}{C_6H_{12}O_6} \end{array}\right\} \text{2d Stage.}$$

But there is every reason to believe that the change is so complicated that it cannot be represented by a simple equation.

Küss gives the following as the change—

$$\left.\begin{array}{lcl} \underset{\text{Starch.}}{2C_6H_{10}O_5} + \text{Ptyalin} & = & \underset{\text{Dextrin.}}{2C_6H_{10}O_5} \end{array}\right\} \text{1st Stage.}$$

$$\left.\begin{array}{lcl} \underset{\text{Dextrin.}}{2C_6H_{10}O_5} + \underset{\text{Water.}}{H_2O} & = & \underset{\text{Maltose.}}{C_{12}H_{22}O_{11}} \end{array}\right\} \text{2d Stage.}$$

But even this does not represent the change accurately, for two or three varieties of dextrin are formed. Further, all the starch does not reappear as sugar.

Taking into consideration the recent researches of Messrs. Brown, Heron, and Morris on the molecular constitution of starch and dextrin, the following provisional statements may be made with regard to the "ptyalasis" of starch.

(1) It is probable that no dextrose is formed.
(2) It is almost certain that the final products are maltose and a stable achroodextrin.
(3) The action may be divided into three stages, as indicated below.

1st Stage. — The starch under the action of ptyalin in the presence of water splits up into—

(*a*) Erythrodextrin.
(*b*) Maltodextrin (a combination of maltose with a dextrin).

2d Stage.—In this stage there is a simultaneous formation of—

(1) Maltose.
(2) Maltodextrin ; and
(3) Achroodextrin (*a*).

3d Stage.—The formation of the stable achroodextrin which remains unchanged, and the maximum quantity of maltose. The changes may be represented in tabular form, as shown below—

1. Starch + Ptyalin and water		=	Erythrodextrin. Maltodextrin.
2. Erythrodextrin +	Ptyalin and water	=	Achroodextrin (*a*). Maltodextrin.

3. Maltodextrin	+	Ptyalin and water	=	Maltose.
4. Achroodextrin (*a*)	+	Ptyalin and water	=	Achroodextrin (*b*). Maltodextrin.
5. Maltodextrin	+	Ptyalin and water	=	Maltose.
6. Achroodextrin (*b*)	+	Ptyalin and water	=	Achroodextrin (*c*). Maltodextrin.
7. Maltodextrin	+	Ptyalin and water	=	Maltose.

8. Achroodextrin (*c*) remains unchanged.

The actions indicated by Nos. 2 to 7 probably go on more or less simultaneously.

Ptyalin acts very slowly on raw starchy foods. The reason of this is, that the starch grains are enclosed in cells with cellulose walls, which cannot be dissolved by the saliva. By the action of heat the cell walls may be burst, and thus the cooked food is more easily acted on. Dextrin is converted into sugar with greater rapidity than starch, and is thus more digestible. It is probable that only a small quantity of starch is digested in the mouth, but this quantity, small though it may be, is of great value, for it is quickly absorbed in the stomach, and possibly increases the activity of the peptic cells.

The action of ptyalin can only go on in the presence of an *alkaline* solution. The presence of even a small quantity of acid arrests the conversion of starch into sugar. The bearing of this on the digestion of bread will be alluded to in a future chapter. Recent researches tend to show that *minute* quantities of certain organic acids, such as lactic, butyric, and acetic, may favour the action of ptyalin.

The following conditions are favourable to the action of ptyalin :—

1. An alkaline reaction of the saliva.
2. A temperature of about 40° C.
3. Starch which has been subjected to heat.

The following circumstances either retard or destroy its action :—

1. The presence of a free acid.
2. A low temperature.
3. The presence of a large quantity of dextrose or maltose.

Proteids are not acted on by saliva, nor are the fats changed. But it dissolves any salts which are soluble in an alkaline solution, as well as such bodies as cane sugar.

The changes which the food undergoes in the mouth may be summarised as follows:—

1. Food is mechanically reduced.
2. Starch is changed into sugar.
3. Soluble substances are dissolved.
4. Salts which are soluble in an alkaline solution are dissolved.

CHAPTER VII

DIGESTION IN THE STOMACH

THE bolus of food which is formed in the mouth is passed through the pillars of the *fauces* into the *pharynx,* and from thence into the *œsophagus,* or gullet. The bolus is then forced down the gullet by peristaltism, brought about chiefly by the successive contraction of the annular muscles of the gullet. The œsophagus dilates just beneath the diaphragm to form a large bag termed the *stomach.* This organ consists of three layers of muscle fibres, which are concerned in bringing about the movements which characterise the stomach, and an inner layer consisting of two coats, in which are found the gastric glands, and a rich plexus of blood capillaries. When the stomach is empty, the inner lining known as the *mucous membrane* has very little blood, and is consequently pale in colour. On the advent of food,

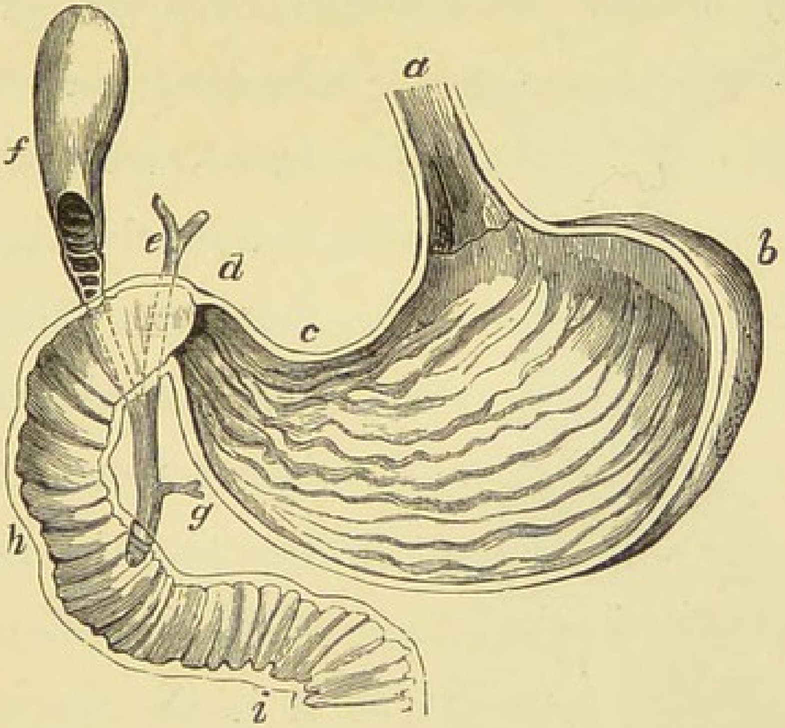

Fig. 9.—STOMACH AND PART OF DUODENUM. *a*, gullet; *b*, cardiac end; *c*, pyloric end; *d*, sphincter muscle; *e*, hepatic duct; *f*, gall bladder with cystic duct; *g*, pancreatic duct; *h*, *i*, duodenum.

however, nervous action is set up, by means of which the blood-vessels dilate, and the mucous membrane becomes deep red in colour; in fact, it "blushes." At the same time the numberless gastric glands are stimulated to activity, and they pour out from their mouths an acid secretion termed the gastric juice. Simultaneously the muscle coat contracts, and the food is forced from one end of the stomach to the other in a double stream, and is thus thoroughly mixed with the gastric juice.

The **Gastric Juice** is secreted by the gastric glands of the stomach. These glands are composed of very minute cells, which have the power of forming the secretion by processes which are not yet thoroughly understood. The formation of the gastric juice is not merely a selective filtration from the blood, as is often stated: it is the result of the extensive metabolism of the protoplasm which forms the cells. The glands may be compared to a number of tubes in the membrane of the stomach, each surrounded by a rich plexus of minute blood vessels.

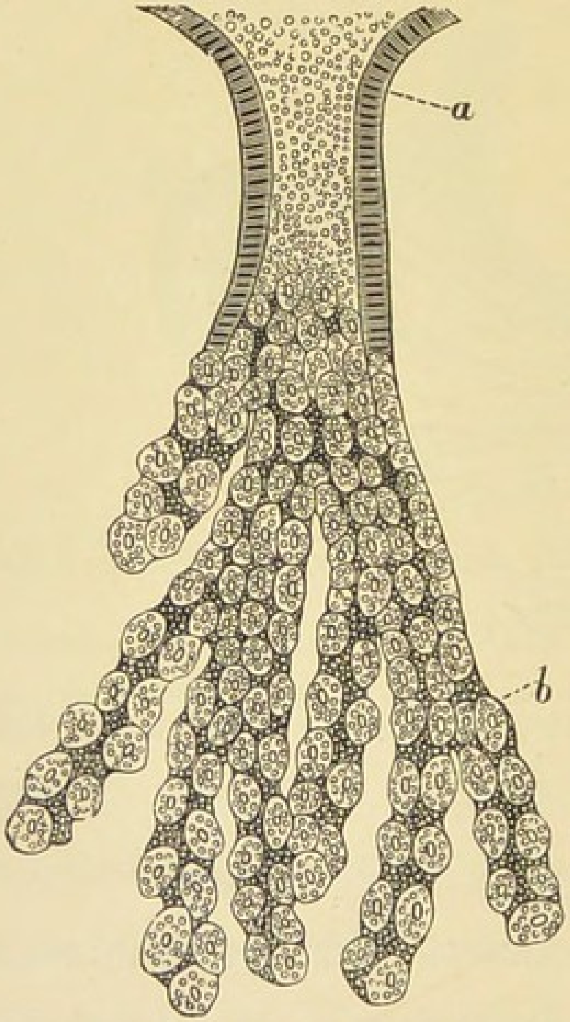

Fig. 10.—GASTRIC GLAND.
a, neck of gland showing columnar cells; *b*, deeper portion showing granulated, nucleated peptic cells.

There is great difficulty in obtaining what may be considered as normal gastric juice, for there are many circumstances which obscure its properties when obtained by artificial means. But all observers are agreed that it is a limpid, colourless fluid, with a sour taste, and an odour like old vinegar. When examined microscopically it does not show any well-marked histological structures.

The reaction with litmus is decidedly acid, and is due, except in certain exceptional cases, to the presence of free hydrochloric acid.

The most important organic constituent is a nitrogenous unorganised ferment named *pepsin*. This body is something like ptyalin of saliva, inasmuch as it has the power of converting certain insoluble bodies into soluble substances, without undergoing any material change itself.

The chief salts of gastric juice are common salt and various phosphates.

The following is an analysis of human gastric juice, but the results must only be regarded as approximately correct:—

ANALYSIS OF GASTRIC JUICE (Man).

Water . .	99·440	= 100 parts.
Total Solids . .	·560	

Pepsin, etc. .	·319	Solids in 100 parts.
Common salt .	·146	
Other chlorides .	·061	
Free acid . .	·020	
Phosphates. .	·012	
Unaccounted for.	·002	

It is believed that the pepsin and hydrochloric acid are elaborated by different cells in the same gland.

Action of Gastric Juice on Food.

Gastric juice probably soon arrests the conversion of starch into sugar by ptyalin, for the free inorganic acid destroys the action of the amylolytic ferment of saliva. It does not act on starch, so that this food stuff remains partially or wholly undigested in the stomach.

The special function of gastric juice is to convert the *insoluble* proteids (albumin, gluten, etc.) into *soluble* bodies known as peptones.

This change is brought about by the ferment pepsin, in conjunction with the free acid. It appears that pepsin cannot efficiently produce this result without the help of the latter.

Peptones are distinguished from the proteids by their extreme solubility, being with difficulty precipitated from their aqueous solutions. They are highly diffusible, passing rapidly and easily through a moist animal membrane.

The action of gastric juice on *gluten* deserves a more detailed consideration.

In some experiments which were performed by the writer in 1889, it was shown that *raw* gluten was most rapidly and completely converted into peptone, nearly the whole of the gluten reappearing in the soluble form. Cooked gluten was not so quickly digested. In the former case the glutinous matter rapidly cleared, but in the latter the conversion into peptone was not completed until a considerable time after the raw gluten had been so changed.

Gluten casein and gluten fibrin were more easily reduced than the other varieties, *especially when they had been cooked with starch.*

Gelatin is dissolved by gastric juice and converted into gelatinoid peptone.

Gastric juice has no solvent action on fat, nor does it emulsify to any great extent. But it performs a most important function in preparing the fat for intestinal digestion. The pieces of fat are held together by connective tissue, which is converted into gelatin during the process of cooking. The gelatin is dissolved by the gastric juice, and the fat is thus disintegrated. Further, the fat cells are surrounded by an albuminous, or, in the case of cream, a caseinous envelope, which encloses the oil. These proteid walls are dissolved in the stomach, and the oil is thus set free, floating on the surface of the contents of the stomach.

A by-product is produced during the digestion of the proteids, which resembles acid albumin. This is known as para-peptone, and may be digested in the intestines.

The action of gastric juice on milk must be described. There is a special ferment termed "the rennet ferment," which curdles the milk into curds and whey. It is especially present in the stomachs of infants and children.

Bulk is a very necessary element in digestion in the stomach. It has been ascertained that animals do not live a healthy life if the nourishment be given in a concentrated form in a small compass. It is necessary for normal gastric digestion that the stomach should be distended, so that the stomachic walls may grasp the contents, in order to produce the necessary churning motion.

In ordinary diets the starch, cellulose, and woody fibre of the vegetable foods give the required bulk.

It is most important that we should be acquainted with the circumstances which favour normal gastric digestion.

1. The greater the surface presented to the action of the juice, the quicker will the proteids be dissolved. This fact proves that the *smaller* the particles of albumin, gluten, casein, etc., the better for the digestion. Large pieces of albumin are very slowly acted on, while finely divided proteid material is rapidly dissolved. The bearing of this on the digestibility of bread will be considered in a future chapter.

2. The amount of acid must be normal, neither much above nor below the proper amount. Excess of acid greatly retards the peptonising action, while neutralisation suspends it altogether. Alkalies destroy the action of the juice.

3. A constant motion of the food in the stomach.

4. A temperature of about 100° F.

The action of gastric juice on proteids is retarded by—

(1) Large pieces of proteid.
(2) Neutralisation or extreme acidity.
(3) Feeble contraction of the muscular walls, producing a slow motion of the food.
(4) Presence of alkalies in the food.
(5) Presence of an excess of common salt.
(6) Accumulation or presence of an excess of peptones in the stomach.

Much of the water, sugar, salts, and peptones is absorbed by the blood capillaries of the mucous membrane, by a process known as *osmosis,* by which soluble matters will readily pass through a moist animal membrane.

Summary of digestion in the stomach—

(*a*) Proteids converted into soluble peptones.
(*b*) Gelatinoids converted into soluble peptones.
(*c*) Fats set free.
(*d*) Milk curdled.
(*e*) Starch, cellulose, and woody fibre usually not acted on.

CHAPTER VIII

INTESTINAL DIGESTION

From time to time the muscular ring at the pyloric opening of the stomach is relaxed, and some of the chyme passes through into the small intestines. The chyme so forced into the *duodenum* consists largely of undigested fat, starch, and proteids (gluten, albumin, etc.), and is of an acid reaction. This chyme now passes very slowly along the small intestines, and the remaining undigested portions of the food are digested.

The chyme mixes with three distinct fluids in its journey through the intestines. These fluids are all more or less concerned in the reduction of the food, and may be enumerated as follows:—

(1) The bile.
(2) The pancreatic juice.
(3) The intestinal juice.

Bile.—Bile is a bright, yellowish-red fluid, secreted by the liver. It has a peculiar odour and bitter taste. It is neutral, with a specific gravity of 1030. It is elaborated by the minute liver cells, and flows into the intestines by a special vessel known as the *common bile duct*. If digestion is not going on, the bile flows back into the *gall bladder*, where it is stored until required (see Fig. 9). Bile taken from the gall bladder always contains a fair quantity of mucus.

The following is an analysis of human bile, but the figures must not be taken as absolutely correct for every specimen, inasmuch as the bile varies considerably in composition :—

HUMAN BILE (Frerich).

Water	85·92
Bile salts	9·14
Fat	·92
Cholesterin	·26
Pigment and mucus	2·98
Ordinary salts	·78
	100·00

Various attempts have been made to estimate the amount of bile secreted in 24 hours, but it seems that only an approximate estimate can be arrived at, as it may vary from 2 lbs. to 3 lbs. daily. The most important constituents of bile are the *bile salts*, which are the active agents in digestion.

The bile salts are compounds of glycocholic and taurocholic acids with soda. They contain the element carbon, and are therefore *organic* salts. Biliary digestion is entirely opposed to gastric digestion. A small quantity of bile is sufficient to arrest the conversion of proteids into peptones by pepsin. The first action of bile on the food is to neutralise the acid chyme, thus preparing the way for the action of the strongly alkaline pancreatic juice. A flocculent precipitate is formed in the upper part of the intestine by the action of bile, and this neutral precipitate is afterwards digested by the pancreatic juice.

Bile is a most important agent in the digestion of fat; the change, however, is not carried on by bile alone, *but in conjunction with pancreatic juice.*

It is very probable, however, that this function is subordinate to others. There is a consensus of opinion that bile is really more of an excretion than a digestive fluid, and has other functions to perform in the body, more important than the digestion of fat.

There is every reason to believe that bile acts as a natural stimulus to the intestinal tract, and that constipation follows if the secretion be not normal. Further, it has been ascertained that the absorption of fat is greatly facilitated by the bile lubricating the intestinal walls, and that a decrease in the amount of bile leads to an excretion of fat.

Finally, bile has an antiseptic action on the contents of the bowels, preventing decomposition, and a diminution of the secretion results in putrefactive changes taking place in the contents of the intestines.

Pancreatic Juice.

This digestive fluid is the secretion of the pancreas (*sweetbread*). It passes into the small intestines by the same duct as the bile.

It is a clear, colourless fluid of a decided alkaline reaction, with a specific gravity of 1015. It is distinguished from all the other digestive juices by the amount of albumin which it contains.

The following is an analysis of pancreatic juice :—

Water	90·076
Ferments and other organic matter .	9·044
Salts	·880
	100·000

When examined carefully it is found to contain—

(1) *Albuminates.*—These bodies are compounds of albumin and alkalies, and give to the juice its special characters.

(2) *Ferments*, of which there are four, viz.—

(*a*) Trypsin.
(*b*) Pancreatic diastase.
(*c*) Fat ferment.
(*d*) Curdling ferment.

(3) *Extractives*, including leucin and tyrosin.

(4) *Salts*, consisting chiefly of common salt, phosphates, and alkaline carbonates. The alkalinity of the juice is probably due to the carbonates present.

The action of pancreatic juice on the chyme depends on the ferments which are present, and is of a variable character. It may be said to sum up the whole work of digestion, for it acts on all the proximate principles.

Action on Proteids.—Proteids which have escaped action of pepsin of gastric juice are rapidly converted into peptones by the ferment trypsin. This unorganised nitrogenous ferment, unlike pepsin, will only act in an alkaline solution. Acidity of the contents of the intestines is therefore detrimental to its action.

But the action of trypsin differs in a more important particular from the action of pepsin. There is every reason to conclude that part of the proteid material is carried beyond the peptone stage, and broken down into two crystalline nitrogenous bodies, known as *leucin* and *tyrosin*. Leucin is a fatty acid, while tyrosin belongs to the aromatic series of carbon compounds. Under certain conditions these bodies may be carried to the liver and there converted into urea, possibly with the elaboration of fat or other bodies. It is thus clear that part of our proteid food may be utilised in the body without ever becoming an integral part of any tissue.

Action on Starch.—Starchy compounds are acted on by pancreatic diastase, and converted into sugar, chiefly maltose. The action of the diastase is comparable to the action of ptyalin of saliva, but the change is more rapid. This would indicate that the amylolytic ferment is more powerful than ptyalin. It is noteworthy that even *raw* starch is quickly acted on by the ferment.

Action on Fat.—Fat undergoes a double change when acted on by a mixture of pancreatic juice and bile. Part of the fat is broken up into its fatty acid and glycerin, but the greater portion is simply emulsified.

The first action is due to the fat ferment of pancreatic juice, which splits up the neutral fat into its constituent radicles. The small quantity of fatty acid thus set free probably combines with the alkali of the bile and pancreatic juice to form a soap. It is probable that the soap is not formed for the purpose of absorption, but to facilitate the emulsification of the neutral fats, for it has been proved that the presence of a small quantity of soap is favourable to a fat being emulsified.

After the soap has been formed, the fat ferment emulsifies the fat; that is to say, it reduces the fat to a very fine state of division.

Action on Milk.—Some authors assert that milk which has escaped the action of the rennet ferment in the stomach is curdled by a special ferment in pancreatic juice.

There is a certain amount of evidence to show that pancreatic digestion is accompanied by the development of bacteria, which produces fermentative changes in some of the products described above.

It is probable, for instance, that part of the sugar is broken up into lactic acid, and the latter further split up into butyric acid, carbonic acid, and hydrogen gas (see Chap. V.)

Intestinal Juice is by some thought to be a product of the minute glands found in the intestine, known as the glands of Lieberkühn. It is difficult to obtain what may be fairly considered pure intestinal juice, as it is liable to become mixed with other fluids.

Most authors ascribe it to an amylolytic action, and some assert that it has the power of inverting cane sugar—that is, splitting it up into dextrose and levulose.

Summary of Digestion in the Small Intestines.

Proteids converted into peptones by trypsin of pancreatic juices.

Starch converted into sugar by pancreatic diastase.

Fat emulsified by the bile and fat ferment of pancreatic juice.

Sugar converted into lactic and butyric acids, by organised ferments.

Digestion in the Large Intestine.

The small intestine joins on to the large intestine, the head of the latter being enlarged to form the *cæcum.* The entrance is guarded by a valve termed the ileo colic valve, which prevents the food passing back into the small intestine. Little or no digestion goes on in the large intestine, as most of the nutriment has already been acted on. But a slight solvent action may take place, for the ferments are carried on with the food.

CHAPTER IX

ABSORPTION OF PRODUCTS OF DIGESTION

In a former chapter it has been pointed out that only *soluble* matters can enter the blood stream, and that the energies of the digestive system are devoted to the task of rendering the insoluble food soluble. It remains now to consider how, and by what channels, these soluble products of digestion are absorbed, and the circumstances which influence the absorption.

It is well known that if two fluids be separated by an animal membrane, there will be a diffusion of the two liquids through the membraneous partition. Thus if pure water be placed in one compartment, and a solution of sugar in the other, the two fluids will interchange, until they are of nearly the same composition.

Similarly with water and a solution of salt. Some bodies possess this property in a marked degree, while others diffuse with the greatest difficulty.

Among the former may be mentioned soluble bodies, like salt and sugar, while the latter include such substances as starch, albumin, gluten, fat.

Peptones, which are produced by the action of gastric juice and pancreatic juice, are highly diffusible, passing through organic membranes with comparative ease. Soluble substances are absorbed by the blood in somewhat the same way as described above. The thin walls of the blood capillaries may be regarded as moist animal membranes through which such bodies as water, salts, sugar, and peptones will easily pass into the blood. The process is known as *osmosis* or *endosmose*.

But this process of osmosis must not be looked upon as one of simple diffusion. We must bear in mind the fact that the walls of the capillaries are *living* membranes, and must exercise a modifying effect on the rate of absorption, and the kind of matter absorbed.

It is very probable that each part of the alimentary canal has a certain selective power, by which it rejects certain bodies and retains others, and this power is believed by many physiologists to reside in the outer layer of columnar cells which lines the whole of the interior of the digestive tract. In many cases of impaired nutrition the fault may not lie with the digestive juices, but may consist in the non-absorption of the soluble products by the mucous membrane of the intestines.

Absorption in the Mouth.

It is very probable that only a little water is absorbed in the mouth. Some authorities maintain that a little sugar and salts may be absorbed with the water.

Absorption in the Stomach.

A little time after an ordinary meal the stomach contains the following soluble bodies, capable of passing through a moist animal membrane:—(1) Water. (2) Salts. (3) Sugar. (4) Peptones.

Now the mucous membrane of the stomach is permeated with vast numbers of blood capillaries, so that the soluble bodies are only separated from the blood by the thin outer layer of the mucous coat and the walls of the capillaries. Here we have the most favourable conditions for diffusion, viz., two fluids, the soluble peptones, etc. on one side, and the blood on the other, separated by a moist membrane. Under these circumstances the peptones, etc. pass into the blood stream, being probably profoundly

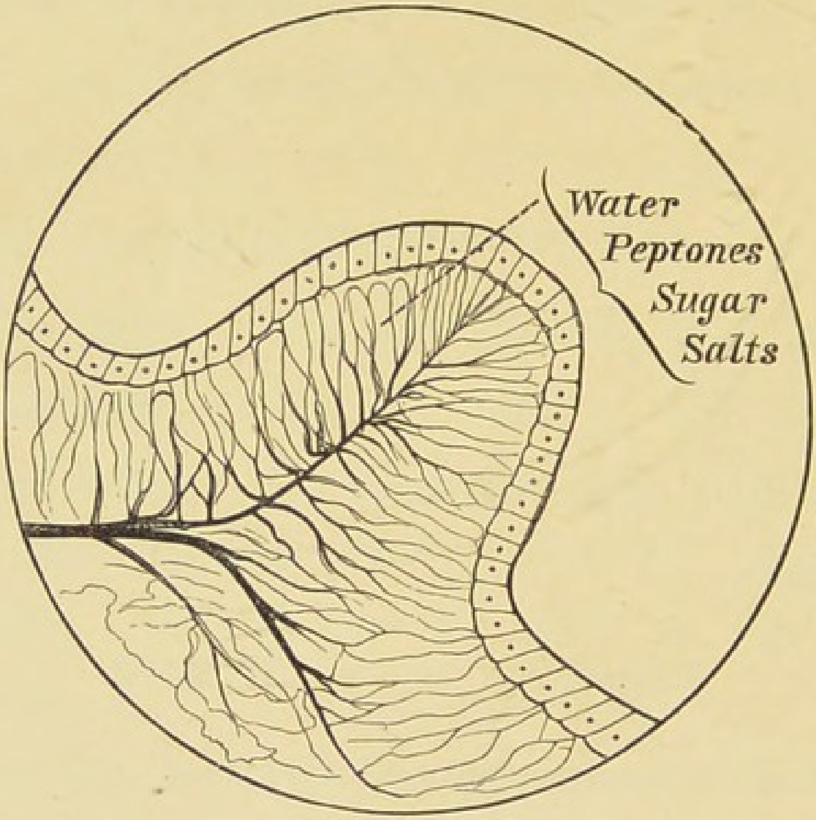

Fig. 11.—Mucous Membrane of Stomach, showing capillaries, and indicating how soluble matters are absorbed by osmosis.

modified by the contact with the living cells. The fat does not pass through, being insoluble and undigested as yet.

Absorption in the Intestines.

The inner coat of the small intestines is covered with thousands of minute finger-like projections termed *villi*. These bodies stand out into the interior of the intestines like the pile on velvet, and are mainly concerned in the absorption of the soluble food.

Each villus is covered with a layer of columnar cells, and contains in the centre a fine tube called a *lacteal*. The lacteal is surrounded by a network of blood capillaries.

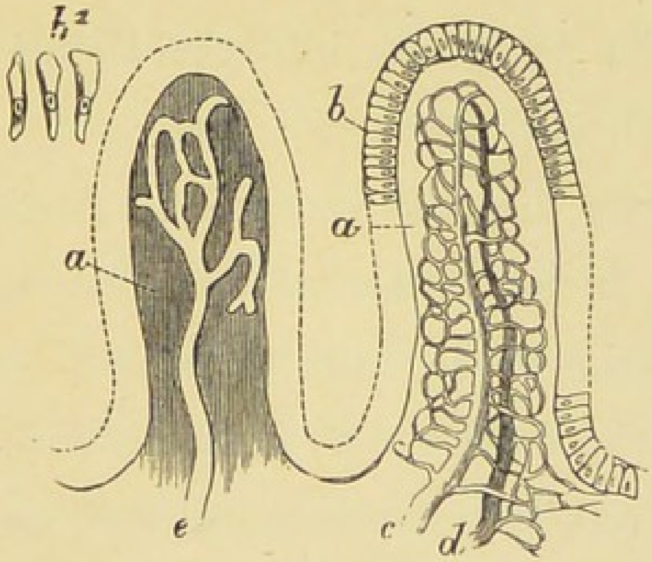

Fig. 12.—DIAGRAM OF VILLI. The villus on left shows the lacteal; the villus on the right shows blood supply. *a*, Supporting tissue; *b*, columnar cells; b^2, isolated columnar cells; *c*, small artery, with accompanying capillaries; *d*, small vein; *e*, lacteal.

These capillaries are probably concerned in the direct absorption of water, salts, sugar, and peptones, which pass through the layer of columnar cells into the blood stream by osmosis. The fat does not pass into the blood in this way, but by a special route to be immediately described.

Absorption of Fat.

After a meal containing fatty matters the villi are found to be charged with highly refractive particles of fat, and the lacteals are seen to be full of a milky fluid known as *chyle.* When the chyle is examined it is found to contain considerable quantities of fat. From these facts it is certain that most of the fat passes into the lacteals, and not directly into the blood.

It appears that the very minute particles of the emulsified fat are absorbed in some way by the columnar cells of the villi, and passed on into the lacteals. The contents of the lacteals flow into the lymphatic vessels in the intestinal wall, and thence to a small reservoir situated just beneath the diaphragm. From the reservoir it flows up a thin tube called the *thoracic duct,* and is discharged into the blood at the junction of the left sub-clavian and left jugular veins.

The fat then ultimately finds its way into the blood, not directly, but indirectly, through the agency of the lymphatic system.

This absorption of water, sugar, salts, peptones, and fat goes on along the whole length of the small intestines, so that by the time the contents reach the large intestine most of the nutriment has been extracted, and only indigestible substances mixed with water and other bodies remain.

Absorption in the Large Intestine.

The contents of the large intestine consist of—(1) Indigestible substances. (2) Water. (3) Digestive juices. (4) Small quantities of peptones, fat, and starch.

At first the mixture is rather fluid, but as it passes along the intestine the water is absorbed and the contents become more and more solid, and acquire a fæcal odour and a decided acid reaction. The leading function of the large intestine appears to be the absorption of water, whereby the contents become consolidated.

The rapidity and thoroughness of the absorption by the mucous membrane of the alimentary canal depends on a variety of circumstances.

In the first place, the presence of common salt appears to facilitate the process. Indeed, many eminent physiologists assert that it cannot take place in the absence of the salt. On the other hand an excess retards the process.

The presence of bile is distinctly favourable to the absorption of fat by the villi. It has not yet been clearly established in what way the bile acts, but it is possible that each fatty particle becomes covered with an exceedingly thin film of soap which facilitates its passage through the wall of the villus into the lacteal.

The presence of fat on the intestinal walls helps the absorption of other bodies like peptones, and lately it has been shown that if only a small quantity of fat be taken, the food is not so thoroughly absorbed as it would have been if more oily matter had been ingested.

Lastly, the amount of matter absorbed depends upon the amount of waste matters present, and the rapidity of the flow along the intestines. All things being equal, the greater the quantity of indigestible substance present, the less rapid will be the absorption. As we shall see in a future chapter, the whole structure of the intestines is calculated to retard the movement of the food. This is necessary in order to allow the mucous membrane time to take up the soluble matters. If by reason of the presence of hard particles, or an excess of bile, the movements of the intestines are increased, it follows that the food is hurried along, and reaches the large intestine with a considerable amount of its nourishment still unabsorbed. The main facts of absorption may be summarised as follows:—

Water absorbed in .	Mouth Gullet Stomach S. intestines L. intestines	by capillaries.
Salts, Sugar „ . *Peptones* „ .	Stomach S. intestines	by capillaries of stomach and of villi.
Fat „ .	S. intestines	by villi, and passed on to the lacteals.

CHAPTER X

DIET

It is impossible for a man to live on any one of the proximate principles alone. Inasmuch as the body is losing every day both carbon and nitrogen, it is clear that carbon and nitrogen must be supplied in the food.

Magendie fed dogs upon sugar and oil alone for several weeks. He found that they thrived for the first week or so, but afterwards they became emaciated, and finally died on the thirty-sixth day. When fed on casein and albumin they lived for a longer period, but became feeble, emaciated, and lost their hair. Ultimately, they succumbed to the effects of the insufficient diet.

Another observer, Dr. Hammond, restricted himself to 1½ lb. of starch and water per day. Soon debility and fever appeared, and he had to abandon the experiment on the tenth day.

On another occasion he fed on albumin alone, but diarrhœa and the appearance of albumin in the urine compelled him to adopt another diet on the ninth day. Careful experiments have shown that it is impossible to live without nitrogenous material in the form of proteids.

A healthy life can only be lived when the diet includes some representative of each proximate principle. A normal diet then must include—

(1) Water.
(2) Proteid material (albumin, gluten, etc.)
(3) Carbo-hydrate material (starch, sugar, etc.)
(4) Fat.
(5) Salts.

The absence of one or more of these principles leads to impaired nutrition. It is a remarkable fact that those foods which contain all the above principles, like milk and bread, never produce satiety.

Of these proximate principles water is the most important, for its absence from the diet speedily results in death. Next in importance come the proteids, as an animal can only live for a short period without them.

It is, however, not sufficient that the diet should merely contain all the proximate principles. It is necessary that they shall be present in the correct proportions.

As we shall see, an excess or deficiency of any one is not good for the health. From a number of observations and experiments, it has been ascertained that a full-grown man doing a fair day's work requires in round numbers about 24 oz. of *dry* solids, and about 80 oz. of water.

Table of Diet for a Man.

	Water	80 oz.
Dry.	Albuminoids	$4\frac{1}{2}$,,
	Carbo-hydrates	$14\frac{1}{4}$,,
	Fat	3 ,,
	Salts	1 ,,
		$102\frac{3}{4}$ oz.

Of the 80 oz. of water, about 20 oz. will be supplied in the ordinary food, so that the amount to be made up by beverages, drinks, etc., is about 60 oz.

The $22\frac{3}{4}$ oz. of dry solids would be contained in about 45 oz. of moist food.

When we speak of a "mixed diet" we do not necessarily mean a *variety of foods*, but rather a mixture of the proximate principles in the right proportions.

Attention has already been drawn to the effects of a deficiency of any one of the principles; it remains now to point out the evils of a surplus.

One or two things may happen to surplus food—(1) It may be stored in the body; (2) it may be excreted.

In the first case, it is usually stored up as fat, which is not favourable to the healthy action of the organs, and may take the place of muscle tissue, in many parts producing weakness.

In the second case, the food is actually lost to the body by being excreted; but the excretion does not represent the whole of the loss. Energy has been consumed in digesting the food, and the organs of excretion have had extra work thrown on them in order to rid the body of the extra quantity.

An extra quantity of carbo-hydrate material or fat is favourable to the laying on of fat, while an excess of proteid material conduces to gout, rheumatism, kidney diseases, and impaired digestion.

It is very important to point out that every table of diet must be corrected by the digestibility of the foods; for instance, a certain weight of food may, on analysis, give the required amount of proteid, viz., $4\frac{1}{2}$ oz. dry; but if it be ascertained that only 75 per cent of that proteid material is digested, then the food will be deficient to the extent of 1 oz. of proteid material.

We may look at the subject from another point of view, by reducing the diet to grains of carbon and nitrogen, neglecting water and salts.

A full-grown man, doing a fair day's work, requires, in round numbers--

C.	4600 grains.
N.	300 ,,

This gives a proportion 1 of N. to 15 of C.

In the first table we get a proportion of 1 nitrogenous to 4 non-nitrogenous.

It will be convenient to reduce these to proportions of 100, as in future chapters the composition of various breads, etc., will be given in parts of 100.

A man requires in 100 parts the following proportions of dry principles—

Albuminoids . . .	about	21
Carbo-hydrates . . .	,,	63
Fat	,,	12
Salts	,,	4

If carbon and nitrogen be taken as the standard, then the following will be the proportion:—

C. = 94
N. = 6

There are very few foods, indeed, which contain all the proximate principles in the right proportions, but by mixing foods we easily obtain a perfect diet.

Broadly speaking, nearly all foods come under one of the following heads:—

(1) Those rich in carbo-hydrate material, but poor in proteids and fat (rice, tapioca, sago, potatoes, bread made from fine flour, arrowroot, fruits).
(2) Those rich in carbo-hydrate material and proteids, but poor in fat (whole-meal bread, peas, beans).
(3) Those rich in proteids, but poor in carbohydrates and fat (very lean meat, maccaroni, white of egg).
(4) Those rich in proteids and fat, but poor in carbo-hydrates (meat).
(5) Those rich in fat, but poor in proteids and carbo-hydrates (butter, oils).

None of these are absolutely perfect foods, but by mixing them the deficiency in one may be made up by the surplus in the other.

For instance, one food from the *first* group should be mixed with one from the fourth. Those of the second with those of the fifth, etc. By this means we are enabled to get a fairly perfect diet without much trouble.

No hard and fast rule can be laid in regard to diet, as there are so many circumstances which influence it.

The following are a few of the more important considerations:—(1) Age. (2) Sex. (3) Amount of work performed. (4) Climate. (5) Season. (6) Digestibility of foods. (7) Price.

It is not the writer's intention to go fully into these circumstances. It will be sufficient if attention is drawn to one or two of them which more closely concern his subject.

(1) The diet for a child requires to be rich in—

(*a*) Proteids.
(*b*) Fat.
(*c*) Phosphoric acid.
(*d*) Lime, potash, and magnesia.

The same may be said of adults until they have reached maturity.

(2) The diet for an adult requires—

(*a*) A less quantity of proteid (comparatively).
(*b*) A greater quantity of carbo-hydrates.
(*c*) A less quantity of earthy salts.

(3) The diet for a female who is *enceinte* should be—

(*a*) Rich in proteids and carbo-hydrates.
(*b*) Rich in phosphoric acid.
(*c*) Rich in lime, potash, and magnesia.

(4) The diet for a nursing mother should be—

(*a*) Rich in proteids and fat.
(*b*) Rich in phosphoric acid.
(*c*) Rich in lime, potash, and magnesia.

(5) The diet for hard workers requires to be rich in carbo-hydrate material, with a slight increase in the proteids.

(6) The diet for cold climates should be rich in fat or oil.

SECTION II.—WHITE BREAD

CHAPTER XI

INTRODUCTORY

Having learnt something about the general principles of diet, and the functions of digestion, the reader will now be prepared to study the value of white bread as a food. It will, however, be advisable to precede this study by a short account of the wheat grain and the changes which the flour undergoes before it becomes bread. The wheat plant is an annual grass belonging to the great natural order *Graminaceæ.* The seeds of many grasses are used as food (wheat, oats, rye, barley, etc.), and the term *cereal* is used to designate these edible varieties. Many different kinds of wheat are grown in different countries, but the two most common varieties in this country are summer wheat (*Triticum æstivum*) and winter wheat (*Triticum hybernum*). If a section be cut across a wheat grain, it will readily be seen that it consists of an envelope, brown in colour, enclosing a white, softer kernel.

The envelope is known as the bran, and the inner portion as the endosperm. The germ or embryo is also contained in the interior of the grain.

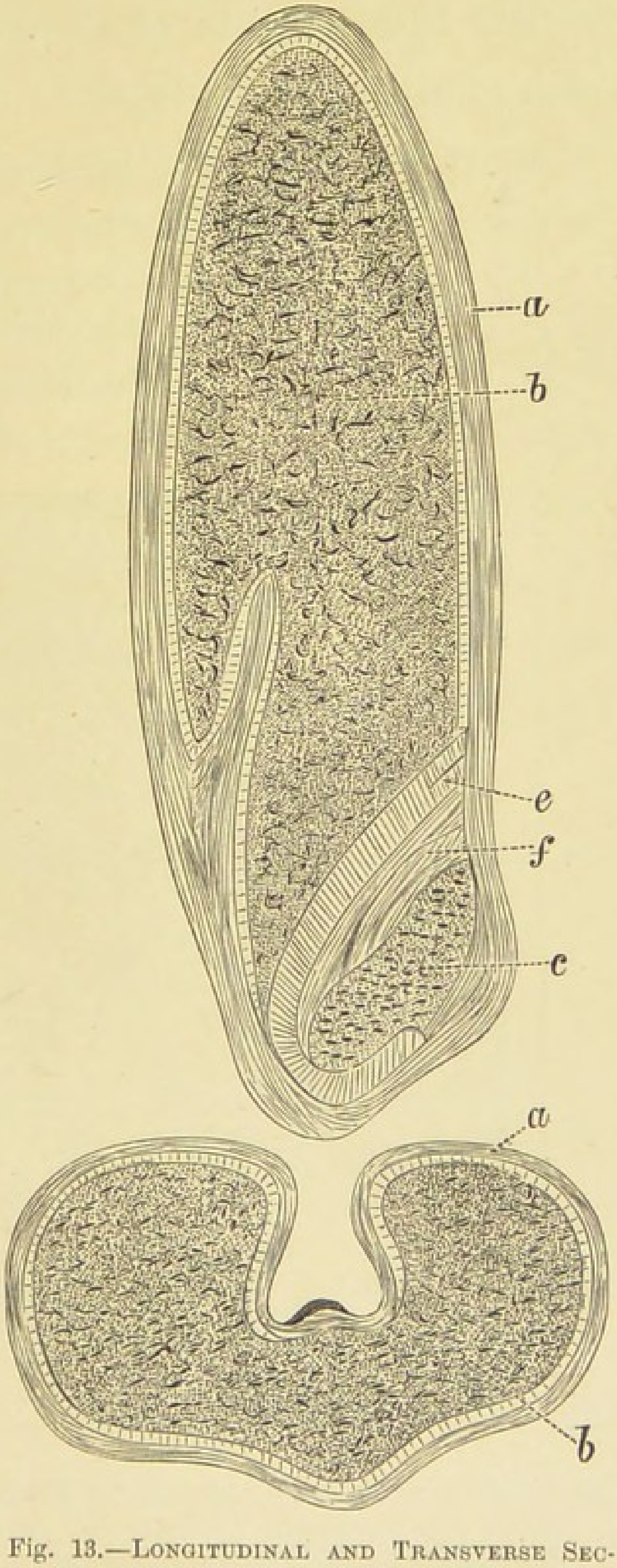

Fig. 13.—Longitudinal and Transverse Sections of Wheat. (Multiplied 15 diameters.) *a*, Bran; *b*, endosperm; *c*, germ; *e*, secretory epithelium; *f*, scutellum.

The bran consists of three well-marked coats, each consisting of two layers—

1. *External coat* { (*a*) Epidermis. (*b*) Epicarp.
2. *Middle coat* { (*a*) Endocarp. (*b*) Episperm.
3. *Internal coat* { (*a*) Membrane. (*b*) Layer of cerealin cells.

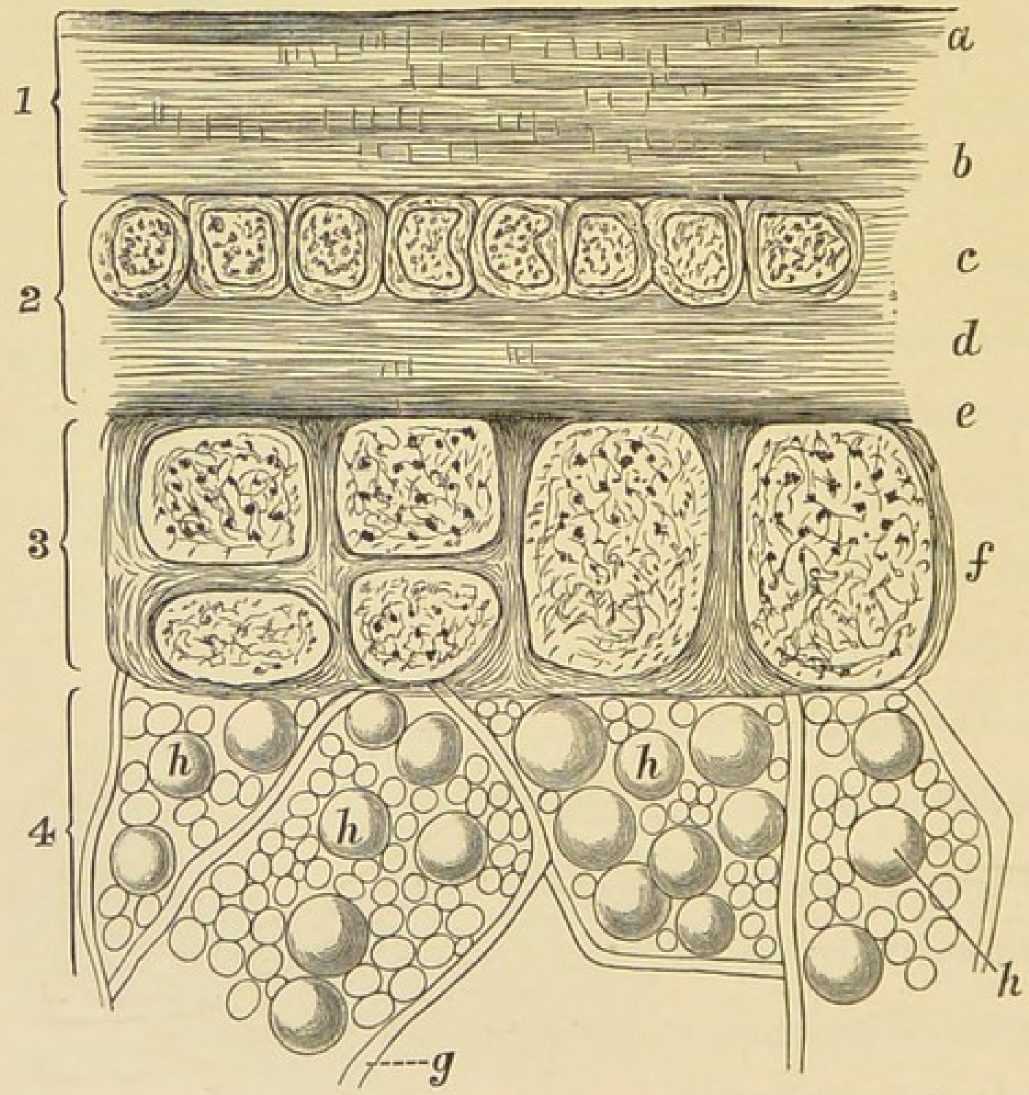

Fig. 14.—SECTION OF BRAN. (1) *External coat*—*a*, epidermis; *b*, epicarp. (2) *Middle coat*—*c*, endocarp; *d*, episperm. (3) *Internal coat*—*e*, membrane; *f*, cerealin cells. (4) *Endosperm*—*g*, wall of cellulose cell; *h*, starch grains.

The **epidermis, epicarp,** and **endocarp** consist chiefly of woody fibre and cellulose, with a little proteid material.

The **episperm,** or testa, is the first proper envelope of the seed. It contains nearly the whole of the pigment of the grain.

The layer of cerealin cells is surrounded by a membrane. The cells are somewhat square in shape, and are composed of cellulose and woody fibre. They contain a large proportion of proteid material. Becquerel states that the proteid material in the cerealin cells consists chiefly of aleurone grains, and not gluten, as is often stated.

This layer develops under certain conditions an hydrolytic ferment, known as *cerealin.*

The bran, without the layer of cerealin cells, forms about 5½ per cent of the entire grain.

The endosperm, when examined microscopically, is seen to consist of large cells of irregular shape, containing starch granules lying in gluten. When examined chemically, the bran of the grain is found to be richer in nitrogenous matter and salts than the endosperm. The germ also contains more proteid material and phosphates than the endosperm.

When the grain is ground, flour is obtained, and it will be quite sufficient for the purpose of this work if the flours are classified as follows:—

(1) Flour obtained from the central portion of the grain very finely ground (fine flour).
(2) Flour obtained from the outer portions of grain as well as the central portion, not so finely ground (fine sharps, or seconds, etc.)
(3) Flour obtained from the entire grain (whole-meal flour).

In roller flours the following are the chief grades in order of fineness:—

(1) First patent.
(2) Second patent.
(3) First bakers'.
(4) Second bakers'.

In the milling operations the germ is for certain reasons separated from the other constituents of the grain, but this will be fully dealt with in a future chapter on "Germ Bread."

The chief difference between these kinds of flour lies in the amount of nitrogenous matter and salts which each contains. As we pass from fine flour to whole-meal flour, so the percentage of nitrogenous material and mineral matter increases. This is well shown in the following table of analyses:—

	Fine Flour.	Medium.	Whole-meal.
Water	12·0	13·0	14·0
Proteids	9·3	12·1	14·9
Fat	0·8	0·9	1·6
Carbo - hydrates (Starch, sugar, etc.) . . .	76·5	72·2	66·2
Fibre	0·7	0·9	1·6
Mineral Matter	0·7	0·9	1·7
	100·0	100·0	100·0

When the food stuffs present in flour are examined according to their solubility, it is found that part of the nitrogenous matter is soluble in water, and that also a small proportion of the carbo-hydrates are soluble. During the process of cooking the soluble albuminoids are coagulated and rendered quite insoluble, while insoluble carbo-hydrates like starch are often rendered into more soluble forms.

During the manufacture of bread many changes take place, mainly produced by the heat of the oven, but also brought about by fermentation.

Changes Due to Heat.

One of the most important changes produced by heat is the breaking up of the starch granules. This is clearly shown when bread is examined microscopically. Very few whole starch grains are seen, and they are often entirely disintegrated and their particles aggregated together to form little angular masses in the bread. This has a most important bearing on the digestibility of bread, as the condition of the starch is such as to allow ready access of the digestive fluids to the constituents of the granule. The whole process is sometimes termed the gelatinisation of starch. The heat of the oven has the effect of coagulating the albumin of the bread, thus rendering it insoluble. At the same time the gluten is rendered somewhat more indigestible by the action of the heat. A very remarkable unstable compound seems to be formed by the combination of gluten, casein, and gluten fibrin, with some of the disintegrated starch. Little is known concerning the exact nature of this compound, but there can be little doubt that it deserves a careful and detailed investigation. The author has already found that, when this compound (?) is acted on by gastric juice, the starch is set free, and the *glutens are much more easily digested* than if they had been heated alone. Similarly, when the combination is acted on by diastase, the starch is very rapidly converted into sugar, the glutens being set free. Another change which takes place is the conversion of some of the starch into the more soluble forms of dextrin and sugar. This is probably not altogether due to the heat, but also to the action of certain ferments. A little caramel is also formed in the crust.

The fat and ash remain unchanged, as also does the fibre.

Summarising the changes, we may say—

(1) The proportion of *insoluble* albuminoids is raised.
(2) The proportion of *soluble* carbo-hydrates is raised.
(3) The starch grains are gelatinised.
(4) The gluten-casein and gluten-fibrin form a combination with some of the starch.
(5) These same two glutens are rendered more digestible.
(6) The starch is more readily acted on by the digestive fluids.
(7) A distinct flavour is developed.

It is important to note that the change of starch into dextrin takes place mainly in the crust.

Changes Due to Fermentation.

When yeast is used to "raise" the bread, fermentation goes on in the dough. The organisms (*saccharomyces cerivesiæ*) which mainly compose the yeast use part of the nitrogenous matter, and also split up some of the sugar into carbon-dioxide

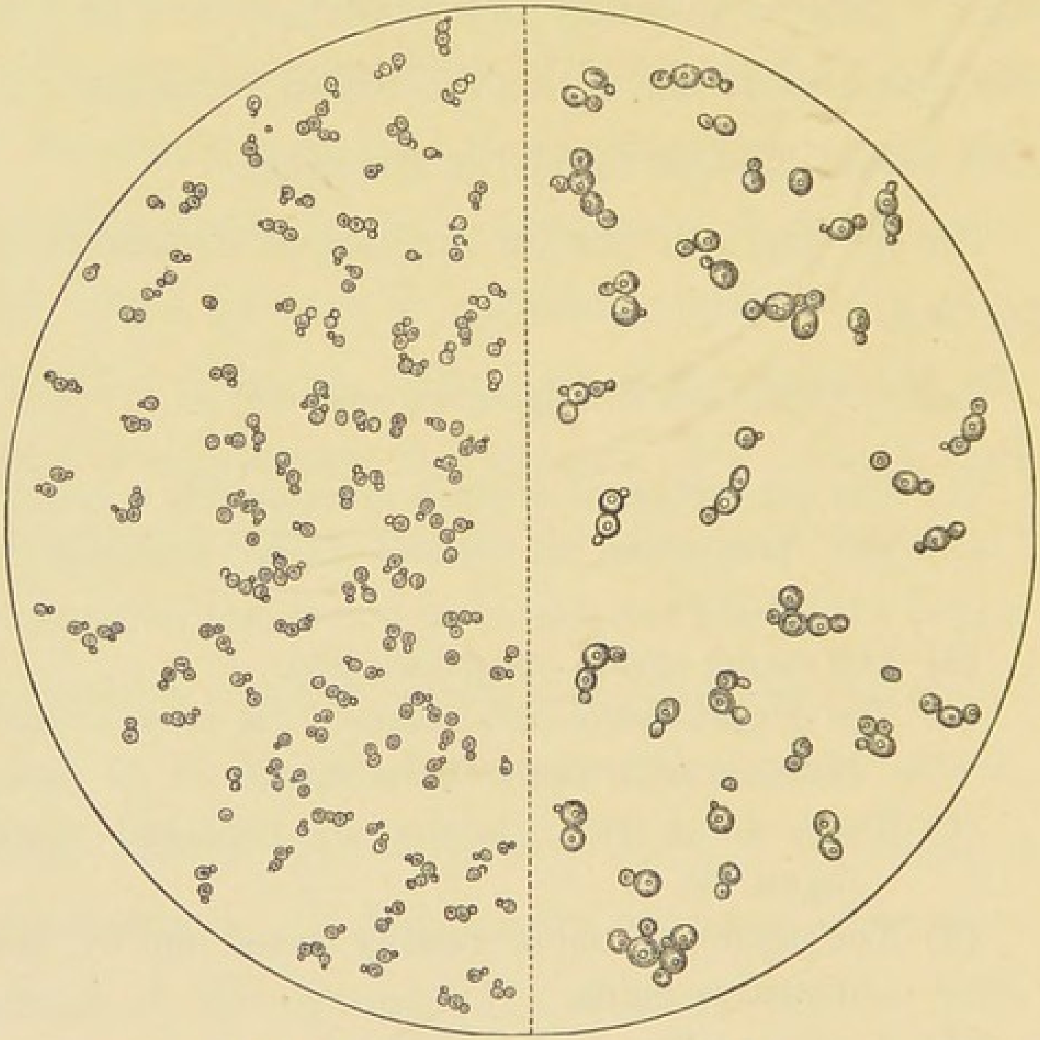

Fig. 15.—SACCHAROMYCES CERIVESIÆ.

(CO_2), and ethylic alcohol, (C_2H_5HO), and other bodies.

Most of the alcohol escapes as vapour, but some remains behind in the loaf. As much as 16 grains of alcohol may be obtained from a loaf by careful distillation. The starch is also slightly affected during the fermentation, and a small portion is probably converted into sugar by the action of bacilli. It is also probable that part of the nitrogenous matter is dissolved by the bacilli. Bread, then, is simply baked dough, made from flour and water, rendered porous by various methods, and

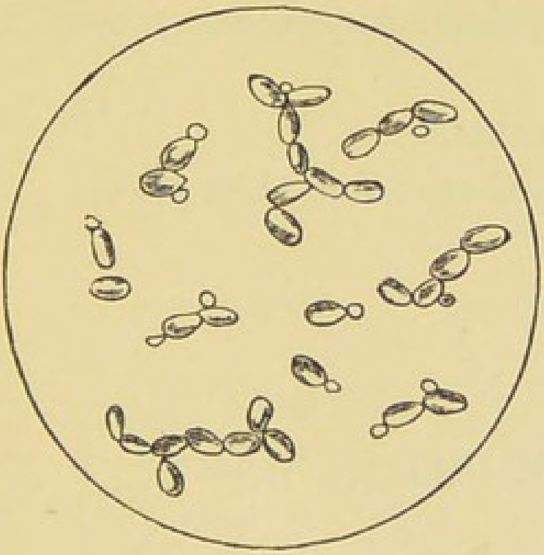

Fig. 16.—Upper Yeast.

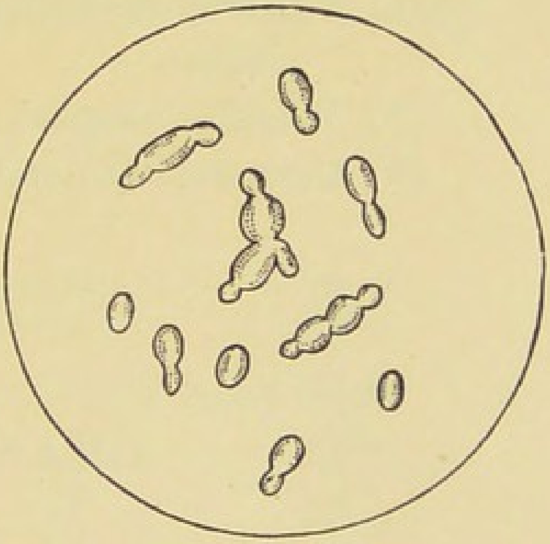

Fig. 17.—Under Yeast.

may be considered to consist of albuminoids, carbohydrates, fat, and salts, all in a highly assimilable condition.

In studying the value of any food we must take into consideration a variety of circumstances, and carefully weigh one point against another.

The following points will be touched on in the succeeding chapters:—

(1) The price of bread as compared with other foods.
(2) The composition of bread both as regards proximate principles and grains of carbon and nitrogen.
(3) The amount and nature of the salts present.
(4) The digestibility of bread as compared with other foods.
(5) The amount of waste present.
(6) Whether bread allows of the free action of the digestive juices.
(7) Flavour, staleness, sourness, and other minor points.
(8) Whether adapted for infants.
(9) Common adulterations (if any), and their effects.

CHAPTER XII

THE PRICE OF WHITE BREAD WHEN COMPARED WITH OTHER FOODS

Every food contains a certain quantity of water, which must be deducted from the weight of food when calculating its comparative price. Waste substances must also be deducted, as they represent no gain to the body. It is only that part of a food which is capable of digestion which may be calculated as actual nourishment.

It is not a difficult matter to work out the comparative value of a food as regards price. If the percentage of water and waste be known, and the average price, it is a simple exercise in the rule of three to ascertain the amount of nutriment obtained for a given sum.

The following table gives the percentage of water in some common foods, together with the average price:—

TABLE I.

Food.[1]	Percentage of Water, etc.	Cost of 16 oz.
W. bread	37 (average)	$1\frac{1}{4}$d.
Oatmeal	15	$1\frac{1}{2}$d.
Rice	15	2d.
Potatoes	75	$\frac{3}{4}$d.
Carrots	90	$\frac{3}{4}$d.
Milk	86	$1\frac{1}{2}$d.
Cheese	36	8d.
Fruit	85	4d.
Mutton	55	9d.
Beef	50	10d.
Fish	75	4d.
Butter	10	14d.
Lentils	15	$2\frac{1}{2}$d.
Peas	15	$2\frac{1}{2}$d.

[1] The price of these foods varies. A fair average has been taken in the table.

Taking bread as an example and 1d. as the standard, the method of working is as follows:—

100 oz. of bread contains 63 oz. of nourishment.

1 oz. " " $\frac{63}{100}$ " "

16 oz. (the amount bought) contains $\frac{63 \times 16}{100}$ " "

which works out to about 10·08 oz.

The second calculation is made as follows:—

$1\frac{1}{4}$d. buys 10·08 oz. of nutriment.

1d. " $\frac{10 \cdot 08}{1\frac{1}{4}}$ " "

which works out to about 8 oz.

In a similar manner the other foods may be reduced to the same comparative value.

The following table gives them in order of merit—

Table II.

1d. worth of	bread	yields	8	oz. of	nutriment.
"	oatmeal	"	$7\frac{1}{2}$	"	"
"	potatoes	"	$5\frac{1}{3}$	"	"
"	lentils	"	$5\frac{1}{2}$	"	"
"	peas	"	$5\frac{1}{2}$	"	"
"	rice	"	$5\frac{1}{4}$	"	"
"	cheese	"	$2\frac{1}{4}$	"	"
"	carrots	"	2	"	"
"	milk	"	$1\frac{1}{2}$	"	"
"	fish	"	1	"	"
"	beef	"	$0\frac{4}{5}$	"	"

1d. worth of mutton yields $0\frac{4}{5}$ oz. of nutriment.
" fruit " $0\frac{1}{2}$ " "

Bread thus stands at the top of the list of foods as regards price (see note above).

But the above list gives no clue as to the relative quantities of the different proximate principles which are obtained for the penny. This is important, for all other things being equal, the cheapest food is that which contains all the proximate principles in the right proportions.

The following is a method by which such a calculation may be made.

In the first place, it is necessary to know the composition of the foods to be compared. The appended table gives the composition, in round numbers, of a few common foods.

TABLE III.

	Bread.	Oatmeal.	Lentils.	Beef.	Fruit.	Rice.	Potatoes.	Butter.
Water . . .	37	15	15	50	85	15	75	10
Albuminoids.	8	13	22	15	·5	6	2	1·5
Carbo-hydrate	53·3	63	59	...	14	78	22	·8
Fat . . .	·8	6	1·8	30	...	·5	·2	86·5
Salts . . .	·9	3	2·2	5	·5	·5	·8	1·2
	100·0	100	100·0	100	100·0	100·0	100·0	100·0

The method of calculation will be readily understood by studying the following example:—

By Table II. it will be seen that 1d. worth of bread gives 8 oz. of nutriment. Now these 8 oz. represent 63 per cent of the total weight of bread bought.

Table III. shows bread to contain 8 per cent of albuminoids and 54·1 per cent of carbo-hydrates (starch, etc.) and fat. The calculation now resolves itself into a simple proportion sum, as follows:—

63 oz. in 100 oz. equals 8 oz. bought for 1d.
1 oz. ,, ,, $\frac{8}{63}$ oz. ,, ,,
8 oz. ,, ,, $\frac{8 \times 8}{63}$, which come out to about 1 oz. of albuminoids.

Similarly with the carbo-hydrates and fat—

63 oz. equals 8 oz. bought for 1d.
1 oz. ,, $\frac{8}{63}$ oz. ,, ,,
$54\frac{1}{10}$ oz. ,, $\frac{8}{63} \times 54\frac{1}{10}$, which works out to $6\frac{2}{3}$ oz. of carbo-hydrates and fat.

The following is a list of the more common foods compared in this way:—

1d. worth of bread contains .	1 oz. of albuminoids. $6\frac{2}{3}$ oz. of carbonaceous matter.

1d. worth of	oatmeal	contains	$1\frac{5}{17}$ oz. of albuminoids.	$6\frac{3}{34}$ oz. of carbonaceous matter
1d ,,	lentils	,,	$1\frac{36}{85}$ oz. of albuminoids.	$3\frac{7}{8}$ oz. of carbonaceous matter.
1d. ,,	beef	,,	$\frac{6}{25}$ oz. of albuminoids.	$\frac{12}{25}$ oz. of carbonaceous matter.
1d. ,,	rice	,,	$\frac{63}{170}$ oz. of albuminoids.	$4\frac{5}{6}$ oz. of carbonaceous matter.
1d. ,,	fruit	,,	$\frac{1}{60}$ oz. of albuminoids.	$\frac{1}{2}$ oz. of carbonaceous matter.

We must now consider the comparative price of bread from another standpoint, viz., the amount of *carbon* and *nitrogen* which is obtained by purchasing a pennyworth of different foods. To calculate this, it is necessary to know the number of grains of carbon and nitrogen contained in a given weight of any food.

The following table is taken from Dr. Letheby's work on food, and shows the number of grains of carbon and nitrogen in 16 oz. :—

Food.	Carbon.	Nitrogen.
Bread	1975 grs.	88 grs.
Oatmeal	2831 ,,	136 ,,
Lentils	2699 ,,	248 ,,

Food.	Carbon.	Nitrogen.
Beef . . .	1854 grs.	184 grs.
Rice . . .	2732 ,,	68 ,,
Potatoes . .	769 ,,	22 ,,
Cheese . .	3344 ,,	306 ,,

These numbers must be reduced to a level by dividing them by the number of pence which the 16 oz. cost, and then the foods come out in the following order—

				Carbon.	Nitrogen.
1	pennyworth	of oatmeal	contains	1887 grs.	90 grs.
1	,,	rice	,,	1366 ,,	34 ,,
1	,,	bread	,,	1180 ,,	70 ,,
1	,,	lentils	,,	1079 ,,	99 ,,
1	,,	potatoes	,,	1025 ,,	29 ,,
1	,,	cheese	,,	418 ,,	38 ,,
1	,,	beef	,,	185 ,,	18·4 ,,

It will be perfectly clear from a study of these facts that bread is one of the cheapest foods, not only with regard to the actual weight of nourishment obtained, but also with regard to the variety of the nutrient constituents; and the purchaser who expends his modest 2½d. in a 2 lb. loaf may rest assured that he could not spend his money to better advantage, except, perhaps, in the purchase of oatmeal, which contains slightly more energising nutriment than bread.

CHAPTER XIII

COMPOSITION OF WHITE BREAD

WHITE bread contains some representative of each division of the main group of "principles," though some of them are only present in small quantities.

The following table shows this in a convenient form:—

FINE WHITE BREAD.

Proximate Principle.	Food Stuff.	Per-centage.
Water	Water	37·0
Proteids	Albumin, gluten	7·5
Carbo-hydrates	Starch[1]	45·4
	Sugar	3·6
	Dextrin	4·8
Fat	Fat	·8
Mineral matter	Salts of potash, soda, etc.	·9
		100·0

If we group the food stuffs together we get the following proportion:—

[1] The relative quantities of sugar, dextrin, and starch vary considerably according to the mode of preparing the sponge ferment or dough, and method of baking, etc.

Water	37·0
Proteids	7·5
Carbo-hydrates	53·8
Fat	.8
Mineral matter	·9
	100·0

It will be seen that the carbo-hydrates greatly preponderate, and that it is poor in fat and mineral matter.

Bread which is made from coarser flour is considerably richer in proteids, fat, and mineral matter, as the following analysis will show.

Bread made from coarse flour—

Water	38·0
Albumin and gluten	9·2
Starch[1]	42·1
Sugar	3·7
Dextrin	4·9
Fat	1·0
Salts	1·1
	100·0

If this be reduced to the percentage of proximate principles we get—

[1] See note on p. 107.

Water	38·0
Proteids	9·2
Carbo-hydrates	50·7
Fat	1·0
Mineral matter	1·1
	100·0

This means a reduction of 3 per cent in the carbo-hydrates and an increase of about 2 per cent in the proteids. This has an important bearing on the dietetic value of bread, as will be pointed out presently.

We are immediately concerned in this chapter with the ratio of the proteids to the carbo-hydrates, and the proportion of fat, in order to ascertain how far white bread fulfils the function of a *perfect food.*

In order to do this we must first know the proportion of proteid, etc., that a full-grown, healthy man requires in 24 hours, and then compare the ratio with that of bread.

Professor Corfield has stated that the following constitutes a normal diet for a man doing a fair day's work:—

Dry proteids	4·50 oz.
Carbo-hydrates	14·25 ,,
Fat	3·00 ,,
Mineral matter	1·00 ,,
	22·75 oz.

making up 22·75 oz. of *dry* food. Now if we calculate what 22·75 oz. of *dry* bread will yield, we shall be able to see at a glance in what particulars white bread fails.

Taking *fine* white bread first, we find that 22·75 oz. yield of—

Dry proteids	2·7 oz.
Carbo-hydrates	19·4 ,,
Fat	·3 ,,

There is thus a deficiency of 1·8 oz. of proteid, 2·7 oz. of fat, and a surplus of 5·15 oz. of carbo-hydrates.

The coarser bread gives somewhat better results, as the following table shows.

22·75 oz. of coarse white bread yield of—

Proteids	3·4 oz.
Carbo-hydrates	18·6 ,,
Fat	·4 ,,

This gives a deficiency of 1·1 oz. of proteids, 2·6 oz. of fat, and a surplus of 4·1 oz. of carbo-hydrates.

Bread made from coarse flour, then, approximates more nearly to a perfect food than bread made from very fine flour.

In a perfect food the proportion of proteids to carbo-hydrates is as 1 is to 3·2. In fine white bread the ratio is as 1 is to 7. In coarse white bread the ratio is as 1 is to 5·4. Studying the subject from the standpoint of *elements* (*i.e.*, grains of carbon and nitrogen), we arrive at nearly the same results.

A man doing a moderate day's work requires daily 4600 grs. of carbon and 300 grs. of nitrogen.

22·75 grs. of white bread yield nearly 4600 grs. of carbon, but only 202 grs. of nitrogen, showing a deficiency of 98 grs. of nitrogen.

The proportion of carbon to nitrogen in a perfect diet is as 15·3 is to 1.

In white bread the ratio is as 22·7 is to 1, which shows that there is a deficiency of the nitrogenous element.

A man would require to eat about 37·8 oz. of dry bread in order to obtain the necessary amount of proteïd material ($4\frac{1}{2}$ oz.) for 24 hours. This amount would be yielded by about 60 oz. of ordinary moist bread. But this amount of bread would supply far too much carbo-hydrate material. Only 14·25 oz. are required, but the 60 oz. of moist bread would yield about 32 oz. of starch, etc., being over twice the quantity required.

This surplus of amyloids would act injuriously on the system, throwing unnecessary work on the digestive organs and leading to the accumulation of fat within the body.

Some authorities have argued that the surplus starch, etc., in bread takes the place of the fat, and that therefore there is no real deficiency of nitrogen.

But they have overlooked the important functions which fat performs in the intestinal tract. It has been already indicated that a certain quantity of fat or oil is required to facilitate the absorption of food, and it is probable that a deficiency would lead to impaired absorptive powers and intestinal inactivity.

Taking grains of carbon and nitrogen as the standard of calculation, we find that 60 oz. of moist bread would yield the necessary number of grains of nitrogen, but would supply a surplus of 2707 grains of carbon.

From what has been stated above it will be perfectly clear that white bread is not a perfect food for the following reasons—

(1) It is deficient in proteids.
(2) It is deficient in fat.
(3) It contains too much carbo-hydrate matter.

It will be also readily understood that white bread can never be made a perfect food by artificial means unless—

(1) The proteid ratio be raised.
(2) Fat be added.

The latter is not very important, as a ready means of supplying the deficiency of fat lies at hand in the use of butter, so that it is unnecessary to take special steps to increase the proportion of fat in the bread. But if the nitrogenous ratio is to be raised it must be done by either—

(1) Using the meals obtained from the whole grain, and thus retaining the nitrogenous matter which exists in the outer part of the wheat grain; or
(2) By adding proteid material to the flour; or
(3) By adding the germ, which is rich in proteids, to the flour.
(4) By removing some of the starch from the flour.

By any of these means the nitrogenous ratio would be raised, and the resulting bread would approximate to a perfect food as regards the proportion of nitrogen and carbon.

Is it necessary to strive after this?

The answer to this depends upon the place which bread occupies as a food in the diet of a community.

If the people live almost entirely on bread, if it forms the chief article of food, then we must answer in the affirmative; but if the people partake of bread sparingly, then the answer must be in the negative, for the deficiency of proteids will probably be made good by other foods.

There can be little doubt, however, that bread is the staple food of the working classes of our great towns, and therefore it is of the utmost importance that it should be as nearly a perfect food as possible, and the author is certainly of opinion that means should be taken to raise the proportion of proteid material in white bread. He has seen and knows much of the mode of life of the poorer classes, and unhesitatingly affirms that they depend largely on bread as their staple food, and he therefore earnestly pleads that bread should be made to come nearer the standard of a perfect food.

The amount of energy which is derivable from a loaf of white bread may now be stated.

Taking the standard of Drs. Frankland and Playfair, the following tables give the different amounts in a 2 lb. loaf:—

	Fine white bread.	Coarse white bread.
Dry Proteid . .	2·40	2·94 oz.
„ Starch, etc. .	16·06	14·72 „
„ Sugar . .	1·15	1·18 „
„ Fat . .	·25	·48 „

1 oz. of dry proteid = 174 foot-tons.
1 oz. of dry fat = 378 „
1 oz. of dry starch = 135 „
1 oz. of dry sugar = 122 „

Working the amounts we get the following:—

FINE WHITE BREAD.

2·40 × 174 = 417·6 foot-tons.
16·06 × 135 = 2168·1 „
1·15 × 122 = 140·3 „
·25 × 378 = 94·5 „

Total . 2820·5 foot-tons.

COARSE WHITE BREAD.

2·94 × 174 = 511·56 foot-tons.
14·72 × 135 = 1987·20 „
1·18 × 122 = 143·96 „
·48 × 378 = 181·24 „

Total . 2823·96 foot-tons.

CHAPTER XIV

THE AMOUNT AND NATURE OF THE MINERAL SUBSTANCES

THE percentage of mineral matter in bread depends upon the kind of flour which is used in its manufacture.

Bread made from fine flour is very poor in salts, but the mineral ratio rises as we pass on to the coarser kinds, and to whole-meal. Taking 1·1 per cent as a fair average, we find that white bread cannot furnish the necessary weight of salts to the body, unless an excessive quantity be taken. By referring to Chapter X., Section I., the reader will see that a full-grown healthy man requires 1 oz. of mineral matter every day. This is exclusive of table salt.

To obtain this quantity he would have to consume 90 oz. of white bread, which would yield a surplus of about 2 oz. of proteid material, and 30 oz. of carbo-hydrate material.

If just sufficient bread were taken to supply the body with the required weight of proteids, there would be a deficiency of nearly $\frac{1}{3}$ oz. of mineral matter.

Although it may be possible by various means to render *white* bread a nearly perfect food, as regards the proportion of albuminoids and carbo-hydrates, it is much more difficult to do the same with regard to the mineral matter.

The tissues of the body do not readily utilise salts which are derived directly from the inorganic kingdom. It appears that mineral matter which has not formed part of an organised structure is not suitable to supply the tissues with the salts they require. This, of course, applies to *normal* tissues, for it need hardly be added that in cases of mal-nutrition and in certain diseases, mineral compounds may act specifically in definite directions, exerting a powerful influence on the nutrition of an organ.

But it is clear that a *healthy* person would be injured by such compounds, for it is natural for the body in a state of health to obtain all its mineral matter from the food. The deficiency of mineral matter, then, in white bread cannot be made up by the addition of any compounds taken directly from the inorganic kingdom, for the continued ingestion of such crude bodies would be certain to exert a harmful influence on the tissues and organs of digestion, as well as on other important systems. The same objection would not hold good if mineral matter extracted from organised structures could be added to the bread, and in a future chapter the question as to how far this plan is successful will be discussed. It is very important that the *nature* of the mineral matter of a food should be examined, for it is very necessary to health that all the salts required by the body should be present, and in the right proportions. Of the total amount of mineral matter excreted, $\frac{4}{5}$ are got rid of by the kidneys, and $\frac{1}{5}$ by the skin and alimentary canal.

The most important salts excreted are—

(1) Chlorides . .	(*a*) Common salt. (*b*) Chloride of calcium.
(2) Alkaline phosphates	(*a*) Phosphate of sodium. (*b*) Phosphate of magnesium.
(3) Earthy phosphates .	Phosphate of calcium.
(4) Sulphates . .	(*a*) Sulphate of potassium. (*b*) Sulphate of sodium.

(5) Various bodies in traces, iron, silica, and alkaline carbonates.

Of these the phosphates are the most important from our present standpoint, as we shall see that they exert a very powerful effect on the health of the body. The ash of white bread contains all the above salts, but not in the required proportion; it is deficient more especially in *phosphate of calcium.*

It is a remarkable fact that in the vegetable kingdom the amount of phosphates bears a constant ratio to the amount of albuminoid matter present.

Boussingault pointed out this long ago, and his results have been confirmed by subsequent researches. It is now well established that, as the albuminoid ratio falls so does the percentage of phosphates. The following table by Boussingault shows this.

In 1000 parts are found—

	Phosphoric Acid.	Nitrogen.
Wheat	9·64	19·7
Wheat straw	1·61	3·8
Oats	4·73	19·0
Oat straw	1·07	3·0

It has been already stated that the outer portions of the wheat grain are richest in albuminoids, while the central parts are comparatively poor in proteids. It follows, then, that the outer portions are also richer in phosphates than the inner kernel.

White bread being made largely from fine white flour, obtained from the starchy centre of the grain, must also be poor in phosphates.

White bread is particularly deficient in *calcium phosphate,* which plays such an important part in the formation of new tissues.

It is only of late years that the great importance of phosphates has been recognised. Not only do they furnish material for the renewal and growth of bone and teeth, but their presence is the determinant cause of certain metamorphoses which the proteids undergo in the body. This is especially the case with calcium phosphate, which is indispensable to the formation of new cells and tissues. Some authorities have even gone so far as to formulate a proposition, "The quantity of phosphate of calcium contained in living beings is proportional to their activity," and to support it with analyses from the animal kingdom.

It was found that the active birds contained 3·67 parts of phosphates to every 100 parts of living weight, while the less active mammalia contained only 2·57 per 100.

The importance of phosphate of calcium is further shown by an experiment first performed by Chossat. An adult pigeon was nourished exclusively on wheat and *distilled* water. It soon showed signs of impaired nutrition, and died at the end of eight months. When examined, it was found that the bones had been reduced to mere splints, scarcely weighing $\frac{1}{10}$ of an ounce. The bones had clearly been absorbed to supply the other tissues with the necessary phosphate, and the animal had succumbed when the reserve was exhausted.

This experiment leads to the conclusion that phosphates have other more important functions to perform *in the adult* than renewing bone, and that wheat is too poor in lime to support life for any length of time, if distilled water be taken.

White bread is, of course, poorer in calcium phosphate than wheat, and is, therefore, less able to support life. The greater part of the phosphates which are present in bread consists of alkaline phosphates, which may react on lime to form phosphate of calcium. If water containing lime, or other foods containing calcium salts, be taken with white bread, a reaction may occur by which the calcium phosphate is formed from the phosphoric acid of the bread, and the lime of the water or food. White bread is also deficient in iron, so that those who are anæmic should not partake largely of it. The iron of the red corpuscles is associated in some way with their power of carrying oxygen gas from the lungs to the tissues, and it is generally believed that some kinds of anæmia may be due to a deficiency of *iron* in the red corpuscles, as well as to a decrease in the number of the corpuscles themselves. There is also a deficiency of sulphur. (See account of experiments in Chapter XXI.)

Those who partake of white bread should take care to supplement it largely with other foods, in order to make up for the lack of lime. If they do this, no ill results are likely to follow by eating white bread. But it is distinctly injurious to the body if it forms the staple food, and is not supplemented by other foods richer in lime.

On no account should it form part of the diet of infants or children, unless supplemented by milk or other foods rich in lime and phosphates, for they require especially phosphate of calcium to form their bones and teeth, and to promote the growth of new tissue.

Many hygienists unequivocally condemn the use of white bread; but the author cannot agree with them, where it only forms a small part of the diet. It is a matter of small moment to the body whether it obtains the mineral matter it requires from vegetable or animal food. If an individual partakes moderately of fresh meat, or other foods which are rich in salts, the use of white bread is not detrimental to a vigorous life, and eaters of white bread need not alarm themselves about a deficiency of phosphates as long as they have variety in their diet.

At the same time, it is just as well to point out that white bread *alone* is incapable of supporting a healthy life, and is not among the foods which are richest in mineral matter.

CHAPTER XV

ITS DIGESTIBILITY

THERE can be no doubt that the demand of to-day is for foods of easy digestibility. The reason is not far to seek. Nowadays the struggle for existence is so keen that many people have little time to put into practice the principles of hygiene. We work at high pressure, and under conditions of life which are decidedly artificial. In a great number of cases this is surely undermining the digestive powers, so that foods which are easily digested are largely taken to counteract the impaired action of the digestive organs.

Another reason for the demand for partially-digested foods is that they consume less energy in their digestion; therefore more energy is available for other purposes.

But it is questionable whether these foods are good in all cases.

The organs of digestion are meant to do a certain amount of work, and, depend upon it, they are all the better for being allowed to do that work. When an organ is relieved of part of its normal work in the body, that organ to a certain extent becomes weaker. The author has recently proved that when *peptonised* foods are given to kittens and dogs, the gastric juice becomes partially *inert* towards proteids. This would lead us to the conclusion that *healthy* individuals are better without partially digested foods, for, by partaking of them, the digestive fluids lose much of their power in reducing the *insoluble* food.

No such objection, however, can be raised to any food which facilitates the action of the digestive fluids *without usurping their functions.* Such a food is distinctly beneficial to the body, and perfectly natural under our present conditions of life. Well baked bread of good quality may be placed at the top of this class of foods, as being pre-eminently digestible, while allowing every digestive juice to exercise to the full its functional powers.

In Chapter VI., Section I., it was pointed out that cooked starch was more easily digested than raw starch.

In a series of experiments conducted by the author the following results were obtained by using "artificial" saliva.

Raw starch (powdered) was acted on very slowly by the ferment. The first trace of sugar appeared at the end of 50 minutes, and complete digestion at the end of 4 hours.

Cooked starch was converted into sugar much more rapidly. The first trace of sugar appeared within 30 seconds, and complete digestion took place in 15 minutes. The starch from bread, after being first freed from sugar, showed traces of sugar in 10 seconds, and complete digestion took place in 8 minutes. In these experiments the same extract was used, and the preparations subjected to the same conditions.

It need hardly be pointed out that the experiments do not in any way indicate the time taken in the digestion of starch in the body. They merely show the *relative* digestibility of the different preparations of starch.

From these experiments we may conclude that the starch in bread is in such a condition that it is easily digested, though, as will be pointed out, by certain special methods it may be made to be even more digestible than it is in ordinary bread. In Chapter VII., Section I., it was stated that the smaller the pieces of albumin, gluten, etc., the more rapid is the stomachic digestion of them. Now light bread offers the largest surface possible to the action of the gastric juice. If the crumb of a loaf be examined it is seen to be permeated with interstices, separated by thin partitions, giving a large area of gluten for the action of the gastric juice. This is extremely favourable to digestion by pepsin, and places bread very high up in the list of foods with regard to digestibility.

In the same chapter it was stated that the peculiar combination of gluten-casein and gluten-fibrin with the starch rendered them more digestible than gluten cooked by itself.

A very important point is the percentage of soluble carbo-hydrates in the bread. The greater the quantity of sugar and dextrin the greater is the digestibility of the loaf. From this it follows that the crust of a loaf is more easily digested than the crumb, for the reason that it contains more dextrin, and being crisper is more readily reduced to fine particles. The proteids are, however, somewhat more difficult to digest.

The author, from a series of experiments on common foods, concluded that the following order accurately conveyed their *relative* digestibility:—

Rice, sago, tapioca, bread, milk, eggs, potatoes, mutton, beef, nuts, pork.

In the first three, it is important to state, only the digestion of starch was considered.

Bread made with yeast is much more digestible than that made by using chemicals. The reasons of this will be clear on studying the chapters on digestion. If sodium bicarbonate be used, then a certain quantity of sodium carbonate remains in the bread. This will be clear from the following equation :—

$$NaHCO_3 + heat = Na_2CO_3 + H_2O + CO_2,$$

which shows that the bicarbonate splits up into carbonate of sodium, water, and carbon-dioxide. Now, carbonate of sodium neutralises the acid gastric juice, thereby retarding digestion. (See Chapter VII.)

The same is true when tartaric acid or cream of tartar is used with the bicarbonate of sodium.

Bread made with sodium bicarbonate and hydrochloric acid is also less digestible than that made with yeast. The cause is that common salt is formed in bread according to the following equation :—

$$NaHCO_3 + HCl = NaCl + H_2O + CO_2,$$

which means that when hydrochloric acid acts on bicarbonate of sodium, common salt and water are formed and carbon-dioxide evolved.

Now, an excess of common salt in a food retards the action of gastric juice, and may produce certain forms of stomachic acidity. More of the proteid material in fermented bread is in the soluble condition than in the case of bread made by salt or the aëration process. On this account, therefore, the former may be said to be more digestible.

Sour bread is not so easily reduced as sweet bread. The cause is the acid which is present in the bread. An excess of acid arrests the action of ptyalin, and hinders the special action of pepsin on proteids. Recent researches, however, indicate that *traces* of certain organic acids may favour the action of the ptyalin.

Bread made from a sponge or dough which has not sufficiently fermented is also somewhat difficult of digestion, owing to the stringy character of the gluten. The gluten is not sufficiently separated, and therefore a smaller surface is presented to the action of the gastric juice and other digestive fluids.

Malted bread is distinctly more assimilable than ordinary bread, owing to the greater proportion of soluble carbo-hydrates present. The same may be said of bread to which *diastase* has been added. But the full consideration of these special breads must be deferred until Section IV. is reached.

CHAPTER XVI

WASTE PRESENT

There is a certain amount of "waste" present in most foods.

In animal foods this waste includes elastic tissues, mucus, and nuclei of cells.

The waste in vegetable foods consists chiefly of two substances known as *cellulose* and *woody fibre.*

Cellulose is a body having the same simple formula as starch and dextrin, consisting of the elements carbon, hydrogen, and oxygen. The two latter elements are present in the proportion to form water; hence cellulose belongs to the great class of the carbo-hydrates. Its simplest formula is $C_6H_{10}O_5$, which may be written $C_6(H_2O)_5$.

Though isomeric with starch and dextrin, it differs from them in several important particulars.

From our standpoint, we are specially interested in the action of certain ferments on cellulose.

When ptyalin of saliva or pancreatic diastase acts on starch and dextrin, the latter are converted into one or more forms of sugar, and thus rendered soluble and available for the nutrition of the body. Not so with cellulose. It remains unchanged under the action of the abovementioned amylolytic ferments. Now cellulose is insoluble in water, therefore it cannot enter the blood stream without undergoing such a change as will produce a soluble form. The only ferments likely to produce such a conversion are ptyalin and pancreatic diastase, and inasmuch as they do not affect the cellulose,—it must be excreted from the body in the same form as taken.

A careful analysis of the excrement has confirmed this deduction, by proving that cellulose is really excreted as such.

Cellulose, then, is of no use to the human being as food, being expelled from the alimentary tract without contributing in any way to the energy of the body.

It appears that the herbivora have the power of utilising cellulose. But it has not yet been clearly ascertained how and where the change takes place.

Some authorities assert that the cæcum performs this function by means of a special ferment, and the enormous development of this part of the alimentary canal in the herbivora certainly supports such a view.

Cellulose is found more or less in nearly every part of a plant, but more especially in the succulent portions. It usually forms the envelopes which enclose the starch grains and other nutritious constituents of vegetables. It is therefore found in small quantities in flour, and consequently also in bread.

Woody fibre is usually found in the more external parts of a plant, and is consequently present in considerable quantities in whole-meal.

It is only present in traces in fine flour, and, therefore, white bread only contains a minute quantity.

Woody fibre has the same composition as cellulose, being isomeric with that body, and also with starch and dextrin.

Ferments have no power to change woody fibre into a soluble form; it is thus of no value as a food. Even in the herbivora it is probable that little or none of the woody fibre is used by the body.

It follows from this that the greater the quantity of cellulose and woody fibre present in a food, the less is its nutritive value.

The proportion of fibre, etc., present in fine white bread does not amount to more than about 3 parts in 1000.

The actual amount of fibre, etc., present, however, does not indicate the total amount of waste. There is usually associated with the fibre a certain amount of nutritious matter, which is not available to the body, owing to the fact that it is locked up in the insoluble portions in such a way that the digestive juices cannot act on it. This modicum of undigested constituents must be regarded as waste.

Bread made from coarse white flour contains rather more cellulose and fibre than that made from very fine grades. White bread is thoroughly digested in the alimentary tract, and only a very small portion is excreted as waste.

When standard artificial digestive juices are used to digest bread, nearly the whole of the gluten appears as peptone, and practically the whole of the starch, etc., as sugar.

The author conducted a series of experiments on the waste of bread in 1889. He used a special churning chamber, and special means were taken to remove excess of peptones. He found that the waste in fine white bread never exceeded 3·8 per cent.

In subsequent experiments upon himself he found the waste to be slightly more—averaging about 4·2 per cent.

Coarser bread averaged about 4·9 per cent. In white rye bread the percentage of waste rose as high as 10·9.

There can be no doubt that white bread is very easily and thoroughly digested, and thus is of the utmost value as a food, when the deficiency of proteids and salts is made up by other foods.

Very careful experiments have been conducted in Continental laboratories by Meyer and others, in which the experimenters lived for fixed periods on certain foods, and ascertained the amount expelled from the body.

The following table gives some of the results obtained—

Food.	Waste in 100 Parts.
Sugar	0
Butter	2

Food.	Waste in 100 parts.
Rice	4
Fish	4·9
Maccaroni	4·3
Beef	5·2
White bread	5·6
Milk	9·0
Potatoes	9·4
Rye bread	10·1
Cabbage	14·9
Carrots	20·7

The results obtained by the author differ somewhat from those obtained above in the case of bread. The differences are shown below—

	Author.	Table.
Fine white bread	4·2	5·6
Coarse ,,	4·9	
Rye ,,	10·9	10·1

The author believes from the results obtained in his experiments that the waste in white bread has been generally overstated.

About 73 per cent of the ash of white bread is assimilated, a very high percentage for a vegetable food.

It will be seen that white bread compares most favourably with other foods in regard to the waste present.

CHAPTER XVII

FLAVOUR, STALENESS, AND OTHER POINTS

THE value of any food is partly determined by its flavour. No matter how nourishing a food may be, if it possesses little or no flavour, it is comparatively useless as a common article of diet. The organs of taste are able to distinguish a large number of different flavours, and it is perfectly possible either to cultivate or deaden their sensibility. Many flavours which are distasteful to an individual at first may become pleasant after a time, owing to the cultivation of the sensory organs concerned in their appreciation.

Few people are aware how intimately the sense of smell is connected with the sense of taste. Yet the co-ordination is so strong that many substances become *tasteless* when the functions of the nose are suspended by a severe cold, or by other means.

Many so-called tastes are really the appreciation of odorous particles, which find their way into the upper chambers of the nose by way of the pharynx and posterior nares, and others are combinations of both taste and smell. Flavours probably partake of the nature of the latter, being the result of sensory impulses which originate in the nose as well as in the mouth.

An experiment was performed some time ago in Germany, in which an individual was given meat deprived of its flavouring bodies. It was found that after a little time the meat was always left and never eaten, and when asked the reason the subject said that it had no taste, and the thought of eating it brought on nausea.

This proves the importance of flavour in foods.

There can be no doubt that the more palatable a food is the better it is for the digestion, provided that the flavour is natural.

The flavour of bread made by the use of yeast is a very pleasant and complex one, and never produces satiety. It is probable that the complex nature of the flavour is due to the presence in minute quantities of certain bodies formed during fermentation. This is proved by the fact that bread made by other means does not possess the same complexity of taste.

The flavour depends largely, also, on the amount of sugar and dextrin present, and varies with the kind of flour used.

The flavour of bread made without yeast is not so complex as that of bread made with yeast, though it may be a pleasant one, and many people even prefer the simpler taste of the non-yeast bread. A most important point is *sweetness*. A sweet loaf is always pleasant to the palate, and far more digestible than a sour one.

Bread never produces satiety if properly made. This does not depend entirely upon the flavour, but also upon the variety of its components. The element of digestibility also enters into the cause of its satisfying action on the body, for the economy is quick to recognise and be satisfied with a food which is easily digested without impairing the functional powers of the digestive fluids.

Flavour, however, does affect the satiety of bread to a certain degree, for bread of bad flavour, if eaten regularly, is soon disliked, and discarded for a better flavoured variety. Well-baked loaves have a better flavour than those which are not well baked, and malted bread made from a sponge which has under-gone quick fermentation develops a fine nutty flavour which makes it very pleasant to the taste. The flavour which appears to be liked best by the public is a sweet and nutty flavour without sourness.

The crust has a different flavour to the crumb, due to the changes which have been caused in the constituents, by the great heat to which it is exposed in the oven. Most people like the flavour of the crust better than that of crumb; a well-baked loaf, therefore, is far more palatable than a softer one.

The flavour of new bread is different from that of stale bread. It is not quite clear how the difference of flavour is brought about. Staleness is not due entirely to the loss of water, though the evaporation has much to do with it. This is proved by the fact that a stale loaf may be reconverted into a new loaf by subjecting it to great heat. It appears that some molecular change, possibly the dehydration of the carbo-hydrates, goes on in conjunction with the simple evaporation of uncombined water during the conversion of the new bread into stale bread.

The following table gives the average loss in white bread. The numbers are the mean of about fifty determinations, the unbroken loaf being used:—

In the first	12	hours,	0·9	per cent
"	24	"	2	"
"	36	"	5	"
"	48	"	8	"
"	60	"	11	"
"	72	"	14	"

If this table be reduced to ounces, then a 2 lb. loaf would lose by evaporation—

In the first	12	hours	about	$\frac{2}{7}$	oz.
"	24	"	"	$\frac{2}{3}$	"
"	36	"	"	$1\frac{3}{5}$	"
"	48	"	"	$2\frac{14}{25}$	"
"	60	"	"	$3\frac{1}{2}$	"
"	72	"	"	$4\frac{1}{2}$	"

Von Bibra gives the loss by evaporation as follows:—

In 24	hours,	7·71	per cent.
72	"	8·86	"
168	"	14·05	"

It is probable that Von Bibra used slices of bread or portions cut from the loaf. The loss of water is more rapid when the loaf is cut than when allowed to remain intact.

Stale bread also contains less alcohol than new bread.

It is probable that the difference in flavour is produced by—

(1) The loss of water.
(2) The loss of alcohol.
(3) A change in the molecular basis of the bread.

Stale bread is more nourishing than new bread, owing to the smaller percentage of water which it contains. It is also more digestible, allowing the digestive juices to act more readily on its constituents.

There is a popular idea that toast "dries up the blood," and many people will not partake largely of it on this account. Nothing could be more absurd than this idea. Toast does not "dry up the blood," or act in any way injuriously upon the body. It is a very pleasant and digestible form of bread.

During the process of toasting certain changes take place in the slice of bread. There is a loss of water by evaporation, and the bread thus becomes very much drier.

So great is the loss of water that the outside of the slice is rendered very crisp.

Part of the starch, too, is converted into the more soluble form of dextrin by the extreme heat of the fire. Caramel may also be formed. This change takes place chiefly in the outer layer, which becomes brown during the process. If the toast be subjected for a considerable time to the action of the heat a portion of it may be carbonised.

Toast is more easily digested than ordinary bread, inasmuch as it contains a greater percentage of soluble carbo-hydrates. It is also more easily acted on by the digestive fluids, being very crisp and readily reduced to small particles by the teeth.

Weight for weight toast contains more actual nourishment than untoasted bread, and to some people has a better flavour. It is probable that the absurd notion about the action of toast on the blood originated in the observation that toast was itself *very dry*, and necessitated the ingestion of a greater amount of coffee, tea, etc., than if ordinary bread had been taken.

Too much butter should not be taken with toast, and it should be eaten immediately after preparation, and not allowed to stand with the butter on inside the oven, or in front of the fire.

The flavour of Scotch and Irish bread is somewhat acid, this being due to the presence of lactic acid in minute quantities.

The acid is produced from the sugar by fermentation, brought about by the action of *B. Lactis.*

The *B. Lactis* is not allowed to proceed very far with the souring fermentation, the object being to produce just sufficient acid to give to the bread a very slightly "piquant" taste.

The acid is not present in sufficient quantities to materially affect digestion.

The flavour of Vienna Bread is also characteristic. The bread gives a very "bland" sensation in the mouth, especially if made with milk. Potatoes are not used in the manufacture of this bread. It is made from very fine flour and compressed yeast.

CHAPTER XVIII

WHETHER ADAPTED FOR INFANT FEEDING

THE natural food of an infant is the mother's milk, but from a variety of causes many infants have to be brought up by hand, and fed on artificial foods.

It does not fall within the scope of this work to discuss the subject fully. We have only to inquire how far *bread* fulfils the conditions of a perfect food for infants.

The most logical method of studying this question is to compare bread with the normal diet of an infant, and to ascertain how far bread supplies the infant with the various proximate principles it requires. Human milk has the following composition :—

Proximate Principle.	Food Stuff.	Percentage.
Water	Water	88·908
Proteids	Casein	3·924
Fat	Palmitin, Stearin, Olein	2·666
Carbo-hydrates	Lactose	4·364
Mineral matter	Phosphates, Chlorides, Iron, etc.	0·138
		100·000

Neglecting the water, we find that the various principles are grouped in the following proportions in 100 parts :—

Proteids	35·3
Fat	24·0
Carbo-hydrate	39·4
Mineral matter	1·3

On studying this table we are struck with the high percentage of proteids and fat. From this we conclude that an artificial infant food should also be rich in proteids and fat.

Another very significant fact is, that the carbohydrate material exists in the form of *lactose* or *milk sugar*, which is soluble. There is no trace of starch or any allied body in milk.

The reason is undoubtedly that the diastasic ferments of saliva and pancreatic juice are not developed properly until many months after birth. At birth the parotid gland is the only one which contains ptyalin, and it has little power of acting on starch. Even after four or five months the saliva of the infant has little amylolytic power.

Pancreatic diastase is entirely absent from the pancreas of a new-born babe, and does not develop fully until the age of 10 or 12 months.

If milk, then, contained starch, it would probably be excreted from the body without being digested.

When the salts of milk are analysed, they are found to consist largely of phosphates of calcium and magnesium.

The former salt is very essential to the formation of new tissues, as it governs certain changes which take place in the proteid matter of the food before it becomes actual tissue. It appears to stimulate the growth of new tissue material in the various organs, and in its absence the nutrition of proteid tissues flags.

Besides this, it is largely concerned with the phosphate of magnesium in the formation of bone and teeth, and rickets are often produced when it is only present in small quantities.

Summing up, we may say that any food to take the place of mother's milk should fulfil the following conditions:—

(1) It should contain the proximate principles in the same proportion as human milk. (See table above.)
(2) It should contain no starch.
(3) It should be of easy digestibility.
(4) It should contain a fair amount of phosphates, especially phosphate of calcium.
(5) It should be anti-scorbutic.
(6) It should be perfectly fresh and not prone to decomposition.

Does white bread fulfil all these conditions?

The answer to this question must be in the negative. It answers fairly well to numbers 3 and 6, but utterly fails to respond to numbers 1, 2, 4, and 5.

White bread gives the following proportions in 100 parts, neglecting water:—

Proteids	12·0
Carbo-hydrates	85·4
Fat	1·5
Mineral matter	1·5

If this table be compared with the one given above, it will be seen that there is a deficiency of 23·3 per cent of proteids, 22·9 per cent of fat, and a surplus of 46 per cent of carbo-hydrate material.

There can be no doubt, after this comparison, that white bread is entirely unsuited for infants, and even when supplemented by milk, the surplus of carbo-hydrates and the deficiency of fat cannot be entirely obviated.

The deficiencies of white bread may be still more strikingly shown if compared with an actual weight of milk—

An infant	1 month old	requires	daily	18 oz.	of milk.
,,	2 months	,,	,,	24 oz.	,,
,,	3 ,,	,,	,,	28 oz.	,,
,,	4 ,,	,,	,,	33 oz.	,,

Taking four months as a basis, the following table gives the total amount of nutriment derived from 33 oz. of human milk and an equivalent of dry bread.

The milk would contain about 3·7 oz. of solid matter. The same quantity of solid matter would be yielded by 6 oz. of white bread. Working these quantities out, we get the following proportions in ounces :—

	Milk, the Normal Food.	White Bread.
Proteids	1·38	0·45
Carbo-hydrates	1·41	3·16
Fat	0·85	0·04
Mineral matter	0·06	0·05
	3·70	3·70 oz.

An infant four months old fed on white bread would receive 1¾ oz. of carbo-hydrate material too much. At the same time there would be a deficiency of nearly 1 ounce of proteid, and ¾ of an ounce of fat.

The importance of fat in the diet of an adult has already been alluded to. But it is far more essential to the wellbeing of an infant. Young children who are brought up on a diet containing too little fat soon become weak, and the growth of new tissues is retarded.

It is generally believed that in young animals fat has a most important influence on the building up of new tissues, besides its ordinary action on the intestinal tract.

An infant also requires a comparatively large proportion of proteid material. Not only have the *existing* tissues to be renewed, but a surplus of nitrogenous matter should be supplied to furnish material for the formation of *new* tissues. If this surplus be not supplied in the diet, the growth of organs is checked, and the child lacks vigour and strength.

As the table above proves, white bread is very deficient in fat and proteids, and would therefore be detrimental to infants.

A very serious objection to the use of bread for infants is the fact that it contains *starch*. It is perfectly true that the starch in bread is far more easily digested than the starch in many farinaceous foods. But, notwithstanding this, bread cannot be recommended as a food for children below the age of 10 months. It has been previously pointed out that the diastasic ferments are not developed in early infancy, and that, therefore, starch is totally unsuited for ingestion into the alimentary canal. Many infants are hurried into an early grave by the serious derangements set up in the intestines by the irritating action of the insoluble starch on the delicate mucous membrane which lines the alimentary canal.

Ulceration of the bowels, often leading to consumption, is sometimes traced to the action of starch, combined with a deficiency of proteid material.

It has been already stated that white bread is very deficient in phosphate of calcium. This fact in itself should be sufficient to prevent parents from feeding infants largely on white bread.

The phosphates are not only concerned in the formation of bone, but no cell growth can efficiently go on in their absence. This is especially the case with calcium phosphate, which is now looked upon as being essential to the formation of new cells.

If this salt be present in insufficient quantities, not only are the bones and teeth retarded in their development, but, what is just as important, *the other tissues are checked in their growth*, and the whole body becomes weak and impaired.

White bread is also lacking in iron, and therefore is unsuitable to nourish the red corpuscles of the blood.

Many forms of anæmia are due to the deficiency of iron in the corpuscles.

It is beyond doubt the iron which is mainly concerned in the conveyance of oxygen to the tissues, and a lack of this body must lead to pallor, lassitude, and a general feeble condition of the body. The nutrition of the tissues is also impaired, for the presence of a good supply of oxygen largely determines the changes which go on within them, and which result in the formation of new cells and fibres. Oxygen is specially required by the infant, as the growth of new tissues is vigorous and rapid, and any food which reduces the oxygen-carrying power of the hæmoglobin of the blood must be detrimental to the health of the child.

Another objection has been urged against bread as an infant food, viz., that it is not sufficiently antiscorbutic, and its use therefore tends to the development of certain forms of scurvy and rickets.

If bread be used at all for infants, it should be prepared according to the formula of Dr. Churchill.

Four ounces of dry bread are soaked in cold water for 6 hours and strained. The pulp is then gently boiled for about $1\frac{1}{2}$ hours, by which operation the starch granules are thoroughly broken up, and the change into dextrin and sugar promoted.

The thick mixture obtained by this boiling is strained and forced through a fine sieve, and allowed to cool.

But this food is deficient in many things, as explained above, and should be supplemented by adding either boiled milk or meat juice and cream, as advised by some high medical authorities. The author prefers the use of Frame Food Extract of Bran, which is very rich in proteids and phosphates, combined with good butter.

Although such a preparation would be fairly satisfactory as regards the amount of proximate principles, yet there is the objection that it contains *starch*—a substance quite unsuited to the infant economy. Moreover, the meat juice would be very liable to decompose, and it contains certain waste nitrogenous bodies which may act injuriously on the body.

Another point is worthy of mention, viz., that white bread is rather favourable to constipation, and often produces this condition of the intestines when given to infants. Constipation is especially harmful to children, and may produce many disturbances in the economy. Convulsions are favoured by constipation during the teething period, and various decompositions are set up in the lower bowel by the food being retained too long within it.

Taking all things into consideration, it may be safely affirmed that white bread is not a suitable food for infants under the age of 10 months, and should not be given until the amylolytic ferments have had time to develop. In no case should it form the *chief* food, for reasons already stated. Bread may be given to children above 10 months, as the diastasic ferments of saliva and pancreatic juice have then sufficient power to act on the starch. No food, with the exception perhaps of porridge, presents starch in so assimilable a form as bread, and for this reason it may with advantage be given to older children. But being deficient in fat, proteids, and phosphate of calcium, it should on no account form the staple food, but be largely supplemented by milk, fresh fruit, vegetables, and genuine butter.

CHAPTER XIX

ADULTERATIONS AND IMPURITIES—EFFECTS

MOST of the works on the chemistry of bread, and the manuals of food analysis, give rather formidable lists of substances which have been used from time to time by fraudulent bakers to adulterate bread. Dr. Winter Blyth, in his great work on the analysis of food, gives the following list:—

(1) *Chemicals.*—Alum, borax, copper sulphate, sulphate of zinc, carbonate of calcium, and carbonate of magnesium.

(2) *Foreign Flours or Meals.*—Rice flour, potatoes, bean flour, pea flour, maize meal.

(3) *Impurities.*—Ergot, fungi of various kinds, acarus farinæ, bacteria, purple cow-wheat, melampyrum arvense.

The substances enumerated in groups 1 and 2 have been added at various times to the flour, in order to increase the yield of bread by causing a greater absorption of water, or to improve the colour of the loaf, thus enabling inferior flour to be used in its manufacture.

In some cases the foreign meals have been used because they are cheaper than wheaten flour.

Although it is undoubtedly true that these bodies have been used at different times by individual bakers, it is now certain that the bread supplied to the people of England is practically pure.

The author is in a position to speak with some degree of confidence and authority on this point.

For the purposes of another work on food he made an exhaustive series of examinations of various foods, in order to ascertain the purity and quality of them.

Among the foods examined bread was accorded the greatest attention and the greatest number of examinations, and the author was struck with the invariable *purity* of the samples examined. Specimens of bread from all parts of England, as well as London, were carefully tested for adulterants, and only in a very few cases were they detected.

The following is a very brief summary of the results obtained in regard to bread:—

LONDON.

No. of Samples examined.	Pure.	Alum.	Foreign Meal, etc.
341	333	3	5

This result is highly satisfactory, giving only a percentage of 2·3 of adulterations. The three samples which were adulterated with alum were otherwise perfectly pure. Of the five samples adulterated with foreign meals, three consisted of wheaten flour and ground rice, and the other two of wheaten flour and British arrowroot.

In no case was copper sulphate or bean flour found present.

The provincial results were slightly below those of London.

PROVINCES.

No. of Samples examined.	Pure.	Alum.	Foreign Meal, etc.
194	189	2	3

All the three samples adulterated with a foreign meal consisted of wheaten flour and ground rice.

In all these analyses allowance was made for "cone flour," and the small percentage of potatoes present derived from their use in the fermentation.

From these researches we may conclude that, in England, the only adulterants used in the making of bread are alum, potatoes, and rice flour, and these in only a very few cases.

Alum is often added by the baker to arrest fermentation. It also gives a whiter colour to the loaf, and enables inferior flours to be used.

It is usually only present in traces, though instances have been recorded where it has been detected in considerable quantities.

It is an astringent, and used in medicine as a gargle and for outward application. It is also used as an injection in certain diseases in which the vessels are relaxed.

Many medical authorities assert that if it is taken internally, and finds its way into the blood, it has an astringent action on the organs. Its local action on the alimentary canal is to produce constipation, and a mild form of dyspepsia. Another effect of alum is to render the phosphoric acid of the bread insoluble by combining with it to form the insoluble phosphate of aluminium. Thus one of the most valuable mineral constituents of the bread is lost to the body.

It is only fair to point out that other authorities maintain that traces of alum do not produce any appreciable ill effects on the body.

Owing to the education of the people in food reform, one reason for the addition of alum has been done away with. They no longer look upon the extreme whiteness of a loaf as being an essential element, but rather judge bread now by its flavour and its satisfying power.

The addition of rice and potato starch to bread lowers its nutritive value. In the first place, the bread takes up more water; and secondly, the nitrogenous ratio is lowered.

We have seen that the nitrogenous ratio is already too low in bread, and that it might with advantage be raised. Anything, therefore, which lowers the percentage of gluten in bread renders it less nutritious.

Rice and potatoes are both rich in starch and poor in albuminoids. This will be seen by glancing at the following tables giving the composition of rice and potatoes:—

	Rice.	Potatoes.
Water	12·5	75·7
Albuminoids	6·2	2·3
Starch, etc.	80·0	20·0
Fat	0·7	1·0
Mineral Matter	0·6	1·0
	100·0	100·0

The effect of the addition of these substances to bread is to increase the percentage of carbo-hydrates (starch, etc.), and to lower the proportion of gluten and phosphates.

The following is a comparison of a loaf of pure white bread with one adulterated by the addition of rice:—

	Pure.	Adulterated.
Water	37·0	43·0
Nitrogenous	7·5	5·5
Carbo-hydrates	53·8	50·0
Fat	0·8	0·7
Mineral Matter	0·9	0·8
	100·0	100·0

Another effect of adding rice to bread is to make it more indigestible, inasmuch as the bread does not rise so easily, and, being of a closer texture, does not present so large an area for the action of the digestive juices.

Of the impurities mentioned, none were found in British flours, and only a very small percentage in flours obtained from foreign wheat.

Most of them are harmless, but a few, like ergot, may produce severe symptoms, if ingested. But the occurrence of such cases is so rare that a lengthy account of them would be out of place in this work. They will, however, be briefly considered in Section V.

A good deal of inferior, though pure, bread is supplied to the public. The reason is not far to seek. The rage of to-day is "cheapness," and people will blindly purchase cheap bread without pausing to inquire whether it is possible to supply a really good loaf at the price they are paying. Bakers must meet the demand for cheap bread; hence the quality of the bread is not always up to the mark. The bakers are not entirely to blame for this. They merely supply the demand of the public for cheap bread. The fault lies with the public. They have not yet recognised the paramount importance of obtaining bread made from the very best grades of flour, and by the most approved methods.

The people require educating in this respect, so as to be able to see the gain to the body of really first-class bread.

Food reformers have been rather hard on the bakers. They have blamed the makers of our bread for making such poor stuff, and eloquently appealed to them to reform. But these ardent hygienists have forgotten that the baker must live, and that he is only meeting the demand of the public as a business man. Let all those who think our bread is not of the very best try to educate the people up to the point of recognising the value of a loaf made from the very best flour, and of appreciating this fact, that a baker cannot use the very best flour, apply the most approved methods of manufacture, and employ thoroughly competent men, unless he charges a fair price for his product.[1]

[1] For the methods of detecting adulterants, the reader is referred to any text book on Food Analysis.

SECTION III

WHOLE-MEAL BREAD

CHAPTER XX

INTRODUCTORY

Ten years ago very little whole-meal bread was eaten in this country. The bread which was supplied under the name of "brown bread" was usually made from a mixture of white flour and bran, and resulted in a loaf far inferior in nutritive value to the ordinary white loaf. But of late years whole-meal bread has been partaken of in increasing quantities, and now a considerable percentage of the English nation have altogether discarded white bread in its favour.

This result has been largely brought about by the writings and lectures of food reformers, and by the influence of a section of the medical profession. Dr. T. R. Allinson has done more than any other living man to spread the use of whole-meal bread in this country, and there can be no doubt that the increased demand for it is mainly due to his writings and lectures. No bread is entitled to be designated "whole-meal" unless it is made from meal, obtained by grinding or pulverising the *entire* wheat grain. Bran bread, decorticated bread, etc., are not really whole-meal breads, inasmuch as the proportions of the various constituents are not the same as in the entire grain in the former case, and some parts of the grain are removed in the latter.

Whole-meal is obtained by reducing the entire grain, so that the outer layers which yield the bran are retained in the flour.

It has been pointed out in a previous chapter that these layers are richest in albuminoids and phosphates, and a careful analysis of whole-meal reveals the fact that it is richer in these food substances than white flour.

The appended table shows this difference clearly—

	Flour.	Whole-meal.
Water	12·0	14·0
Proteids	9·3	14·9
Carbo-hydrates	76·5	66·2
Fat	0·8	1·6
Fibre	0·7	1·6
Mineral matter	0·7	1·7
	100·0	100·0

From the chemical analyses, it would be assumed that whole-meal bread is far more nutritious than ordinary white bread. But an analysis does not always indicate the dietetic value of a food, and we shall see that the value of whole-meal bread depends almost entirely on the degree of fineness of the meal.

Large bran particles are really quite indigestible, and lock up much of the valuable proteid matter in such a manner as to render it impossible for the digestive juices to act on it.

The important phosphates are also imprisoned in a similar way, so that only minute quantities are dissolved by the fluids of the body.

The hard particles of bran also act as an irritant to the delicate mucous membrane of the intestines, and as mechanical stimuli to the involuntary muscles and the nerve plexuses of the walls of the bowels. The intestines are thus irritated to contract with greater force, and the food is passed along the internal tract too quickly.

If the bran particles be large these effects are very marked, and may even produce diarrhœa, and inflammation of the internal coat of the intestines.

The author is not opposed to the use of whole-meal bread, *provided the meal is properly prepared.*

From a careful series of experiments performed by the author for the purposes of this work, details of which will appear in succeeding chapters, he has come to the conclusion that the whole-meal bread made from *ordinary* whole-meal is not always a desirable food. It is usually far too coarse, and lacks good flavour. He maintains that ordinary methods of grinding do not reduce the bran to a sufficiently fine state of division. Special means are required to reduce the hard envelope of the wheat grain to very fine particles, and no whole-meal is satisfactory unless the bran is very finely divided.

In this section *ordinary* whole-meal bread will be dealt with—that is to say, bread made from meal which has been ground in the ordinary way. The whole-meal breads, made from special whole-meals prepared by patent processes, will be considered in Section IV., under the head of Special Breads. The author does not intend to enter into the subject of the "natural food of man" in connection with whole-meal bread. He believes that it is useless to attempt to determine what is our natural food in these days by reference to the probable food of ancient man. The conditions of life have so altered that the "natural" food of our ancestors would be unnatural now, living, as we do, under such different conditions.

The most logical method of determining the dietetic value of a food is to examine and test it by the light of modern science, and to judge it by the effects which it produces on the body.

In the succeeding chapters the following points will be considered:—

(1) The composition, especially the nitrogenous ratio.
(2) The amount and nature of the salts present, and their solubility.
(3) The digestibility.
(4) The waste present, and the action of bran on the intestines.
(5) Flavour, satiety, and dryness.
(6) Effects on infants and children.

CHAPTER XXI

COMPOSITION OF WHOLE-MEAL BREAD

WHOLE-MEAL bread varies in composition according to the kind of wheat from which the meal is obtained.

The following may be said to represent the analysis of a fair average sample of ordinary whole-meal bread:—

WHOLE-MEAL BREAD.

Water	40·0
Proteids	12·2
Carbo-hydrates (starch, etc.)	43·5
Fat	1·2
Fibre	1·8
Mineral Matter	1·3
	100·0

On comparing this percentage composition with that of white bread, it will be seen that the ratio of nitrogenous bodies is much higher, and the ratio of carbo-hydrates much lower. It will also be noticed that there is slightly more fat and mineral matter.

On the supposition that whole-meal bread is digested to the same extent as white bread, it would approximate very closely to a perfect food as regards the nitrogenous ratio.

Careful experiments, however, have proved that whole-meal bread contains far more waste material than white bread.

This point will be fully dealt with in a succeeding chapter. All that need be said now is that about $12\frac{1}{2}$ per cent of ordinary whole-meal bread is excreted undigested from the alimentary canal in the form chiefly of woody fibre, cellulose, salts, proteid material, and fat.

This $12\frac{1}{2}$ per cent of waste is not spread equally over the various food stuffs. The mineral matter suffers most in this respect. Nearly the whole of the starch is digested and absorbed, but the albuminoids, fat, and salts are in a great measure excreted unchanged.

We are mainly concerned in this article with the ratio of the nitrogenous matter to the carbohydrates. The deficiency of fat is so easily and universally made up by the use of butter that it need not enter into the present calculations.

The amount and nature of the salts present will be taken in the next chapter.

The author has calculated from a careful series of experiments that at least $\frac{1}{5}$ of the proteids and $\frac{2}{5}$ of the fat in ordinary whole-meal bread are excreted undigested from the body. Of the total amount of carbo-hydrates, about $\frac{1}{20}$ is excreted undissolved.

Taking Professor Corfield's figures as the standard, we find that a man requires 4·5 oz. of dry proteids, and 14·25 oz. of dry carbo-hydrates daily, yielded by 22·75 oz. of dry mixed food.

If we take 22·75 oz. of *dry* whole-meal bread, and calculate the amount of proteid and carbo-hydrate material yielded to the body, we shall be able to see how far whole-meal bread comes up to the standard diet as regards proteids and carbo-hydrates.

Working the calculation out, and allowing for waste, we find that 22·75 oz. of dry whole-meal bread yield to the body 3·7 oz. of proteids and 16 oz. of carbo-hydrates.

This gives a deficiency of ·8 oz. of proteid, and a slight surplus of amyloids. Ordinary whole-meal bread is thus more nearly a perfect food than white bread as regards the nitrogenous ratio. The nitrogenous ratio in a perfect food is as 1 is to 3·2. In ordinary whole-meal bread it is as 1 is to 4·3. It can never, however, be a *perfect* food in every respect, for there would always be a deficiency of fat and mineral matter.

If we take grains of carbon and nitrogen as the standard we arrive at the following results:—

22·75 oz. of dry whole-meal bread yield about 260 grains of nitrogen and 4107·5 grains of carbon. This gives a ratio of 1 to 15, or nearly that of a perfect diet, the latter being 1 to 15·3.

This calculation also shows that the standard weight of food in bread would be insufficient for a full-grown man, who requires 4600 grains of carbon and 300 grains of nitrogen daily.

In order to supply the body with the necessary 4·5 oz. of proteid, an individual would have to consume 27·6 oz. of dry whole-meal bread. This amount would be yielded by about 46 oz. of moist bread. But the 46 oz. of moist bread would furnish a surplus of about 4·75 oz. of carbo-hydrate material.

It has already been explained (Chapter III., Section II.) that a surplus of amyloids cannot well perform the functions of fat, and that it acts injuriously on the body. These theoretical results have been fully confirmed by actual experiments. (See Chapter XXIV.)

Ordinary whole-meal bread, then, is not a perfect food for the following reasons :—

(1) It yields too little proteid to the body.
(2) It yields a surplus of carbo-hydrate material.
(3) It is deficient in fat.
(4) It is deficient in mineral matter.

It is not, however, very far removed from an ideal food as regards its nitrogenous ratio, and if all, or nearly all, its proteid material were digested in the body, the proportion of nitrogen would be perfect.

The only method of obtaining this result is to render the particles of bran *much finer*, for the larger part of the undigested nitrogenous matter is found in connection with the bran, and there can be no doubt that the finer the bran particles the more thoroughly whole-meal bread is assimilated.

The energy derivable from a 2 lb. loaf of ordinary whole-meal bread is shown in the following table.

The method of calculation has already been given in Chapter III.

Taking the standards of Drs. Frankland and Playfair we find that a 2 lb. loaf of ordinary moist whole-meal bread gives about 2500 foot-tons.

It will be convenient if a comparison be given of the three kinds of bread already dealt with.

(1) Ratio of Nitrogenous Matter to Carbohydrates.

Standard	1 : 3·2
Fine white bread	1 : 7·0
Coarse white bread	1 : 5·4
Ordinary whole-meal	1 : 4·5

(2) Ratio of Nitrogen to Carbon.

Standard	1 : 15·3
Fine white bread	1 : 22·7
Coarse white bread	1 : 19·0
Ordinary whole-meal	1 : 15·0

(3) Energy Derivable from 2 lb. Loaf.

Fine white bread	2820·5 foot-tons.
Coarse white bread	2823·9 "
Ordinary whole-meal	2500·0 "

CHAPTER XXII

THE AMOUNT AND NATURE OF THE SALTS PRESENT

ANALYSIS shows that a loaf of ordinary whole-meal bread contains a greater quantity of mineral matter than a loaf of white bread; but this fact must not be taken as indicating that all the mineral matter is absorbed, or that ordinary whole-meal bread yields a much larger proportion of salts to the body. As will be pointed out when the waste in whole-meal bread is considered, much of the mineral matter is excreted with the *fæces.*

In fine white bread about 27 per cent of the ash is excreted, but in ordinary whole-meal bread the percentage rises to about 50.

100 oz. of moist fine white bread yield to the body ·65 oz. of mineral matter.

100 oz. of moist ordinary whole-meal bread yield to the body about the same amount.

The reason of this will be pointed out in a succeeding chapter on the waste present in whole-meal bread. In a previous chapter it was stated that about 40 oz. of moist whole-meal bread were required to furnish the body with the normal amount of proteid material. This weight of bread would yield to the body ·26 oz. of mineral matter, being nearly ¾ of an ounce *too* little. That ordinary whole-meal bread is deficient in salts is easily proved.

The author has confirmed the conclusion of Chossat, that the amount of salts is not sufficient to keep a warm-blooded animal in good health by repeating and extending the experiments of that observer.

He found that an adult pigeon fed on wheat and *distilled* water soon showed signs of feebleness, and there was evidence of absorption at the expense of the bones. When extracts from meat and other substances rich in animal salts were added to the wheat, the pigeon rapidly recovered its strength and vigour, and the absorption of the bones was checked.

Similar results were obtained in the case of fowls.

The following are the chief details of the experiment:—

The wheat left by incineration 1·7 per cent of ash.

On analysis the ash yielded ·23 per cent of calcium phosphate and ·63 per cent of alkaline phosphate.

The pigeon weighed 365 grams, and was confined in a large cage with an enamelled bottom and side.

Exercise was allowed at stated intervals under supervision.

The excrement was carefully collected and the amount of phosphates estimated.

The experiment was carried on for 10 weeks, during which time no food was allowed but wheat and distilled water.

The following table gives the results obtained. No account was taken of the first week.

	Wheat Consumed in Grams.	Weight of Calcium Phosphate Ingested.	Weight of Alkaline Phosphate Ingested.	Weight of Calcium Phosphate Excreted.	Weight of Alkaline Phosphate Excreted.	Weight of Bird.
First three weeks	432	·99	2·72	1·89	2·21	310
Second three weeks .	429	.98	2·70	1·63	1·93	305
Third three weeks .	419	·96	2·63	2·03	2·10	302
	1280	2·93	8·05	5·55	6·24	Total loss in 10 weeks = 63 grams.

The table shows that during the 10 weeks the pigeon ingested 1·280 grams of wheat, containing—

2·93 grams of calcium phosphate
8·05 ,, alkaline ,,

It excreted during that period—

5·55 grams of calcium phosphate
6·24 ,, alkaline ,,

There was thus an excretion of 2·62 grams of calcium of phosphate (probably absorbed from the skeleton) over and above the amount ingested.

This shows conclusively that wheat alone is too poor in calcium phosphate to support animal life.

The experiment was stopped at this period instead of being carried to the extreme stage in which the animal dies, and a solution of bicarbonate of calcium was given instead of distilled water.

The bird rapidly regained its vigour, and in 6 weeks weighed 358 grams.

The wheat consumed during the latter period weighed 990 grams, containing 2·27 grams of calcium phosphate, and 8·23 grams of alkaline phosphates.

During that period there were excreted 8·69 grams of calcium phosphate and only ·21 grams of alkaline phosphates.

The only conclusion possible from this result is that a reaction had occurred between the alkaline phosphate and the bicarbonate of calcium by which the phosphate of calcium had been formed.

In the case of two fowls similar results were obtained, the birds being restored to vigour by the addition of extract of meat containing the salts.

Notwithstanding the assertion of many hygienists that ordinary whole-meal bread is sufficient to sustain life alone, the author maintains that sooner or later its exclusive use would lead to impaired nutrition, due to the deficiency of fat and salts.

It is a very significant fact that the *finer* the whole-meal bread, the greater the percentage of salts absorbed, and it will be shown in Section IV. that many of the special whole-meal breads yield a far greater quantity of mineral substances to the body than the ordinary whole-meal bread. The salts in whole-meal bread are practically the same as those present in fine white bread, but the proportions are different. There is more phosphoric acid in whole-meal bread, and more lime. The percentage of iron is also higher. It may be fairly claimed for even ordinary whole-meal bread that the ratio of the various salts yielded to the body is very nearly that of the normal ratio, except in phosphate of calcium. It is very probable that the beneficial results often seen following the use of whole-meal bread are partly due to this fact.

Inasmuch as whole-meal bread contains much more iron than white bread, and yields a greater proportion to the body, it is more suited to anæmic individuals, and is largely recommended by many medical authorities for this complaint.

Careful analyses of the phosphates present in whole-meal bread lead to the conclusion that it is rich in the *alkaline* phosphates, but very poor in the earthy phosphates, especially phosphate of calcium.

The author made a very careful series of analyses of the ash of wheat for the purpose of this work.

He found in 100 parts of phosphates—

72·54	per cent of	alkaline	phosphates
20·08	,,	magnesium	,,
4·99	,,	calcium	,,
2·39	,,	other	,,

The average amount of phosphate of calcium present in whole-meal bread was found to be about ·24 per cent, while the alkaline phosphates rose to ·62 per cent. It is quite clear from the above that whole-meal bread is certainly deficient in the important phosphate of calcium. Whole-meal bread is also slightly deficient in the alkaline chlorides, but this is not of great importance, as the lack may be made good by common salt.

An examination of the ash of whole-meal bread shows that it contains all the salts necessary for the body, but hardly in sufficient quantities, and not quite in the right proportion.

The following is an analysis of the ash of ordinary whole-meal bread :—

Bases	Potash	31·1
	Soda	2·2
	Lime	3·4
	Magnesia	12·0
	Ferricoxide (Iron)	1·4
Acids, etc.	Phosphoric	47·3
	Silica	2·1
	Chlorine	0·2
	Sulphuric	0·3
		100·0

From many experiments the author has come to the conclusion that ordinary whole-meal bread is deficient in phosphate of calcium, and that the amount of salts present is not sufficient to sustain the body in a state of health, when it forms the only food. He is of the opinion, however, that the proportions of the various salts are nearer those of the normal diet than the proportions in the case of white bread. The deficiency of mineral matter is, however, not very important when only a small quantity of whole-meal bread is taken, for the other foods would probably supply the body with the required quantity. But he maintains that when it practically forms the only food, the body is not supplied with the necessary quantity of mineral matter.

CHAPTER XXIII

ITS DIGESTIBILITY

THERE is a great difference of opinion among physiologists as to the relative digestibility of whole-meal bread. Some authors maintain that it is more easily digested than white bread, while others assert the contrary.

There can be no doubt that properly made whole-meal bread contains relatively a greater percentage of soluble matter than white bread, and so may be said to be more digestible on that score.

This soluble matter has been produced from the starch and albuminoids by the action of certain ferments known to be present in the bran and the germ.

This action goes on in the bread until the high temperature of the oven destroys the power of the ferments.

But the action of the ferments in thus partially softening and dissolving a portion of the albuminoids causes the bread to be "heavier," because the dough has not the same power of holding gas.

It has already been pointed out that white bread is very digestible, on account of the great surface presented to the digestive fluids, and that the extensive surface is obtained by the gas permeating the tenacious gluten and forming interstices separated by very thin partitions.

Whole-meal bread does not hold such a large quantity of gas, and consequently the interstices are fewer, and the dividing walls thicker. There is thus less surface presented to the action of the digestive juices.

By great care, however, whole-meal bread may be rendered light and spongy, as the many excellent examples now supplied to the public abundantly testify.

There is a great tendency for whole-meal bread to become hard and solid during the baking. This is due to the fact that most bakers expose whole-meal batches to the heat of the oven for a longer time than batches of white bread, in order to counteract the soddenness of the unbaked loaf.

Such bread, unless well masticated, is rather difficult of digestion, owing to its compactness.

Another point worthy of consideration is, that the indigestible particles of bran occupy a considerable area of the total surface exposed to the action of digestive fluids, and thus reduce the proportion which is capable of being acted on. This may lower its rate of digestibility.

It has been asserted that the ferments present in the germ and bran aid digestion in the body. In order to test the truth of this statement, the author conducted some experiments with various ordinary whole-meal breads.

The loaves were treated with glycerine, and the extract used as a ferment in the ordinary way. In every case there was no indication of hydrolytic action, which proved that the ferments in the bread were practically inert towards starch and proteid material. It is probable that the power of the ferments is destroyed by the heat of the oven.

It has been urged by several well-known hygienists that the bran *separates* the particles of the actual foods, and so facilitates the action of the various digestive fluids. There is a certain amount of truth in this, but the benefit is balanced by the area taken up by the indigestible particles of bran, which would otherwise be occupied by substances capable of being reduced by the ferments. The author has come to the conclusion that ordinary whole-meal bread, if made properly, is not far behind white bread in the rapidity of its digestion.

In an experiment with white bread and brown bread (both freed from sugar), in which the same amylolytic ferment extract was used, and the preparations subjected to the same conditions, it was found that the brown bread showed traces of sugar as soon as the white bread. Complete digestion, however, took place in the former later than in the latter. In the case of the brown bread, it was proved by another experiment that some of the proteids were slightly more digestible than in the case of white bread; but complete digestion took place much later. It was also proved that much of the proteid material was left behind unacted on.

Summing up, we may say that the digestibility of ordinary whole-meal bread depends largely on the lightness of the loaf and the fineness of the bran particles. With regard to the relative digestibility of different kinds of whole-meal bread made with yeast, salt, acids, etc., the reader is referred to Chapter XV., Section II., as the remarks made there about white bread are equally applicable to whole-meal bread.

In the same chapter reference is also made to the relative digestibility of sweet and sour bread.

Bulk is a very necessary element in good digestion, and whole-meal bread fulfils this condition in a great degree. The author is inclined to the opinion that ordinary whole-meal bread gives too much bulk, and too little available nutriment, so that an individual is satisfied before having taken sufficient. This is a common experience among those who eat very largely of ordinary whole-meal bread. It has been asserted that this feeling of satisfaction is due to the greater sustaining power of whole-meal bread, but it is more reasonable to assume that it is produced by the large percentage of indigestible substances present, for the sustaining power of any food is only evident some time after digestion.

In some instances this property of whole-meal bread is very useful in preventing over-eating and checking excessive appetites.

In the case of white bread the necessary bulk is supplied almost entirely by the starch, which is not acted on in the stomach, but remains undissolved.

CHAPTER XXIV

THE WASTE PRESENT — ACTION OF BRAN ON THE INTESTINES—EFFECTS ON THE WASTE OF OTHER FOOD

THE waste in ordinary whole-meal bread consists mainly of—

(1) Woody fibre.
(2) Cellulose.
(3) Nitrogenous matter.

(4) Salts.
(5) Starch and fat.

The average waste may be stated as near $12\frac{1}{2}$ per cent.

The author, in his experiments, found that in very coarse whole-meal bread quite 14 per cent was excreted unacted on by the digestive juices, while in whole-meal bread made from ordinary grades of whole-meal the percentage fell to about $12\frac{1}{2}$.

The following is a brief *résumé* of the details of the experiments. The object was to ascertain the amount of undigested matter in the fæces, derived from the whole-meal bread. The subject was a healthy man, aged 28 years; weight, $130\frac{1}{4}$ lbs. The period for which he lived on whole-meal bread was 28 days.

No account was taken of the excreta for the first week, in order to give time for other food to be excreted.

The whole-meal bread was analysed before ingestion by the ordinary methods.

The excreta was received into rectified methyl alcohol, and carefully dried.

The ash and fat were estimated in the ordinary way.

The proteids were converted into peptones and then estimated, while the starch was changed into sugar by diastase, and estimated as such.

The peptone method was adopted by the author, in order to ascertain the actual amount of *proteids* present in the fæces. Had other methods been applied, the *total* nitrogen would have been estimated, which would have included certain other organic nitrogenous bodies not derived from the food.

About 24 oz. of dry whole-meal were allowed per day, apportioned as follows:—8 A.M., 7 oz.; 1 P.M., 10 oz.; 6 P.M., 7 oz.

Only distilled water was allowed as a drink.

AVERAGE RESULTS.

	Amount Ingested in Ounces.	Amount Excreted in Ounces.	Waste, per cent.
Proteids and peptones .	4·97	0·98	19·7
Carbo-hydrates . .	20·95	1·22	5·7
Fat	0·56	0·22	39·2
Fibre	0·84	0·84	100·0
Mineral matter [1] . .	0·68	0·35	51·4
	28·00	3·61	12·8

[1] In the estimation of mineral matter, allowance was made for that derived from the digestive juices.

There were no means of ascertaining whether any of the proteid used in the body was decomposed into leucin and tyrosin by trypsin, and subsequently excreted as urea. Some of the nitrogenous matter excreted in the fæces was ascertained to be in the condition of peptones or allied bodies.

The total nitrogen excreted from all sources exceeded considerably the amount ingested. There was a slight loss of weight amounting to 3·8 lbs.

Two other subjects were also experimented on with similar results.

Dr. A. Wynter Blyth, in 1889, communicated the results of two experiments to the Royal Society.

One paper contained the results of the experiment of Dr. T. R. Allinson, who lived for a month on whole-meal and distilled water.

The other paper contained the results of a similar experiment of an Oxford graduate. The results may be briefly summarised as follows:—

Dr. T. R. Allinson.—The experiment was divided into three periods.

1st Period.

Weight, 129 lbs. 16 oz. of whole-meal (453·59 grams) allowed per day.

	Dry Substances ingested in Grams.	Dry Substances excreted in Grams.	
		Fæces.	Urine.
Dry whole-meal	392·35	40·40	27·62
Nitrogen	9·07	1·72	9·57
Fat	8·25	2·52	...
Mineral matter	6·94	3·88	4·38
Phosphoric acid	3·17	1·50	2·03
Sulphuric acid	0·27	0·05	1·46
Chlorine	...	...	1·05

The table shows that 17·4 per cent of the whole-meal was excreted.

There was an excretion of sulphur and chlorine in excess of that ingested. Loss of weight equalled 7 lbs.

2ND PERIOD.

Weight, 122 lbs. 20 oz. of whole-meal ingested per day.

	Dry Substances ingested in Grams.	Dry Substances excreted in Grams.	
		Fæces.	Urine.
Dry whole-meal . .	490·44	47·50	29·16
Nitrogen . . .	11·34	2·02	9·75
Fat	10·31	2·29	...
Ash	8·67	3·70	3·99
Phosphoric acid .	3·97	1·91	1·95
Sulphuric acid . .	0·34	0·03	1·71
Chlorine . . .	...	...	0·88

The table shows that 15·7 per cent of the whole-meal was excreted.

There was a daily excretion of sulphur and chlorine. Loss of weight 3 lbs. *Total* loss of weight equalled 10 lbs.

3rd Period.

Weight, 119 lbs. 28 oz. of whole-meal allowed per day.

	Dry Substances ingested in Grams.	Dry Substances excreted in Grams.	
		Fæces.	Urine.
Dry whole-meal . .	686·62	78·40	33·60
Nitrogen . . .	15·87	2·60	8·39
Fat	14·44	9·24	...
Mineral matter . .	12·04	7·90	3·28
Phosphoric acid .	5·59	3·50	1·93
Sulphuric acid . .	0·47	0·17	1·82
Chlorine . . .	...	...	1·06

The table shows that 16·4 per cent of the whole-meal was excreted.

There was an undiminished output of chlorine and sulphur.

There was a gain of 1½ lb., so that in this case the 20 oz. of whole-meal constituted a sufficient diet as far as quantity goes.

Dr. Blyth summarises the results as follows:— "The quantities of whole-meal consumed *per diem* were, it is obvious, *deficient in nitrogen, fat, and in salts.* If the excretion by the bowel be considered waste, then on an average 15·6 per cent of the total nitrogen in the whole-meal is not in an assimilable form; about 37 per cent of the fat is also not digested, and 51·8 per cent of the ash also passes away." Dr. Blyth also indicates that the mineral matter of whole-meal is deficient in sulphur and chlorine.

The results obtained by the author were confirmed by experiments made with standard digestive extracts, in which a special churning chamber designed by the author was used. Certain weights of whole-meal bread were subjected at a temperature of 100° F. to the action of the standard digestive extracts, and the soluble products removed as fast as they were formed. When the appearance of soluble substances had completely ceased, digestion was assumed to be ended. The undigested residues in every case, after due allowances were made for the prolonged action of the juices, confirmed the results arrived at by the experiments on the body.

One important point was brought out in these investigations, viz., that the percentage of waste was greatest in the proteids, fats, and in the salts.

The excreta of those individuals who were living entirely on whole-meal bread showed a large percentage of proteid material which had not been dissolved, and peptones which had not been absorbed.

The waste in the proteid constituents was found to average about 20 per cent. Dr. Wynter Blyth gives the waste as $15\frac{1}{2}$. This large proportion of waste was probably mainly due to the fact that the nitrogenous bodies contained in the bran were not in a position to be acted on by the various ferments. That this is the case may be easily proved by digesting bran with the standard digestive extracts, or by analysing the bran after it has been excreted.

In the former case little peptone is recovered from the preparation, and in the latter the analysis of the bran still shows a comparatively large percentage of undigested proteid matter.

Over 50 per cent of the salts of ordinary whole-meal bread is excreted undigested. The author has come to the conclusion that only a very small quantity of the mineral matter of the bran of ordinary whole-meal bread is dissolved in the body.

This conclusion is based on the results obtained by the determination of the ash of the bran before ingestion and after excretion, and by the experiments detailed above.

This result was confirmed by heating bran at a temperature of 100° F. with the standard extracts, and examining the solution for salts. There can be little doubt that ordinary whole-meal bread is really a wasteful food, and does not yield to the body the same percentage of nourishment as equal weights of many other foods.

Experiments performed under the direction of the author proved very clearly that the *finer* the particles of bran the less the waste.

In special preparations of bran, in which the particles were very fine, the percentage of undigested proteids was much lower, and the amount of salts dissolved out much greater.

In whole-meal bread containing *very* fine bran particles, specially prepared for the author, only $\frac{1}{7}$ of the proteids was excreted undigested, and nearly 60 per cent of the ash was dissolved. Comparing white bread with ordinary whole-meal bread, the percentages of waste stand as follows:—

White bread	4·5 (average)
Ordinary whole-meal . .	12·5 ,,

The large percentage of waste in the latter bread is, however, partly due to the mechanical action of bran on the intestines.

It has been pointed out in a previous chapter that the structure of the intestines is calculated to *retard* the passage of food through them. The small intestines have circular ledges running round them known as *valvulæ conniventes,* which have the effect of delaying the journey of the altered chyme through the intestines, besides increasing the absorbing surface.

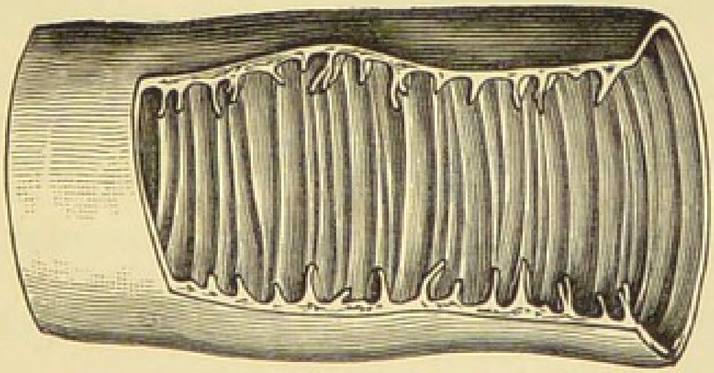

Fig. 18.—VIEW OF SMALL INTESTINE, showing *vàlvulæ conniventes.*

The large intestines (colon) have numerous sacculations, which have the same effect as the *valvulæ conniventes* of the small intestines.

The movements of the intestines are brought about by the combination of the contractions of two muscular coats—one longitudinal and the other circular, producing the peculiar motion known as "peristaltis."

The movements of the intestines are largely automatic, the automatism being characteristic of the muscles themselves, as well as of the nerve plexuses found in the wall of the bowel.

The nerve centres and plexuses in the walls of the intestines, as well as the muscle fibres themselves, readily respond to mechanical and chemical stimuli. The sharp rough particles of bran act as mechanical stimuli, producing increased activity of the muscular coats of the intestines. The first action of bran, then, is to increase peristaltic action, and so the food is forced along at a quicker rate. If the bran particles be large, the stimulation may produce very marked results, ending in diarrhœa and considerable irritation of the intestinal tract.

Another effect of bran is to modify the layer of cells found covering the villi. The author found, in the case of a rabbit and kitten, that the villi were more or less altered in appearance, especially in the layer of striated columnar cells which covers them.

The author believes that continued ingestion of large particles of bran exercises a harmful effect on the villus coat of the small intestines, lessening its absorbing power. Slight inflammation may even be produced in the inner coats by the continued action of large particles of bran on the intestines.

That these conclusions are well founded is indicated by the fact that many persons suffer from diarrhœa on partaking of ordinary whole-meal bread, and that the intestines of young animals fed on bran invariably present an appearance compatible with chronic slight irritation.

Fine particles of bran do not produce such marked effects.

One of the advantages claimed for whole-meal bread is that it overcomes that most harmful condition known as constipation.

There can be no doubt that in most cases it does do this. But often a condition is set up which is almost as bad. It is no uncommon occurrence for an individual who eats ordinary whole-meal bread to evacuate the bowels two and three times daily. This must be detrimental to the health, and results in a loss of nutritious matter to the body.

The beneficial result may be obtained without relaxation by using *fine* whole-meal bread, which stimulates the bowels to healthy activity without undue irritation.

The author believes that the mechanical action of *fine* bran on the intestines may be conducive to good health, but he firmly maintains that coarse bran acts injuriously on most constitutions. He therefore earnestly urges the use of *fine* whole-meal in the preparation of whole-meal bread, and advises all who value their health not to partake of whole-meal bread in which the particles of bran are large. There are many fine grades of whole-meals now in the market, so that every facility is afforded to bakers for the production of fine whole-meal bread.

It may be pointed out that the action of bran is "inverted" in some individuals, *producing* constipation. This inversion depends on an idiosyncrasy of the person.

The ingestion of a large quantity of ordinary whole-meal bread with other foods increases the percentage of waste in those foods. When an individual lives on milk alone for a considerable period, the waste varies from 5 to 9 per cent, according to the digestive powers of the individual.

In a subject experimented on by the author, the waste was found to be about 8 per cent when milk formed the only food. When ordinary whole-meal bread was given in addition to the milk, the waste in the milk rose to nearly 11 per cent.

The same results were obtained with other foods.

This increase of waste in the other foods is probably due to the more frequent evacuations of the bowels, produced by the irritation of the bran particles.

Summing up, we may fairly come to the following conclusions concerning ordinary (*i.e.*, coarse) whole-meal bread—

(1) It contains more actual waste matter (fibre, etc.) than white bread.

(2) It is not so thoroughly digested as white bread.

(3) Its ingestion in considerable quantities leads to an increase of waste in other foods.

(4) It may cause diarrhœa, and irritate the villus coat of the intestine.

(5) It counteracts constipation.

(6) It usually produces looseness of the bowels.

CHAPTER XXV

FLAVOUR—SATIETY—DRYNESS

THE different flavours of whole-meal breads made by different methods—by yeast, salts, acids, etc.—need not be enlarged on in this chapter, as the remarks made in a previous chapter on white bread are equally applicable here.

It will be more to the point if the general flavour of ordinary whole-meal bread be considered and compared with that of white bread.

It is quite certain that the flavour of many foods is largely modified by the presence of particles which, while having little or no flavour themselves, produce sensations of *touch*.

The tongue is not only the organ of *taste*, but it is the organ in which the sense of *touch* is most delicately developed.

In some experiments, performed on a number of students, in which certain foods were mixed with tasteless particles, it was found that the intrinsic flavours of the foods were considerably modified by the presence of the flavourless portions, and further, that the *fineness* of the particles also influenced the flavour. It follows from this that the coarse and almost flavourless bran particles present in ordinary whole-meal bread must modify in a similar way the flavour of the loaf.

Very few people really like the flavour of ordinary whole-meal bread, and the author believes that the distaste for ordinary brown bread is caused by the presence of the *coarse* particles of the bran, which produce an unpleasant sense of touch in the mouth.

Ordinary whole-meal bread produces an effect which many people term "chaffy," and this is undoubtedly due to the hard portions of bran.

The author has been at some trouble and pains to ascertain as far as possible how the general public like the flavour of ordinary whole-meal bread, and as far as he can judge he is of opinion that they do not readily take to it.

It has been his experience that only one person out of ten who tries ordinary whole-meal bread can honestly say the flavour is pleasant. He has been told by bakers over and over again that it is their experience that comparatively very few persons take kindly to the ordinary brown bread.

Ordinary whole-meal bread as a rule does produce satiety in most individuals. They soon tire of the flavour, and do not eat the bread with that relish which is so conducive to good digestion.

They may partake of it for a time, but it soon palls on the palate, and the chaffy loaf is discarded for the white loaf again.

This assertion will no doubt be contradicted by the few who find that the ordinary brown bread does not produce satiety, but the writer is convinced from careful and extensive inquiries that his conclusion is well grounded. No matter what food reformers may say, the fact remains that the large majority of individuals do not like the flavour of ordinary whole-meal bread. They enjoy it for a change, but do not partake of it exclusively for any length of time.

The author's experiments showed, however, that the *finer* the flavourless particles, the more pleasant was the flavour, and there can be no doubt that *fine* whole-meal bread does not produce that "chaffy" taste which is so objectionable in ordinary whole-meal bread.

Without entering very deeply into the *technique* of the subject, it may be stated that the freshness of the whole-meal has a considerable effect on the flavour. All other things being equal, a loaf made from fresh whole-meal has a better flavour than one made from stale meal.

It has been the author's experience that whole-meal bread of a superior flavour is produced when the fermentation is quickened by the use of malt extract.

Whole-meal is very liable to internal fermentations owing to the presence of the germ and the bran. These fermentations lead to the breaking down of the proteids, and the formation of dextrin and sugar, so that the conditions are favourable to the development of the acid fermentations. Slow fermentation at a high temperature under these conditions will probably produce a sour loaf.

By quickening the fermentation at as low a temperature as possible a sweet loaf is produced, with a very pleasant flavour. This flavour may, however, be materially modified by the presence of large particles of bran.

Ordinary whole-meal bread becomes dry and hard much quicker than white bread. This is partly due to prolonged baking, which renders the loaf less able to retain its moisture, and partly to a molecular change which manifests itself much sooner than in the case of white bread. The flavour of stale whole-meal bread is not very appetising, and comparatively few people can relish such bread.

Many flavours which are distasteful at first may become pleasant after a time, owing to the cultivation of the sensory organs concerned in their appreciation. Few people, however, get to really like the flavour of coarse whole-meal bread. It appears that coarse and comparatively tasteless particles can never produce pleasant sensations; hence the almost flavourless coarse particles of bran produce a more or less unpleasant sensation in the mouth, which can seldom be removed by even constant indulgence in the food containing them.

If the general public are ever to be induced to eat more freely of whole-meal bread, it will be done by supplying them with better flavoured whole-meal bread, produced by the use of *finer* grades of whole-meal, and by quick fermentation.

CHAPTER XXVI

WHETHER SUITED FOR CHILDREN AND NURSING MOTHERS

WHOLE-MEAL bread in any form is unsuitable for children under the age of about 10 months, or, at least, until they have cut two teeth.

The grounds for this assertion are very fully given in Chapter XVIII., Section II., and need not be repeated here.

In addition to the objections urged in the above-named chapter, the stimulating action which the bran would have on the tender intestines of the infant must be taken into consideration. There can be little doubt that such irritation by hard and indigestible particles would act injuriously on the undeveloped digestive system of the young child.

Nature points out that the typical food of an infant should practically contain *no indigestible portions*, for very little of the mother's milk is excreted undigested from the alimentary canal, provided the child is not overfed. It has been pointed out in a previous chapter that the effect of the bran on the intestines would be to increase the peristaltic contraction, and this would lead to increased evacuations. Now, the fæces of infants fed on whole-meal bread and milk contain far more *undigested nutriment* than the fæces of infants fed on mother's milk alone, and the author attributes this loss of nourishment to the mechanical action of the bran in stimulating the movements of the intestines, and thus hurrying the food along, so that the digestive fluids have not sufficient time to digest all the available nutriment.

After two teeth have been cut the amylolytic ferments have so far developed as to be able to act on cooked starch with considerable power and rapidity. Now it has been pointed out in the chapter previously noted, that the starch in light bread is peculiarly adapted for digestion, being in a very assimilable form, and bread in moderate quantities may therefore be given with confidence to children after two teeth have appeared.

The deficiencies of white bread as children's food have already been discussed; it remains now to consider whether whole-meal bread is any better in regard to those deficiencies, which for convenience are given below.

White bread is not a perfect food for children because—

(1) It is deficient in proteids, fat, and mineral matter, especially phosphate of calcium and iron.
(2) It contains a surplus of carbo-hydrate material (starch, etc.)

The same may be said of whole-meal bread. Although the proportions in the latter are much more nearly what they should be, yet there is still a deficiency of proteids, fat, and mineral matter, and a surplus of starch, etc.

Whole-meal bread is more nearly a perfect diet for an adult than for a child, for the latter specially needs proteids and mineral matter, and requires comparatively more of these foods than an adult to build up new tissues.

Ordinary whole-meal bread will not yield a very much larger quantity of mineral matter to the body than white bread, although the *proportion* of the various mineral substances is more nearly that of a perfect diet.

Nor does ordinary whole-meal bread yield to the body a larger quantity of nourishment, but the *proportions* of the proximate principles are more nearly those of the normal diet.

On these grounds whole-meal bread is better for children than white bread, *provided it be fine.*

In the author's opinion the ordinary whole-meal bread made with the ordinary grades of whole-meal is far too coarse for children, and is injurious to their welfare.

He has personal knowledge of many cases in which the substitution of very fine whole-meal bread for the ordinary variety in the diet of children has been followed by most marked beneficial results.

Fine whole-meal bread may be a very valuable food for children, and may be largely given in the place of white bread. But the author believes that the ordinary whole-meal bread is not a desirable article of diet for them.

Fine whole-meal bread yields considerably greater quantities of iron and phosphate of potassium to the body than white bread.

This is of great importance, for the experiments detailed in previous chapters prove that if *lime* be taken in with other foods an interaction may go on in the body by which the essential *phosphate of calcium* is formed. This fact explains why it is that fine whole-meal bread is so beneficial in certain forms of rickets. Until recently the beneficial results seen in the development of bones and teeth, following the use of fine whole-meal bread, were believed to be due to the phosphate of calcium which the bread contained. It is now known that even whole-meal bread is poor in calcium-phosphate, so that the good results could not be due to the ingestion of that salt. But fine whole-meal bread yields a comparatively large quantity of the alkaline phosphates, which by interaction with calcium salts are converted into calcium-phosphate.

Fine whole-meal bread also counteracts anæmia, by yielding to the body a fair quantity of iron, and is thus beneficial to children.

Summarising, we may say ordinary whole-meal bread (*i.e.* coarse) is unsuitable for children because—

(1) It irritates unduly the intestinal tract.
(2) It increases the waste of other foods.
(3) It may produce diarrhœa.

(4) It yields a less quantity of nutriment, both organic and inorganic, to the body than white bread.

Fine whole-meal bread may be recommended as food for children because—

(1) It stimulates the bowels to healthy activity without undue irritation.
(2) It is far more thoroughly digested than ordinary whole-meal bread.
(3) It furnishes the body with a larger quantity of the valuable alkaline phosphates and iron.
(4) The proportions of the various food-stuffs yielded to the body are nearly those of a perfect diet.

When bread is given to very young children, it should be prepared according to the formula of Dr. Churchill, given in Chapter XVIII., Section II.

Or it may be prepared in the following manner:—

The bread is allowed to get stale, and then crumbled between the hands into a basin. Boiling milk is then poured on, and the whole allowed to stand until cool.

The author has seen very good results follow this plan, when *fine* whole-meal bread has been used.

In cases of delicate children the author recommends the following method:—

The bread is allowed to get stale, and then crumbled into a basin. A boiling mixture of barley-water and milk is then poured on, and the whole allowed to digest for an hour in a "digester" in a hot oven.

By adopting this plan the change of starch into more assimilable bodies is promoted, and the extraction of the nourishment from the bran facilitated. For reasons already pointed out, ordinary whole-meal is not to be recommended to nursing mothers. But *fine* whole-meal bread in moderation may be taken with advantage.

Human milk contains a comparatively large quantity of calcium phosphate, and the alkaline phosphates of whole-meal bread contribute very largely to the formation of that salt in the body. White bread is deficient in phosphoric acid, while whole-meal bread contains comparatively a large proportion, so that it is a distinct gain to the economy to substitute *fine* whole-meal bread for white bread while nursing an infant.

Those who are *enceinte* may also be greatly benefited by a moderate indulgence in fine whole-meal bread.

During the first eight months of pregnancy there is a marked decrease of phosphate of calcium in the urine. It is probable that the phosphate of calcium, having performed its ordinary functions in the body, is *reabsorbed* and stored up for the future use of the fœtus. Ducrest, a very able observer, maintains that this reabsorbed phosphate is fixed on the skeleton, and instances the thickening of the cranial bones, so common in those who are *enciente,* as a proof of the statement. Follin has also asserted that a similar thickening may often be seen in the pelvic bones. These concretions are spoken of as osteophytes, and disappear towards the ninth month of intra-uterine life.

During this latter period the urine again shows phosphates in considerable quantities. The French authors alluded to above state that the phosphate of calcium is thus stored up during the first period of pregnancy in order to constitute a reserve for ulterior use, when the cartilages rapidly take up the calcifying matter, and the muscles grow apace. It appears that part of the salt is fixed in the skeleton, and the residue, after having performed its functions in connection with the formation of new tissues, is excreted.

It will be clear from what has been stated that the diet during the whole of this period should be rich in either alkaline or calcium phosphates, and inasmuch as *fine* whole-meal bread yields far more alkaline phosphates than white bread, it may be substituted for the latter with advantage.

Fine whole-meal bread is also to be recommended to nursing mothers, on account of its higher nitrogenous ratio.

Summarising the subject, it may be said that the *ordinary* whole-meal bread is not a desirable food, and far inferior to good white bread as regards the weight of actual nourishment and the thoroughness of the digestion. Its ingestion is often followed by diarrhœa, and the action of the bran increases the waste of food.

Fine whole-meal bread may be recommended in the place of white bread, inasmuch as it is fairly well digested, and it does not produce irritation of the alimentary tract.

It must not be concluded, however, that even fine whole-meal bread is a panacea for every disease under the sun, as many food reformers would have us believe. Although in some respects it is decidedly better than the best ordinary white bread, its ingestion will not lead to very markedly beneficial results unless the general laws of health are obeyed. The author believes that much of the improvement which so frequently follows the use of fine whole-meal bread must be attributed to the fact that usually the change of diet is accompanied *with a change of habit*, which certainly must produce an appreciable effect on the body.

The question as to whether fine whole-meal bread should permanently replace white bread will largely depend on the amount of bread eaten. If only a very small quantity of bread be taken, it is not essential to good health that it should be whole-meal. But if it forms a *large* proportion of the diet, fine whole-meal bread should be largely eaten. A *moderate* quantity is beneficial, but an excessive amount is prejudicial to the health of the body.

Finally, we may fairly conclude that fine whole-bread may be of *special* value to—

(1) Those who suffer from constipation.
(2) Those who are inclined to put on flesh too rapidly.

(3) Nursing mothers.

(4) Those who are *enceinte.*

(5) Children above the age of 10 months.

(6) Those who have a tendency to the decay of the teeth.

(7) Children inclined to rickets.

SECTION IV.—SPECIAL BREADS

CHAPTER XXVII

AERATED BREAD

THE mechanical aeration of bread was invented by Dr. Dauglish.

The process may be briefly described as follows :—

Carbon-dioxide is generated in separate vessels by the action of sulphuric acid on limestone, according to the following equation :—

$$CaCO_3 + H_2SO_4 = CaSO_4 + H_2O + CO_2.$$

Calcium sulphate is formed and CO_2 liberated.

The gas is then forced into slightly acid water by special pumps, and the solution used for making the dough.

The doughing operations are carried on in strong receivers *where the pressure is maintained.* When the kneading is finished, the dough is allowed to pass out, with the result that the imprisoned CO_2 immediately expands and permeates the dough, thus aerating it.

The white bread which is produced by this method is usually of a very even texture, and possesses a fine colour. The composition does not materially differ from that of ordinary white bread, except that it contains slightly more proteid material, but the flavour is not nearly so complex.

There is no appreciable fermentation of any kind; consequently those complex changes which occur during panary fermentation in ordinary bread, and which are largely instrumental in producing the characteristic flavour of such bread, do not go on in the doughing stage of the aerated bread.

The flavour is thus very simple and raw, reminding one very forcibly of the taste of baked flour and water. The aerated bread lacks the subtle flavour which characterises fermented bread.

One advantage of the aerated bread is that there is very little danger of getting a sour loaf.

Usually the aeration process necessitates the entire working of the dough, etc., by machinery, so that such bread is untouched by human hands, and quite free from any possible organic impurity from the human body.

The aeration process is most successful in the manufacture of whole-meal bread, as, owing to the ferments which whole-meal contains, it does not readily lend itself to successful panary fermentation.

Lime-Water Bread.

Lime-water bread is prepared by using a mixture of calcium hydrate and water to form the dough.

Calcium hydrate may be prepared by adding distilled water to quicklime, according to the following equation :—

$$\underset{\text{Calcium oxide.}}{CaO} + \underset{\text{Water.}}{H_2O} = \underset{\text{Calcium hydrate.}}{CaH_2O_2}.$$

The amount which is added to the dough averages about 7 gallons of lime water per sack. The objects of adding lime water are—

(1) To retard the formation of dextrin and sugar.
(2) To prevent the degradation of the gluten.
(3) To produce a moister loaf.
(4) To increase the percentage of *lime* in the bread.
(5) To produce a white loaf.

The most important action of the lime water is to concentrate and harden the gluten, and to check the conversion of starch into sugar.

This increases the absorbing power of the dough, which consequently takes up more water.

An important point is the chemical reaction which occurs in the bread between the lime water and the carbon-dioxide, by which the insoluble carbonate of calcium is formed, according to the following equation:—

CaH_2O_2	+	CO_2	=	$CaCO_3$ +	H_2O.
Calcium hydrate.		Carbon-dioxide.		Calcium carbonate.	Water.

Lime-water bread has the advantage of keeping moist for a considerable period, and seldom develops an acid reaction. It has been claimed for lime-water bread that it is most valuable for children, on account of the lime it contains. It has been assumed that the lime in the bread may take part in the formation of teeth and bone.

This assumption is well grounded.

A series of experiments on pigeons and fowls, conducted by the author, proved conclusively that if a food were given deficient in lime, but rich in alkaline phosphates, the addition of carbonate of calcium made up the deficiency. It seems certain that a reaction occurs in the body between the alkaline phosphates and the calcium carbonate, by which *phosphate* of calcium is formed.

Such a crude mineral substance as $CaCO_3$ is not, however, a desirable food, and it is possible that harm may result from a continued ingestion of such a body.

Most medical authorities are agreed that the lacto-phosphate of calcium is the most satisfactory preparation for the purpose of supplementing lime derived from the actual food, and as this salt cannot satisfactorily be used in breadmaking, it would be advisable to partake of a non-lime-water bread, and take in any lime which may be required in a more suitable form.

It is only fair to add that the quantity of calcium carbonate in most lime-water breads is very small.

Bran Bread.

Bran bread is prepared from a mixture of white flour and bran.

It approaches whole-meal bread in composition, but contains usually a greater percentage of fibre.

The bran being procured from the millers, who have rejected it during the milling operations, is very coarse, for, being a "waste" product, no special means are taken to grind it finer.

In previous chapters the use of ordinary whole-meal bread has been condemned as being too coarse for ingestion.

Bran bread is far coarser, and therefore must be condemned with greater force. The waste averages quite 16 per cent, and the bran particles being so large act most injuriously on the digestive system. The author considers bran bread to be quite unfit for human food, except in special cases, to be mentioned in Section VI.

Milk Bread.

Milk bread is made from dough, to which milk, or milk and water, has been added.

The object of adding the milk is to obtain a better flavour.

The bread so made is also more nutritious than ordinary white bread.

Milk bread does not keep sweet very long; it should therefore be eaten soon after baking.

It is very important that the milk should be fresh and boiled before being used. If not perfectly fresh the lactic acid fermentation may be set up by the introduction of the *B. Lactis.*

Milk bread contains more fat than ordinary bread, and is richer in mineral matter, especially calcium phosphate.

Unleavened Bread.

Unleavened bread undergoes no fermentation, and no means are taken to aerate the dough.

The flour is mixed with water in a copper kettle, and then kneaded to the proper consistency.

The dough is then passed between iron rollers and flattened out into thin strips.

The strips are operated on by a man, who uses a roller covered with short spikes. The spikes pierce the dough and form the holes so characteristic of the passover cakes.

The strips are now cut into the proper lengths, and the pieces passed into the oven for two minutes. They come out as thin flaky cakes, very crisp, but without much flavour.

In composition they do not differ materially from the flour used in their manufacture.

Rye Bread.

Rye bread is prepared from rye flour. The rye plant belongs to the cereals, and is cultivated chiefly for malting purposes. It grows to perfection in much poorer soils and in colder climates than those required for wheat; hence it is extensively grown in Northern Europe, and used for the manufacture of flour and bread.

The black bread of Germany is prepared wholly from coarse rye flour. Sometimes whole-rye meal is used, and the bread is then very coarse and unpalatable. The author recently had the opportunity of examining some specimens of rye bread made from whole-rye meal, and a mixture of rye meal and wheaten flour. The bread was very dark, and of close texture. The standard digestive extracts acted with difficulty on the constituents. The flavour was far from pleasant, and decidedly sour. The bread produced a very coarse sensation in the mouth.

The waste amounted to about 16 per cent.

Such bread is certainly not a desirable or economical food when wheaten bread can be obtained, on account of the waste present, the unpleasant flavour, and its indigestible character.

In this country rye bread is made from fine rye flour. Rye flour has the following composition:—

Water	13·1
Proteids	9·9
Fat	1·5
Carbo-hydrates	71·2
Fibre	2·7
Mineral matter	1·6
	100·0

Rye bread made from fine rye flour is much more digestible than that prepared from whole-rye meal. Its flavour is not so unpleasant, and the waste is not so great. The following is an analysis of a sample of rye bread:—

Rye Bread (without Caraway Seeds).

Water	41·6
Proteids	7·8
Fat	0·5
Carbo-hydrates	48·5
Fibre	0·4
Mineral matter	1·2
	100·0

It will be seen that it resembles white bread in composition.

The waste in this specimen amounted to about 9 per cent.

The mineral matter is rich in potash and phosphoric acid.

Fine Rye bread, as a rule, seldom becomes sour, and keeps moist for a longer period than ordinary white wheaten bread.

The flavour of English rye bread is not altogether unpleasant, and it is frequently improved by the addition of caraway seeds.

This bread is not so valuable an article of diet as wheaten bread, but it forms a pleasant change now and again.

CHAPTER XXVIII

MALTED BREADS

MALT is produced from barley by partial germination. The general conditions necessary for the process are moisture and warmth.

The barley is placed in a cistern of water for about 40 hours. At the end of that time the water is drained off, and the grains allowed to lie exposed to the air for 24 hours.

During this period germination begins, and diastase and other ferments are formed in the grain.

The grains are then made into heaps, and frequently turned for three weeks.

During the malting operations the ferments act on—

(1) The albuminoids.
(2) The starch.

The action on the albuminoids is to soften and render them more soluble, during which process they acquire limited diastasic powers.

The starch is mainly converted into dextrin and maltose by the action of the diastase.

The object of malting is to obtain the *maximum* quantity of sugar from the barley grain.

It is necessary, in order to secure this result, to arrest the germination at a certain stage, otherwise the growing plant would use the sugar for food.

This is accomplished by removing the partially developed plants to a kiln, where they are spread out on perforated brick floors, and subjected to a temperature of 145°-160° F.

The heat destroys the embryo, and further germination is thus prevented.

The diastase is not destroyed at this temperature, and therefore continues the diastasis of the starch.

The malt is finally sifted in order to remove dust and other impurities.

Malt extract is added to the sponge or dough by the baker in order to quicken the fermentation, and to impart a sweet nutty flavour to the bread.

The first object is accomplished by the larger proportion of *soluble* nitrogenous matter and maltose which the malt contains. The soluble nitrogenous substances act as direct incentives to the reproductive power of the yeast organisms, and the sugar provides abundant food for the vigorous young cells.

Fermentation is thus accelerated.

One of the changes which occurs during a long fermentation is a softening of the gluten, with the result that the colour, pile, and bulk of the bread are improved.

This action on the gluten is no doubt due to certain hydrolytic agents, which develop during fermentation.

Long fermentation, however, is favourable to the production of *sour bread,* so that any preparation which produces the same desirable results that are obtained by long fermentation in a shorter time, is a distinct gain and advantage.

The maltose which is present in the extract imparts a sweet taste to the bread, and the diastase which it usually contains also increases the percentage of sugar in the bread by acting on the starch.

Malted breads are more digestible than ordinary breads, and, to most people, the flavour is more pleasant.

Leconte's Malt Bread.

This bread is manufactured by the use of a special malt extract, without the use of potatoes.

The extract, according to the manufacturers, is produced from carefully-selected malted grain, and contains soluble albuminoids and maltose.

The colour for a malt extract is remarkably pale. This desirable result (from a baker's point of view) is obtained by kiln-drying at a low temperature.

The quantity of extract which should be added to the sponge or dough is very small, when compared with the improvement of the bread in digestibility and flavour.

About 1 lb. of the extract to 280 lbs. of flour is generally found to be sufficient.

Where the extract is used no potatoes need be added, and this is a distinct advantage, from the hygienist's standpoint.

In the first place, the work connected with the baking operations is more cleanly, and the bread has distinctly a higher nutritive value, as well as being of easier digestibility; and, secondly, a better flavour is obtained.

The following analyses show the difference between bread made by the use of potatoes and that made by the use of Leconte's malt extract.

The dough was prepared from the same grade of flour, and baked under the same conditions.

ANALYSIS OF DRY SOLIDS.

	No. 1.	No. 2.
Proteids	12·1	12·9
Insoluble carbo-hydrates	74·1	71·3
Soluble ,, ,,	11·1	13·1
Fat	1·3	1·3
Mineral matter	1·4	1·4
	100·0	100·0

No. 1 sample was made with the use of potatoes.

No. 2 sample was made with Leconte's malt extract.

Leconte's malt bread is thus slightly more digestible than ordinary bread.

A very important point to which allusion has been made in previous chapters is the time which a loaf will keep *moist.*

In this respect, the bread under consideration is certainly entitled to a word of praise.

The author has ascertained by experiment that, even on the third day, a loaf of this bread is quite moist enough to make it pleasant eating.

The flavour—a crucial test to many people—is decidedly sweet, and gives the peculiar pleasant taste which is now generally designated by the term "nutty." The author has bought many loaves of bread in London made by the use of this malt extract, and has never yet come across one which showed the least trace of sourness.

This alone is a great gain, for a sweet loaf is to be recommended both as to the palate and digestion.

Whole-meal bread benefits to even a greater degree than white bread by the use of the malt extract.

The flavour of *fine* whole-meal bread made according to Leconte's plan is delicious, and the loaves do not get stale and dry after 24 hours, as is the case with ordinary whole-meal bread.

Carefully considering all points, it may be stated that Leconte's malt bread has a higher dietetic value than ordinary bread, for the following reasons :—

(1) It is more digestible.
(2) Its flavour is better.
(3) It keeps moist for a longer period.
(4) The nitrogenous ratio is slightly higher.

Montgomerie's Malted Bread.

Montgomerie's Patent Bread resembles, in certain respects, the ordinary malted bread. But it differs from the latter in one most important particular. The malt extract is added to part of the flour before the *doughing stage,* so that the diastase contained in the malt has sufficient time to act on the starch.

The process may be briefly described as follows :—

A portion of flour is mixed with water and raised to a temperature sufficient to gelatinise the starch. The malt extract is then added and time allowed for the diastase to effect the conversion of the starch into dextrin and sugar.

The mixture is then added to the dough, and the malt extract subsequently acts as a stimulus to the fermentation.

This process secures—

(1) A large proportion of soluble carbo-hydrates in the bread.
(2) All the advantages of ordinary malt bread which have been detailed previously.

The bread is one of the most digestible in the market, and the flavour is most delicate and pleasing.

A speciality of Mr. Montgomerie is "infant rusks." These "rusks" are the most suitable kind of white bread for infants above 10 months that the author has ever examined.

They contain an unusually large percentage of soluble carbo-hydrates (sugar and dextrin), and are most digestible.

The advantages of the bread under consideration may be enumerated as follows:—

(1) It contains a large percentage of dextrin and sugar.
(2) The colour, flavour, and texture are far above the ordinary standard.
(3) The bread is moister than ordinary bread.

Malto-Peptone Bread.

Malto-peptone bread is prepared without the use of potatoes by the addition of malto-peptone extract to the ferment, sponge, or dough. Malto-peptone extract is a combination of malt extract with peptone and hops. The objects of this threefold constitution may be stated to be—

(1) To quicken fermentation.
(2) To render the bread moister by softening the gluten, and causing the dough to absorb more water.
(3) To develop a distinct flavour.

The fermentation is quickened and rendered vigorous by the maltose and peptone which the extract contains, which supply the yeast organisms with abundant food in an available form. All the advantages of quick fermentation which have been detailed previously are obtained, and in addition the gluten is softened, probably by traces of ferments which are mixed with the peptone. Distillers' yeast is now very largely used by bakers, because it is more rapid and certain in its action than brewers' yeast. But the use of the former is attended with a slight deterioration of flavour, and the resulting bread is dry and soon gets stale. The use of malto-peptone extract remedies these deficiencies to a certain extent and restores to the bread many of the good qualities which characterise bread made by the use of brewers' yeast. The presence of the extract of hops produces a flavour in the bread which is certainly very different to, and much more pleasant than, that of bread made by ordinary methods. All the samples of malto-peptone bread tasted by the author were far superior in flavour to many breads in the market, and reminded one of the delicious flavour of the farm-house bread of bygone days, made by the use of the slow fermenting brewers' yeast. On account of the moisture and flavour malto-peptone bread is entitled to rank higher than ordinary bread as a food.

CHAPTER XXIX

MEABY'S TRITICUMINA BREAD

This bread is made from a special meal prepared by a patent process. The process of preparation provides that the bran of the wheat shall be reduced to an exceedingly fine state of division, and that the starch shall be in such a condition as to greatly facilitate the action of the digestive fluids. The first desirable effect is produced by special machines which so reduce the bran as to render it almost invisible in the loaf, and the second important result is attained by an ingenious process, by which the starch is naturally converted to a most assimilable form, with a considerable quantity of sugar.

The whole of the nutritious elements of the wheat are retained in the meal, so that the bread is really whole-meal, or, as the patentees term it, entire wheat-meal bread.

In a previous chapter it has been pointed out that whole-meal bread, made from ordinary grades of meal, is not the nutritious or desirable article of diet which some hygienists would have us believe it is.

Whole-meal bread, to be palatable, nutritious, and innocuous, must be made from meal which has been specially prepared for the purpose. The ordinary grades of whole-meal are not fine enough. The triticumina meal has not this disadvantage. The bran particles are so fine that they do not produce that injurious irritation of the alimentary canal that the ordinary whole-meal does, while they gently stimulate the bowels to healthy action. The object of producing a whole-meal loaf is first to raise the nitrogenous ratio; secondly, to furnish the body with an increased amount of mineral matter.

As has been pointed out, these objects are not accomplished to any great extent by ordinary whole-meal bread, for a large proportion of the nitrogenous matter remains undigested, and the mineral matter is locked up in the bran in such a way that it cannot be dissolved by the digestive fluids.

It is only when the particles of bran are very fine that the salts are set free, and the nitrogenous matter digested.

In ordinary brown bread quite $12\frac{1}{2}$ per cent is expelled from the alimentary canal undigested. In the bread under consideration the writer found by careful experiments that only $7\frac{1}{2}$ per cent was excreted unacted on by the digestive fluids. The experiments also proved that a very large proportion of the mineral matter was absorbed by the body.

An analysis of the bread gave the following results:—

"TRITICUMINA BREAD"—ANALYSIS OF DRY SOLIDS.

Nitrogenous (gluten, albumin, etc.)	19·39
Starch	50·33
Soluble carbo-hydrates	21·32
Fat	2·21
Fibre, etc.	3·40
Mineral matter	3·35
	100·00

It will be seen that the nitrogenous ratio to the carbo-hydrates is much higher than in white bread. In the latter it is about 1 to 7. In the former it is 1 to 3·6, or approximately what it is in the normal diet.

But the analysis does not indicate the full value of the triticumina bread, inasmuch as it is necessarily silent on the digestibility of the proximate principles.

The writer has ascertained by an exhaustive series of experiments that the starch in this bread is more easily digested than the starch contained in ordinary bread. It is rapidly acted on both by ptyalin of saliva and pancreatic diastase. This is a distinct advantage, inasmuch as it still allows the ferments to be *functionally* active, while facilitating their action. It would be of no advantage to the healthy individual for the main portion of the starch to be converted into sugar, for then the ptyalin and diastase would have no work to do, and they would gradually become weak as regards their action on starch.

This would be detrimental to health, and result in impaired nutrition. But if by any means the starch can be so acted on that, while it is still starch, it is nevertheless in a condition more favourable to the action of the ferments, then the condition is distinctly beneficial, and constitutes a gain to the economy, inasmuch as while the ferments have still to render the starch soluble, they perform their functions at less cost to the body.

A hundred parts of the dry solids yield about 3·35 per cent of mineral matter, which, being derived from the whole-wheat grain, is very rich in phosphoric acid, potash, and magnesia. The amount of lime is also in excess of that derived from white bread.

The following is an analysis of the ash of triticumina bread:—

Phosphoric acid	49·19
Potash	30·40
Magnesia	11·89
Lime	3·29
Soda	1·94
Silica	1·29
Sulphuric acid	1·04
Ferric oxide	0·71
Chlorine	0·23
Undetermined	0·02
	100·00

The high percentage of phosphoric acid, potash, etc., gives to this bread a special value for children who require such a large proportion of phosphates.

There can be no doubt that if fine whole-meal bread, such as the kind now under consideration, were given to children, many cases of rickets would be avoided. Being a *fine* whole-meal bread, it is also specially adapted for those who are *enceinte*, and for nursing mothers. Anæmic individuals would also derive benefit by partaking of it.

The triticumina bread has the quality of keeping moist for a considerable time, which is a valuable property in any bread. This is partly due to the fact that the meal from which the bread is made is very dry, so that when it is made into bread it absorbs a large percentage of water. The large percentage of soluble bodies also helps to keep the bread moist.

One of the great objections to ordinary whole-meal bread is that it so soon gets dry and hard.

This fault may be obviated by using a fresh meal containing as large a proportion of soluble substances, and rendered as dry in preparation as the triticumina, in which case the water is so intimately incorporated with the constituents of the loaf that the evaporation of moisture is retarded, and those molecular changes which result in stale bread delayed.

The bread has a very pleasant flavour, quite different to the chaffy taste of ordinary whole-meal bread, and it appears to give, like good white bread, no satiety.

This is most important, for, as has been already pointed out, most people soon tire of ordinary brown bread. But from extensive inquiries it appears that this is not the case with the bread under consideration.

The composition approaches approximately to a perfect food, but necessarily, like all breads, it is deficient in fat and salts.

Professor Corfield's standard diet—

Albuminoids	$4\frac{1}{2}$	oz. dry.
Carbo-hydrate	$14\frac{1}{4}$	,,
Fat	3	,,
Mineral matter	1	,,
	$22\frac{3}{4}$	

Amounts yielded by $22\frac{3}{4}$ oz. of dry triticumina bread—

Albuminoids	4·0	oz.
Fat	0·5	,,
Carbo-hydrates	14·9	,,
Mineral matter	0·6	,,
	20·0	

The patentee may fairly claim the credit of producing a whole-meal bread which is as near a perfect food as such bread can be.

The author is of the opinion that it is a perfect whole-meal bread, and deserves the universal commendation which has been accorded to it by the medical and analytical world.

Summing up, we may say that the high dietetic value of the triticumina bread depends on—

(1) Its high nitrogenous ratio.
(2) The digestibility of the constituents—especially the starch.

(3) The fineness of the bran particles.

(4) The large proportion of phosphoric acid and potash present.

(5) The low percentage of waste.

(6) Its power of retaining moisture.

(7) Its pleasant flavour.

CHAPTER XXX

CYCLONE BREAD

Cyclone bread is a whole-meal bread prepared from cyclone whole-meal. The mode of preparation of the meal is unique, and marks a new departure in milling operations of intense interest to hygienists and food reformers.

The old millstones are superseded, and the modern rollers are not requisitioned in this process, but the wheat is simply pulverised by small, terrific cross-currents of air, which produce a veritable miniature cyclone, in which the grains are ground against one another with great force, and reduced to any required degree of fineness.

The air currents are produced by fans which revolve reversely at a high rate of speed. The process may be briefly described as follows:—

The whole of the milling is performed in a small chamber provided with two fans, revolving in opposite directions. The wheat is introduced into the milling chamber by means of a hopper, the supply being carefully regulated.

When the raw product descends to the "cyclone" chamber, it is subjected to the action of the artificial cyclone, and speedily broken up and pulverised. Communicating with the air chamber is a reel, which is kept constantly revolving, and a fan placed at its upper extremity creates a strong exhaust current from the air chamber along the reel. The pulverised meal is thus drawn out of the milling chamber, and passes into a collecting room.

Two moving arms collect the products into the required position for the conveyer, from which it is drawn off into bags.

Should different grades of meal be required of different degrees of fineness, a simple mechanical contrivance is brought into play by which the meal is conveyed over the receivers, the lighter or heavier, and consequently the finer or coarser, particles finding their way into the different chambers by their own specific gravity.

By regulating the suction and speed of the exhaust fan, the time that the meal is subjected to the milling operations may be varied, and thus any degree of fineness can be obtained.

The advantages of this unique method of reducing wheat are many and substantial.

In the first place a *fine* whole-meal is obtained.

The importance of this has been fully stated in previous chapters. Coarse whole-meal is not a desirable food for any one, and yields to the body a far less percentage of nutriment than white bread, but, as has been pointed out, whole-meal bread made from *fine* meal may be taken with benefit by most individuals.

The second advantage which may be fairly claimed for this meal is that it is completely and perfectly aerated. Thus much cannot be said for the majority of meals in the market.

Another advantage possessed by the meal is its freedom from taint or impurity of any kind. During the milling operations it is untouched by human hands, and the chambers being sealed no contamination from the external air is possible. Metallic and stony impurities are entirely absent.

Cyclone bread is decidedly a *fine* whole-meal bread, and as such may be recommended with confidence as a beneficial substitute for ordinary white bread.

The bran particles are very fine, and do not therefore produce the objectionable effects which have been described as often following the ingestion of ordinary whole-meal bread.

The following is an analysis of a sample of cyclone whole-meal bread:—

"CYCLONE BREAD"—ANALYSIS OF DRY SOLIDS.

Nitrogenous (gluten, etc.)	19·41
Carbo-hydrates (starch, sugar, etc.)	71·67
Fat	2·19
Fibre	3·44
Mineral matter	3·29
	100·00

The ratio of proteids to carbo-hydrates is about 1 to 3·6—very near the normal.

The waste in ordinary whole-meal bread is quite 12½ per cent, but from careful investigations and experiments the waste in the finest varieties of cyclone bread has been ascertained not to exceed 8 per cent.

This is a very low rate of waste for a whole-meal bread.

The flavour of the bread is exceedingly fine, especially if made with malt extract at a comparatively low temperature. It is sweet, pleasant, and does not pall on the palate like the coarse whole-meal breads.

The loaves remain moist for a much longer period than ordinary whole-meal bread, which is an important point to most people. Seeing that cyclone bread fulfils the conditions of a perfect whole-meal bread as regards flavour, fineness, and purity, it yields to the body—

(1) A comparatively large percentage of nitrogenous matter.
(2) A large proportion of the valuable phosphoric acid, potash, and iron.

It is thus a specially valuable food for children, nursing mothers, and brain workers generally.

The bread also counteracts constipation without irritation to the delicate lining membrane of the intestines.

The cyclone bread, when properly made, is very digestible, especially if malted or prepared according to the process of Mr. Fletcher.

Medical authorities and analytical experts are agreed as to the good qualities of this bread, and from many experiments and investigations the author has no hesitation in endorsing their reports.

CHAPTER XXXI

GERM BREAD

THE wheat grain may be described as consisting of three parts—

(1) An outer coat of many layers (bran).
(2) The endosperm.
(3) The embryo and surrounding structures (germ).

The "germ" consists of the embryo, or young plant, lying in a curious shield-like body known as the *scutellum*. The scutellum is separated from the other part of the grain by a layer of columnar epithelium cells, which Messrs. Brown and Morris name the *secretory epithelium*, because the ferments which develop in germinating wheat have their origin in this coat. The endosperm constitutes

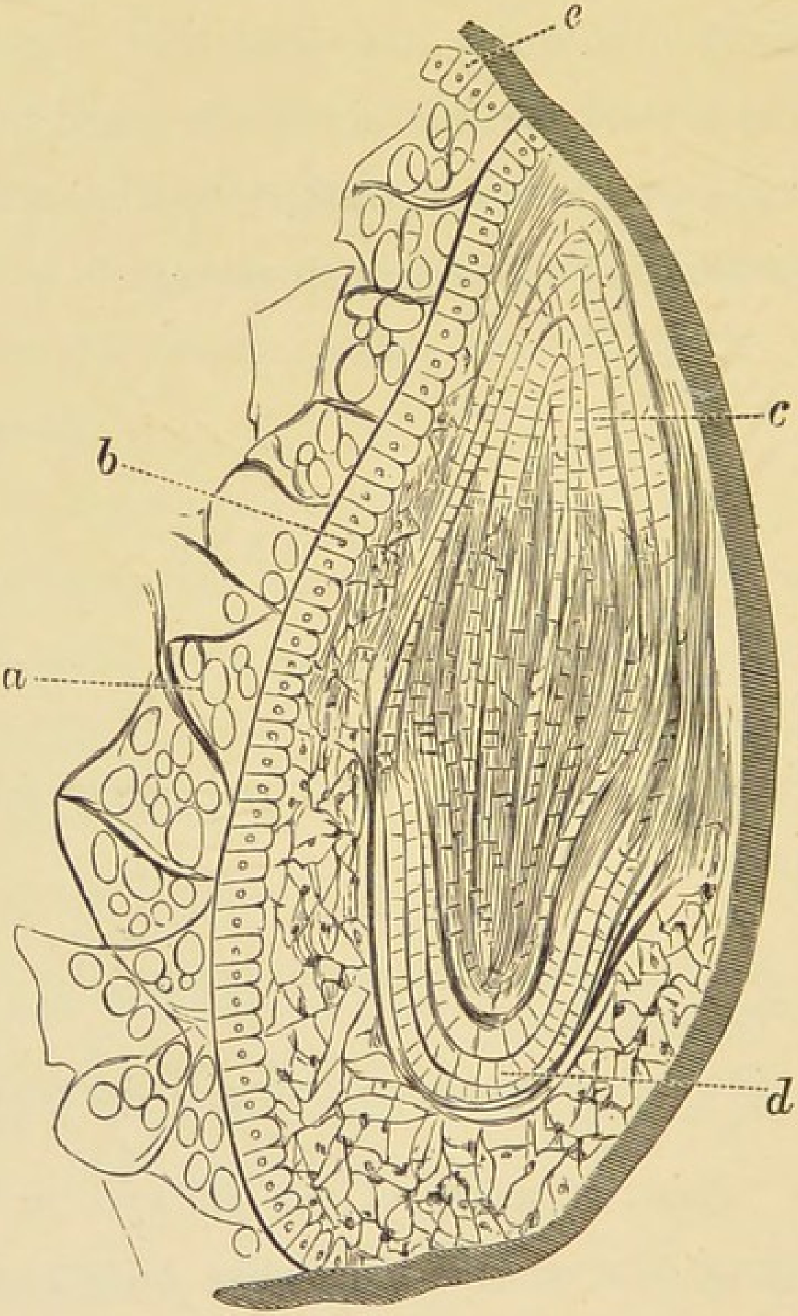

Fig. 19.—Section of Germ. *a*, Starch grains; *b*, secretory epithelium; *c*, plumula; *d*, radicle; *e*, termination of cerealin cells of bran.

the part of the grain which adjoins the germ. It is composed of irregular cells containing starch grains and gluten. The walls of the cells are mainly made up of fine woody fibre and cellulose.

Adjacent to the secretory epithelium of the scutellum are a number of cells filled with proteid particles, known as aleurone grains.

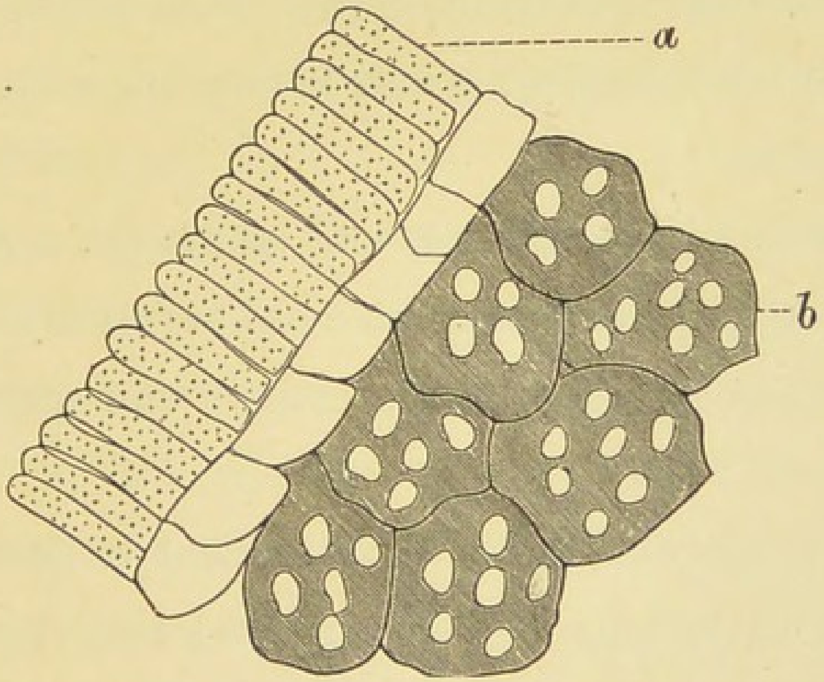

Fig. 20.—Diagram of Secretory Epithelium. *a*, Secretory cells; *b*, cells containing aleurone grains.

Broadly speaking, we may say that the germ contains the vitality of the grain, and will develop under certain conditions into a wheat plant, while the endosperm is simply a storehouse of food material upon which the young plant draws until its roots have developed, and it is able to get nourishment direct from the soil.

When the grain is placed under favourable conditions (moisture and warmth) certain changes take place in the germ. There is an absorption of water, and the secretory epithelium rouses to activity. Two ferments are developed from certain antecedents which exist in the cells. One acts on the cellulose, and the other acts on the starch of the endosperm.

The latter ferment is well known under the name of diastase.

The insoluble cellulose and starch are converted by these ferments into soluble bodies (mainly sugar), which are absorbed by the embryo and utilised as food.

It is probable that a third ferment is developed, analogous to trypsin of pancreatic juice, which acts on the proteids of the endosperm, as well as the aleurone grains of the scutellum, converting them into bodies closely allied to the soluble peptones produced in the intestines, which by further decomposition are changed into crystalline nitrogenous substances termed amides. The young plant is thus abundantly supplied with both nitrogenous and carbo-hydrate material, and is enabled to grow vigorously until it has sufficiently developed to cater for itself in the air and soil.

In ordinary flour the germ is absent. It is rejected on account of its bitter flavour, and the readiness with which it develops the unorganised ferments (*enzymes*) described above.

The untreated germ imparts to bread a peculiar unpleasant flavour, which is far from desirable, and its presence in flour leads to fermentation and decomposition.

Millers, therefore, always remove the germ by mechanical means from the various grades of flour.

The result is a loss of nutriment, for the germ is by far the most nutritious part of the wheat grain. The percentage of proteids is very high, and the fat of the grain is largely found in the germ. It also contains a very large proportion of phosphates.

The following analysis will give some idea of the proportion of the various constituents:—

GERM—ANALYSIS OF DRY SOLIDS.

Proteids	34·2
Carbo-hydrates (starch, sugar, etc.)	43·5
Fat	15·3
Fibre	1·8
Mineral matter	5·2
	100·0

If by any means the active properties of the germ could be destroyed without affecting its nutritive value, and the bitter principle extracted or neutralised, it could be retained in the flour, and would thus give the latter a higher value as food, especially in relation to the proteids, fat, and phosphates.

Lately there have been patented two or three methods of dealing with the germ, to secure the objects stated above, and there are now two or three good "germ meals" in the market.

Smith's Patent Germ Bread.

Mr. Richard Smith was the first to invent a really effective method of treating the cast-out germ.

The process, which is at the same time both simple and ingenious, may be described as follows:—

The germs are fed into one end of a paddle worm, which is surrounded by a steam jacket. Steam jets also communicate with the interior of the worm. The worm slowly revolves, so that the germs are gradually forced to the other end, where they fall out by an appropriate channel.

Steam is passed through the jacket, as well as along the worm, and the result is a very high temperature, which destroys the active power of the protoplasm of the secretory epithelium, and the ferments are therefore never fully developed in the treated germ. The steam which passes through the worm, and which has thus come into contact with the germs, dissolves out or destroys the bitter principle found in them. But the inventor ascertained that the steam also extracted certain bodies, which, if retained, imparted a very delicate and nutty flavour to the bread made from the germ flour. The difficulty is got over by conducting the escaping steam from the worm over semolina, which absorbs those flavouring substances without taking up the bitter principle. The semolina is used in the preparation of the germ flour, so that the desirable flavouring bodies are restored to the meal.

Smith's germ flour contains about 25 per cent of the germ, and thus has a very high dietetic value. Germ bread is made from the prepared germ flour, and the result is a bread of great value.

On referring to a previous chapter on white bread, the reader will gather that it would be advantageous to obtain a bread with a larger proportion of nitrogenous matter and mineral substances than is present in fine white bread. The use of "germ flour" secures this.

The following is an analysis of Smith's germ bread (*a*) compared with white bread (*b*):—

	(*a*)	Fine White Bread. (*b*)
Proteids (nitrogenous) .	21·2	12·0
Carbo-hydrates (starch, etc.)	72·4	85·0
Fat	3·1	1·2
Fibre	1·2	0·4
Mineral matter . .	2·1	1·4
	100·0	100·0

The ratio of proteids to carbo-hydrates is as 1 is to 3·4.

Another very important point is the comparatively large percentage of fat present in this bread—far in excess of that present in either ordinary white bread or whole-meal bread.

An analysis of the ash of this bread reveals the fact that it contains nearly four times the quantity of phosphates contained in white bread, and about 20 per cent more than whole-meal bread.

Germ bread is of special value in all those conditions which need—

(1) A large proportion of proteids.
(2) A large proportion of phosphates.

It has already been pointed out that nursing mothers, those who are *enceinte,* and children, thrive best on a diet fulfilling the above conditions, and therefore the bread under consideration can be recommended to such individuals with great confidence.

The medical journals and eminent medical authorities have given very favourable reports on "germ bread," and the author is certainly of the opinion that it is far superior to fine white bread or ordinary whole-meal bread as a food.

The *waste* of the bread is just slightly above that of fine white bread; it is therefore thoroughly digested, and does not produce any irritation of the intestinal tract.

The flavour of "germ bread" is delicious, and is retained by the bread for a very long period after baking.

Careful experiments with artificial digestive juices prove that the bread is easily digested, and it is therefore adapted for those who suffer from indigestion.

"Cyclone" Germ Whole-meal Bread.

This bread is prepared from "cyclone" whole-meal, to which is added a certain quantity of treated germs. The germs are prepared by a method invented by Mr. J. T. O'Callaghan. The process may be briefly described as follows. The raw germs are treated with lime water in order to neutralise the bitter principle found in them. The germs are then subjected to a temperature sufficiently high to destroy the diastase and other ferments. When the germs have cooled down to 160° F. they are blended with diastase from malt, and subsequently mixed with whole-meal in the proportions of 1 of the treated germs to 3 of whole-meal by weight.

This bread is characterised by a very high percentage of proteids and a considerable proportion of *soluble* carbo-hydrates. It may be said to combine the qualities of malt bread, germ bread, and whole-meal bread.

The following is an analysis of cyclone germ whole-meal bread:—

ANALYSIS OF DRY SOLIDS.

Proteids	21·6
Carbo-hydrates	68·6
Fat	4·9
Fibre	2·1
Mineral matter	2·8
	100·0

The ratio of proteid material to carbo-hydrates may be taken as perfect. This bread is one of the most nutritious in the market, and it is more digestible than ordinary bread inasmuch as a considerable portion of the carbo-hydrates are soluble. The soluble carbo-hydrates are produced from the starch by the action of the diastase during the first stages of baking. Provided the whole-meal used in the preparation of this bread be fine, it forms a most valuable food for children, and might with advantage form a large part of the diet of nursing mothers and those who are *enciente.*

Mr. O'Callaghan's Germ White Bread.

The germs for use with white flour undergo a different process. An extract of malt is prepared and mixed with the germs, and then the whole treated with lime water. The mixture is then made into dough and afterwards rolled out into sheets. The sheets are allowed to dry, and then ground into very fine meal. This "germ" meal is added to fine white flour and used in the manufacture of the "germ" white bread.

The resulting bread is more nutritious than ordinary fine white bread, and contains more of the valuable phosphates.

CHAPTER XXXII

FLETCHER'S PATENT DIASTASE BREAD

THIS variety of bread may be made from either white flour or whole-meal. The special point in which it differs from all other kinds of bread is the large proportion of soluble carbo-hydrates which it contains.

This result is obtained by the addition of *diastase* to the water which is used to make the dough. About 8 oz. are allowed to every 280 lbs. of flour.

Diastase belongs to the class of ferments known as the *enzymes,* and is analogous to ptyalin of saliva, and the animal diastase of pancreatic juice.

The action of this class of ferments is not yet thoroughly understood. They are all nitrogenous bodies, readily soluble, and have the power of acting on certain insoluble bodies, and converting them into highly diffusible substances.

They appear to undergo no change themselves during the manifestation of their activity, but seem to induce certain changes in the molecules which come in contact with them. For this reason they are often called *catalytic* agents.

There is a good deal of evidence to show that they have the power of causing molecules to combine with water, and undergo deduplication. For this reason they are often spoken of as *hydrolytic ferments.*

Diastase is produced in nearly all germinating seeds, but more especially in the cereals like barley, wheat, etc.

The mode of production and the function of the diastase were given in the last chapter, so that it need not be referred to here, except to give in detail the action of the diastase on starch, and the influence of temperature on its activity. Diastase has the power in a slightly alkaline or neutral medium, and, at a suitable temperature, of converting the starch into dextrin and sugar.

The whole series of changes has not yet been fully worked out, but it is probable that the conversion of starch into sugar takes place in two stages. In the first stage various dextrins are formed, and in the second stage sugar.

Although the formula of starch may be written $C_6H_{10}O_5$, yet it is probable that the molecule of this body is not so simple as the formula represents. For this reason it is better not to endeavour to show the change in the form of a simple equation.

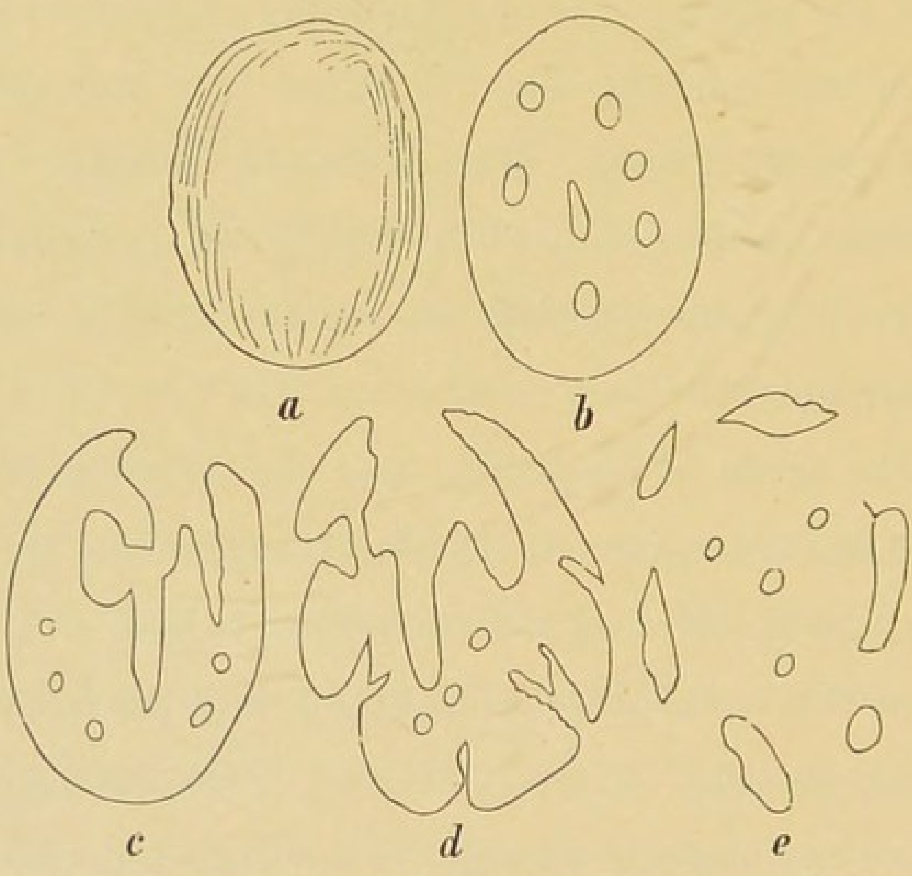

Fig. 21.—Diagram of Starch Grain being dissolved by Diastase. *a*, *b*, *c*, *d*, *e* represent different stages.

Messrs. Brown, Heron, and Morris have given this subject very careful and detailed consideration, and communicated at various times the results of their researches to the Chemical Society. The full details of their experiments and conclusions will be found in the journals of the Society for the years

1879, 1885, and 1889, but a very brief *résumé* may be given here. They look upon starch as having the following molecular formula :—

$$C_{180}H_{300}O_{150},$$

and to be constituted as follows :—

$$\text{Starch} = \begin{cases} (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \end{cases}$$

That is to say, it consists of five groups, each having the constitution—

$$\left\{ \begin{matrix} C_{12}H_{20}O_{10} \\ C_{12}H_{20}O_{10} \\ C_{12}H_{20}O_{10} \end{matrix} \right\}$$

The first change which takes place when diastase acts on starch is the formation of erythrodextrin and a body termed maltodextrin, by the combination of water with one of the groups constituting the starch molecule.

$$\underset{\text{Starch.}}{\left\{ \begin{matrix} (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \\ (C_{12}H_{20}O_{10})_3 \end{matrix} \right\}} + \underset{\text{Water.}}{H_2O} = \underset{\text{Erythrodextrin.}}{4\{(C_{12}H_{20}O_{10})_3\}} + \underset{\text{Maltodextrin.}}{\left\{ \begin{matrix} C_{12}H_{22}O_{11} \\ \left\{ \begin{matrix} C_{12}H_{20}O_{10} \\ C_{12}H_{20}O_{10} \end{matrix} \right\} \end{matrix} \right.}$$

Maltodextrin is believed to be a combination of maltose and dextrin.

The maltodextrin is then converted into maltose, according to the following equation:—

$$\left\{ \begin{matrix} C_{12}H_{22}O_{11} \\ (C_{12}H_{20}O_{10})_2 \end{matrix} \right\} + 2H_2O = 3C_{12}H_{22}O_{11}$$

Maltodextrin. Water. Maltose.

The erythrodextrin $4\{(C_{12}H_{20}O_{10})_3\}$ left undergoes a similar change, breaking up into achroodextrin (*a*) and maltodextrin. The latter is converted into maltose, while the former is converted into achroodextrin (*b*) and maltodextrin. The same change goes on until only maltose and a form of achroodextrin remain.

The latter is stable, and is not converted into maltose.

It must not be assumed that all these changes take place in regular sequence. It is probable that many of them go on simultaneously.

The complete change may be represented equationally as follows:—

$$5\{(C_{12}H_{20}O_{10})_3\} + 12H_2O = (C_{12}H_{20}O_{10})_3 + 12C_{12}H_{22}O_{11}$$

Starch. Water. Achroodextrin. Maltose.

Whatever the intermediate changes may be, it is important to remember that the final products of the diastasis of starch are—(1) Maltose; (2) A stable achroodextrin.

The action is very slow with raw starch, but gelatinised starch is acted on with rapidity. The most favourable temperature for the fermentation is about 125° F. A high temperature (180° F.) or a very low one arrests its action.

The object of adding the diastase to the dough, and so to the bread, is to convert a large proportion of the starch into sugar, and so render the bread more digestible.

During the doughing operations very little starch is acted on, for the reason that it is practically raw. But when the bread is placed in the oven the temperature soon rises to about 140° F., when the starch granules begin to gelatinise, and the diastase then acts very vigorously on the starch. This diastasic action goes on until the temperature reaches 180° F., when it ceases.

The time, then, during which the ferment acts on the starch, is limited to the period which elapses between the temperatures of 140° F. and 180° F.

This time varies, of course, according to the heat of the oven, but may be stated to be on an average about 15 minutes, which is quite long enough for the diastase to do its work.

An analysis abundantly proves that the Patent Diastase Bread contains far more soluble carbo-hydrates than ordinary white or brown bread.

Analysis of Dry Solids.

	Patent D. Bread (White Loaf).	Fine White Bread.
Albuminoids (gluten, etc.)	12·5	12·1
Insoluble carbo-hydrates (starch)	60·8	72·1
Soluble carbo-hydrates (sugar and dextrin)	23·9	13·1
Fat	1·3	1·3
Mineral matter	1·5	1·4
	100·0	100·0

On comparing these two analyses it will be seen that the diastase bread contains over 82 per cent more soluble carbo-hydrates than fine white bread. The other constituents are present in about the same proportion as in ordinary white bread.

The inventor may fairly claim for this variety of bread that it is distinctly more digestible than ordinary white bread, inasmuch as it contains relatively less of the insoluble *starch,* and more of the soluble maltose. This has no weakening effect on the digestive organs, which secrete the amylolytic ferments, for there remains sufficient starch for the healthy exercise of their functions, without the liability of overwork.

A very important point which appears to have been overlooked by the many authorities who have examined this bread is the fact that the *starch is in a very assimilable form.* A number of experiments with the standard extract of pancreatic diastase clearly proved that the starch is in such a condition as to be acted on rapidly and completely by the amylolytic ferments of the digestive organs. This fact renders the bread very useful to those who possess weak digestions.

A loaf of this bread keeps moist for a longer period than ordinary bread on account of the larger proportion of soluble constituents which it contains, and does not lose its flavour on being kept.

A very important point in the consideration of the value of any bread is the flavour.

In this respect the diastase bread is certainly beyond reproach. The flavour is sweet, and leaves a very pleasant after-taste in the mouth.

Besides its general value, this bread is of *special* use to—

(1) Children, because they require starch in an assimilable form.
(2) Individuals who are inclined to indigestion.
(3) Convalescents and invalids.
(4) Nursing mothers.

The latter will find the soluble matter present in the bread a good and healthy stimulus to the secretion of nourishing milk.

CHAPTER XXXIII

"FRAME FOOD" BREAD

This variety of bread is made from ordinary white flour, to which a certain quantity of the extract from bran is added.

The result is a loaf which is far more nutritious than the ordinary white or whole-meal variety.

The patentee seeks to add to ordinary flour the valuable constituents of the bran of wheat without the woody fibre, in such a form as will be available to the body.

It has been pointed out in a previous chapter that a large percentage of the nourishment in the bran of *ordinary* whole-meal bread is excreted undigested, owing to the close relations of the food substances with the indigestible portions.

It is not so with Frame Food Bread, for the extract which is added is practically entirely available.

No chemical means are adopted to extract the nutriment from the bran, so that the extract is perfectly pure and free from any added mineral matter.

The bran is heated at a high temperature, and the food substances extracted by mechanical means.

The extract is either concentrated or dried.

Only accurate analysis can show how far the method is a success, and the verdict of experts is entirely in its favour.

Dr. P. F. Frankland, F.R.S., gives the following analysis of the extract (powder), which the author has confirmed:—

Albuminoids	21·40
Sugar	12·30
Dextrin	22·60
Starch	13·00
Other organic matter	10·43
Phosphoric acid	3·68
Potash	4·24
Iron and other mineral matter	2·77
Water	9·58
	100·00

Professor Attfield states the composition as follows:—

Albuminoids	22·5
Carbo-hydrates	57·5
Phosphates	10·0
Moisture	10·0
	100·0

The patentee may fairly claim that his method is successful in extracting the most nutritious part of the bran and presenting it to the body in a very assimilable condition.

The ash of the extract is very rich in the alkaline phosphates, especially phosphate of potash. Professor Attfield states that the preparation contains quite 7 per cent of the latter salt. Iron is also present in considerable quantities.

Dr. Frankland gives the following analysis of the inorganic matter of the Frame Food Extract:—

Silica	0·36
Sulphuric acid	0·35
Chlorine	0·17
Phosphoric acid	3·68
Ferric oxide (iron)	0·15
Lime	0·15
Magnesia	1·14
Potash	4·24
Soda	0·15
	10·39

A very important point is that practically the whole of the inorganic matter is *soluble in cold water,* so that it is all available for the nourishment of the tissues.

Inasmuch as the inorganic matter has been extracted from a substance which once formed part of a *living plant,* it is eminently suited to meet the requirements of the body.

The same mineral constituents added to bread from the laboratory would not be so readily assimilated, and would probably do harm, owing to their crude condition.

The amount of extract to be added to the flour depends upon whether the powder or the liquid be used. In the former case it is 1 oz. to 7 lbs. of flour. In the latter it is 1 lb. to 14 lbs. The cost amounts to 2d. per 7 lbs. When the small cost is compared with the great increase in the nutritive value of the loaf it is inconsiderable.

The following table gives the analyses of fine white bread and frame food bread:—

	Fine White Bread.	Frame Food Bread.
Water	37·0	38·4
Proteids	7·5	11·4
Carbo-hydrates	53·8	48·1
Fat	0·8	0·9
Mineral matter	0·9	1·2
	100·0	100·0

Frame food bread contains 3·9 per cent more nitrogenous matter and ·3 per cent more mineral matter than fine white bread.

The increase of mineral matter largely consists of phosphoric acid and potash, two of the most valuable inorganic food substances.

In fact, the frame food bread may be regarded as approaching whole-meal bread in composition, minus the particles of bran.

The author has ascertained that the waste in frame food bread is about $5\frac{1}{2}$ per cent. The waste in fine white bread is slightly below this, while in ordinary whole-meal bread it is more than double.

The ratio of nitrogenous matter to carbo-hydrates in frame food bread is compared below with those of other breads—

Standard	1 : 3·2
Fine white bread	1 : 7·0
Coarse white bread . . .	1 : 5·4
Ordinary whole-meal . . .	1 : 4·3
Fine whole-meal	1 : 3·6
Frame food bread	1 : 4·2

The ratio of proteids to carbo-hydrates is thus seen to approximate very nearly to the standard ratio.

The bread keeps moist for a longer period than ordinary whole-meal bread, and the distinct flavour of the loaf is pleasant.

Frame food bread does not counteract constipation to the same extent as fine whole-meal bread, owing to the absence of the bran particles, and for this reason it is to be strongly and specially recommended to those who find that whole-meal bread produces too great a relaxation of the intestines. Such individuals will obtain all the nutritious aliments of the wheat from the frame food bread without undue looseness of the bowels.

The value of the frame food bread as a food depends on—

(1) Its high ratio of proteids to the carbo-hydrates.
(2) The large proportion of phosphoric acid, potash, and iron present.

There can be no doubt that it is far superior to white bread as a food, and ought to be largely eaten by those people who do not care for fine whole-meal bread, or who find that the latter disagrees with them.

Frame food bread may be eaten with beneficial results by—

(1) Those who are anæmic. The iron which the bread contains is certainly useful in counteracting the lack of hæmoglobin in the red corpuscles, and promoting a development of new red corpuscles.
(2) Those who are *enceinte.* The alkaline phosphates and nitrogenous matter are very favourable to the development of a healthy child.
(3) Nursing mothers. The bread will assist to

supply the phosphates for the milk far better than white bread, which is deficient in them.

(4) Children, more especially those inclined to rickets.

(5) Those who find the teeth are decaying.

The bread has received high praise from the highest medical authorities, who are agreed that it is a distinct advance in food reform. It may interest bakers to know that the frame food extract has the effect of quickening fermentation, thus helping the baker in producing bread of good flavour, besides giving it a higher nutritive value.

CHAPTER XXXIV

GLUTEN BREAD

Gluten bread is prepared from "crude gluten," obtained from flour by removing the starch and the soluble bodies.

The simplest way of obtaining "crude gluten" is to enclose a sample of "strong" flour in a muslin bag, and carefully knead it under water.

The starch is gradually removed from the flour, and remains suspended in the water, while the gluten is left behind as a soft, sticky mass.

It is necessary to wash the gluten in successive waters until there is no milkiness.

Another method of obtaining the crude gluten may be adopted, in which the flour is gently washed in running water. Such gluten is practically free from starch and sugar, but contains a little fat.

The gluten is usually baked in the form of rolls, buns, and small loaves. They "rise" enormously in the oven, and, when cut, show large spaces, separated by glistening partitions of gluten.

A comparatively large loaf of gluten bread weighs only a few ounces.

The ordinary gluten bread, when eaten, forms a very unpleasant "doughy" mass in the mouth, and is comparatively flavourless.

Gluten bread is chiefly partaken of by those individuals who suffer from the disease known as *diabetes.*

Diabetes is characterised by the appearance of sugar in the urine. Under ordinary circumstances the small percentage of sugar present in the blood passes through the kidneys without being removed.

But if the proportion of sugar in the blood be increased very much beyond the normal, the surplus is removed by the cells of Bowman's capsule, and it passes away from the kidney as a constituent of urine.

It will be convenient if a brief sketch be given of the chain of events which may lead to a surplus of sugar in the blood.

Most authorities are agreed that the liver is chiefly affected in this disease, and that it is connected in some way or other with the glycogenic function of that organ.

It is well known that the starch of our food is converted into sugar by certain ferments in the body. (See Section I.)

This sugar, together with any sugar which may have existed in the food, is absorbed by the blood in the stomach and intestines.

The blood from these organs, before reaching the general circulation, passes through the liver, where it is brought into very close relations with the hepatic cells. The latter effect certain changes in the products of digestion, but act more especially on the sugar.

The whole change has not yet been thoroughly worked out, but the simplest view which can be taken is to assume that a dehydration occurs according to the following equation:—

$$\underset{\text{Sugar.}}{C_6H_{12}O_6} - \underset{\text{Water.}}{H_2O} = \underset{\text{Glycogen.}}{C_6H_{10}O_5}$$

The glycogen is stored up by the hepatic cells, and the blood leaves the liver by the hepatic veins poorer in sugar. Glycogen is isomeric with starch and dextrin, but differs from them in physical and chemical properties. It has sometimes been termed "animal starch."

The glycogen, however, does not remain as such in the liver. It appears to be very slowly reconverted back again into sugar by a special ferment, and slowly passed back again into the blood.

The object of these series of changes seems to be to prevent the large quantity of sugar derived from an ordinary meal from being thrown into the general circulation. Under such a condition part of the sugar would be excreted, and so lost to the body.

It appears that only a certain quantity of sugar can be used by the tissues under ordinary conditions, and the liver, by storing up the sugar derived from digestion in the less soluble form of glycogen, and then slowly doling it out to the blood as required, prevents the waste of sugar, and keeps up the normal percentage in the blood.

A surplus of sugar in the blood, and consequently its presence in the urine, may be due to—

(1) The failure of the hepatic cells to form glycogen.
(2) The too rapid conversion of glycogen into sugar by the liver ferment.

In the first case the sugar derived from the meal passes through the liver unchanged, and thus finds its way into the general circulation, with the consequence of excretion by the kidneys.

In the second case the sugar in the urine has its origin in the sugar derived from the glycogen of the liver.

In both cases carbo-hydrate food—starch, sugar, dextrin, etc.—is distinctly favourable to the abnormal condition, and a withdrawal of all amylaceous food is usually followed by the disappearance of sugar from the urine. Most medical authorities advise diabetic patients to abstain from all starchy and sugary foods, including ordinary bread, and recommend nuts, green vegetables, lean meat, etc.

Gluten bread, inasmuch as it is practically free from starch, forms a very valuable food indeed for those who suffer from diabetes.

It is interesting to state, however, that sometimes the withdrawal of starch, etc., from the diet is *not* followed by the disappearance of sugar from the urine.

In such cases it is obvious that the glycogen, and consequently the sugar, must have some other origin than in the carbo-hydrates, and it is generally believed that proteid material may be a source of glycogen and sugar, possibly splitting up into a non-nitrogenous moiety (glycogen and other bodies) and a nitrogenous portion (urea).

Recent observations seem to show that a diet free from starch and other amyloids will not of itself permanently cure the disease. A careful and regular life, together with specific treatment, must be combined with the non-amylaceous *régime*.

John Bonthron's Gluten Bread.

This bread is made by a special process from prepared gluten.

The loaves are exceedingly light, and the flavour far surpasses that of the ordinary gluten bread.

One of the greatest objections to gluten bread is the unpleasant taste and sensation it produces in the mouth. Mr. Bonthron's gluten bread has not this disadvantage, for the flavour is certainly pleasant for such a bread, and quite palatable even to healthy individuals.

The lightness of the loaves is all that could be desired, consequently they are very digestible.

An analysis proves that they are practically as free from starch and sugar as is possible. Dr. Pavy, the eminent authority on diabetes, says, in his great work (p. 245), that "Mr. Bonthron's gluten bread is far more eatable than anything of the kind I have ever yet met with. The bread is moist, and will keep good for about 10 days. It serves to increase the variety at the command of the diabetic; and, independently of this, possesses the advantages of presenting an approach to the condition of ordinary bread."

Mr. Bonthron also supplies a bread containing a specially-prepared bran, so that the diabetic patient obtains the benefit of the mineral matter. The bran is specially washed and freed from starch, and the fibrous outer layers are rejected. The bread is thus non-irritating.

The author has no hesitation in saying that the bread under consideration is a most valuable food for all those who are troubled with diabetes, and is by far the best preparation of its kind that has ever been produced.

CHAPTER XXXV

BLACK'S PATENT FERMENTED BREAD

THE characteristic of this variety of bread is a high nitrogenous ratio.

The patentee secures this by mixing with ordinary dough a special preparation of gluten, which is obtained from "strong" flours by a mode known as "Black's" Patent Fermentation process.

This process is very effective in precipitating the starch and concentrating the gluten, so that the resulting mixture is very rich in proteid material.

The following table gives the mean of three analyses of Mr. Black's bread compared with the average composition of fine white bread:—

ANALYSIS OF DRY SOLIDS.

	Black's Patent Bread.	Fine White Bread.
Albuminoids (gluten, etc.)	20·3	12·0
Carbo-hydrates (starch, sugar, etc.) . . .	76·9	85·3
Fat	1·2	1·3
Mineral matter . .	1·6	1·4
	100·0	100·0

It will be seen that the bread under consideration contains over 68 per cent more proteid material than fine white bread.

This constitutes a distinct gain, for, as has been pointed out at length in previous chapters, ordinary white bread is deficient in proteid material, and any process which tends to increase the percentage of nitrogenous substances in white bread must be regarded as a valuable addition to food reform.

An analysis of the mineral matter reveals the fact that the bread is richer in *lime* than ordinary fine white bread.

The ratio of nitrogenous matter to carbo-hydrates is about 1 to 3·6, which is very near the normal.

The high percentage of proteid material is obtained without any deterioration of colour, flavour, or texture, and the bread keeps moist for a considerable period.

The bread made by this process is very light, and is thus easily acted on by the digestive fluids of the body.

The process may be applied to all kinds of bread, malted, whole-meal, etc., but is especially valuable in the manufacture of white bread from fine flours.

By this method bread made from the finest flours may be turned out with as high a percentage of proteid material as the best whole-meals.

The process is a valuable and useful one, and from the hygienist's standpoint should be adopted by all bakers of white bread.

This bread is far more suitable for children, nursing mothers, and those who are *enceinte*, than ordinary white bread, on account of the larger proportion of nitrogenous matter which it contains.

Seatree's Health Bread.

This bread is a brown variety manufactured from Seatree's Cumberland brown bread meal.

The meal is prepared from the finest cereals, in order to secure, as far as possible, uniformity of quality and the highest proportion of nutrient matter.

The process of preparation provides that the coarsest particles of the outer coat of the bran are rejected, while the remaining layers are retained and very finely granulated.

This results in the retention of the main part of the nutriment of the wheat grain, and the rejection of the coarse woody portions, which are indigestible, and may be irritating to the intestinal tract.

The meal is exceedingly fine and very dry, so that it possesses great powers of absorbing moisture.

The mineral matter present in the meal is far in excess of that found in fine flour. An analysis gave the amount as 1·2 per cent, of which nearly two-thirds consist of phosphoric acid.

The bread prepared from this meal has practically the same composition as whole-meal bread, but without the very coarse woody particles of bran.

The following is an analysis of the dry solids of "health bread":—

Proteids (gluten, etc.)	19·85
Carbo-hydrates (sugar, starch, etc.)	72·83
Fat	2·21
Fibre	2·29
Mineral matter	2·82
	100·00

The amount of fibre is slightly below that of ordinary whole-meal bread, and the percentage of proteids and carbo-hydrates higher.

The ratio of the nitrogenous matter to the carbo-hydrates is as 1 is to 3·6, the normal being as 1 is to 3·2.

The proportion of waste matter in this bread is much below that of ordinary whole-meal bread.

In the latter the waste averages $12\frac{1}{2}$ per cent. In health bread the waste averages about 8·5 per cent.

The high nitrogenous ratio, combined with the low percentage of waste, makes this bread a very desirable and healthy food, far superior to ordinary white or whole-meal bread.

The absence of coarse particles of bran is also a most important point in favour of this bread. It has already been stated that the great objection to ordinary whole-meal bread is the presence of the sharp, coarse particles of bran, and bread reformers have directed their chief attention to the problem of "how to retain the nutritious elements of the entire wheat grain without large and coarse bran particles." Among others, the manufacturers of health bread have succeeded admirably in this respect, for by careful analysis and experiments the author has ascertained that this bread does really contain the largest proportion of the nutriment of the wheat grain, without the coarse husk.

The amount of phosphoric acid present compares favourably with the best whole-meal breads. 100 parts of the ash contain 47 parts of phosphoric acid.

The bread keeps moist far longer than ordinary whole-meal bread, and does not readily develop any trace of sourness.

The flavour is very pleasant, and the bread does not produce the undesirable sensation of touch without agreeable taste, which is so characteristic of ordinary whole-meal bread.

Health bread may be regarded as one of the best brown breads in the market, for the following reasons:—

(1) Its high nitrogenous ratio.
(2) The absence of coarse bran particles.
(3) The low percentage of waste.
(4) The absence of intestinal irritation on ingestion.
(5) Its pleasant, sweet flavour.
(6) The large proportion of phosphoric acid present.
(7) Its power of retaining moisture.

Besides its ordinary value as a food, health bread is specially adapted for children—not only on account of the large proportion of proteid material and phosphoric acid present, but more particularly because its ingestion produces no injurious irritation of the alimentary canal, and does not lead to undue relaxation of the bowels.

CHAPTER XXXVI

"DORASE" BREAD

THIS variety of bread is made from flour or wholemeal, fermented by yeast, with the addition of a special substance termed "dorase."

Dorase is so constituted that it stimulates the yeast to healthy and vigorous growth, thereby quickening fermentation.

The advantages of quick and vigorous fermentation have already been pointed out. It improves the flavour of the bread, and minimises the danger of obtaining a sour loaf.

Dorase being a highly fermentable substance, supplies the yeast cells with suitable nourishment in a highly available form. They consequently grow rapidly and vigorously, producing a large quantity of gas in a comparatively short time.

At the same time the vigorous and rapid growth of yeast prevents the development of souring germs.

Other important effects of "dorase" are—

(1) To render the gluten more tenacious; and
(2) To increase the water absorbing power of the dough.

The gluten being thus made more elastic, is capable of holding the gas which is so rapidly evolved from the yeast, and the resulting loaf is moister than ordinary bread.

The most important advantage gained by the use of "dorase" is, that there is no need to employ potatoes.

The bread is thus more nutritious, and the baking operations more cleanly.

The flavour and texture of "dorase" bread are very fine, and even after three days the bread is still moist enough to be palatable.

The colour is also good.

Summing up, the good points of dorase bread may be stated as follows :—

(1) It possesses a good colour.
(2) The flavour is sweet and nutty.
(3) The bread is very "light" and of even texture.
(4) It keeps moist far longer than ordinary bread.
(5) There is little danger in getting a sour loaf.

Preston's Lentilalmo Bread.

It has already been explained that white bread is not a perfect food. It is deficient in proteids, fat, and mineral matter.

Mr. Preston attempts to produce a perfect food by the addition of extra proteid matter and oil to the bread.

The substances used for this purpose are lentils and oil of sweet almonds.

Lentils are the seeds of the *Ervum lens*, a leguminous plant growing to perfection in Egypt, Algeria, Turkey, and South Europe.

They are allied to peas in properties and composition.

In the preparation of lentilalmo bread the lentils are ground to a fine powder, and added in certain quantities to the wheaten flour.

The composition of lentil flour is compared with wheaten flour in the following table:—

	Lentil Flour.	Wheaten Flour.
Water	9·07	12·0
Proteids	27·42	9·3
Fat	1·93	0·8
Carbo-hydrates	55·34	76·5
Fibre	3·71	0·7
Mineral matter	2·53	0·7
	100·00	100·0

The addition, therefore, of lentil flour to wheaten flour raises the nitrogenous ratio, and increases the proportion of fat and mineral matter.

It is important to state that about 20 per cent of the nitrogenous matter in lentil flour is indigestible.

The inventor uses "oil of sweet almonds" because it is tasteless, and possesses some of the demulcent properties of cod-liver oil.

The addition of the oil not only raises the proportion of fat in the bread, but confers upon the bread valuable keeping properties.

The flavour of the bread is pleasant, and it remains moist and palatable for many days.

Lentilalmo bread is far superior to ordinary bread for the following reasons:—

(1) Its high nitrogenous ratio.
(2) The high percentage of fat present.

The waste in the bread is a little above that of fine white bread.

Clarkson's Home-Made Bread.

The method adopted in the manufacture of this bread is very simple.

The dough is prepared in the usual way with yeast, and then placed in a tin mould. The mould is allowed to stand in a warm place until the dough has risen to within half an inch of the top of the mould. A lid is then put on, and the mould placed in a saucepan of hot water, which is allowed to boil for 2 hours.

The bread after that time is turned out on to thick cloth, which absorbs the excess of moisture.

The bread so made is very moist, and if properly made possesses an excellent flavour. The crust of the loaf is very much softer than that of ordinary bread.

The author believes that this method of making bread is especially useful in the home preparation of whole-meal, which requires a little more moisture than white flour to make a palatable loaf.

L. Mouline's Potato Bread.

This bread is made entirely from potatoes.

The method adopted is as follows:—

The potatoes are boiled and then pounded in a large mortar. 50 per cent of "treated farine" is now added and thoroughly mixed with the potatoes. The mixture is moulded into small cakes by rollers, which are left to dry, and then baked in a quick oven.

The "treated farine" is obtained as follows:—

Farinaceous food stuffs are taken and subjected to a vapour bath at a temperature of 160° C., under a pressure of four atmospheres.

The resulting bodies constitute the "farine." The farine consists chiefly of various forms of dextrin.

The advantages of this potato bread are—

(1) Small quantities can be prepared if required to be eaten fresh.
(2) About $\frac{2}{3}$ of the carbo-hydrates are soluble.
(3) The bread keeps for a long period.
(4) It is very cheap.

The great objection to the use of this bread is the small quantity of proteid material which it contains. But it is distinctly digestible, and may with advantage be eaten with nitrogenous substances in place of starchy foods.

Aleuronate Bread.

Aleuronate bread is distinguished from all other kinds of bread by the very high proportion of proteid material which it contains. This result is produced by the addition to ordinary flour of a nitrogenous substance known as aleuronate.

The method employed in the preparation of aleuronate is the invention of Dr. Mundhausen of Hamm, Westphalia, who has successfully devised a method whereby the by-products in the preparation of wheaten starch may be utilised in the manufacture of bread. In the preparation of wheaten starch, the husk of the grain is removed and the kernel reduced to the state of flour. The flour is then washed with water, with the result that the starch is more or less completely removed, and the insoluble constituents of the flour left behind. These bodies form the basis of the aleuronate, and consist chiefly of gluten, aleurone grains, and a little fat. The gluten, etc., is now treated with small quantities of phosphoric acid, which enters into chemical combination with part of the gluten. The whole is then dried and crushed into powder. The great features of aleuronate are—

(1) The high percentage of proteids it contains.
(2) The fact that it keeps perfectly well for a long time.

The sample of aleuronate analysed by the writer was found to contain 88·56 per cent of proteid material.

The aleuronate powder is very dry, and according to Dr. Mundhausen should be added to ordinary white flour in the proportion of 1 part of aleuronate to 5 parts of flour.

A sample of bread made according to the above proportions gave the following results on analysis:—

ANALYSIS OF DRY SOLIDS.

Proteids	30·13
Carbo-hydrates	68·27
Fat	0·36
Mineral matter	1·24
	100·00

It will be seen from the above analysis that the ratio of proteids to carbo-hydrates is as 1 is to 2·2. The author believes that this ratio is too high, especially if such a bread formed the staple food. But this is a defect which could easily be remedied by the addition of less aleuronate to the flour, so as to reduce the percentage of proteids to about 23.

Provided that the aleuronate and flour are mixed in the correct proportions, this bread is far superior to ordinary white bread as a food on account of the large proportion of proteids which it contains.

RIZINE BREAD.

Rizine Bread is prepared from a mixture of "rizine" and ordinary wheaten flour, in the proportion of one-third of the former to two-thirds of the latter. Rizine is a special preparation of rice. The rice grains are first subjected to the action of steam.

This has the effect of softening the grains and gelatinising the starch granules. The softened grains are then passed through rollers and thus flattened out into thin flakes. The author had several loaves prepared according to the above formula, which gave the following results on analysis :—

ANALYSIS OF RIZINE BREAD.

Water	42·6
Proteids	6·9
Carbo-hydrates	49·0
Fat	0·7
Mineral matter	0·8
	100·0

The addition of rizine to the flour has the effect of lowering the nitrogenous ratio in the bread. The resulting bread was not unpleasant in flavour, and kept moist for a very long time. A loaf which had been kept unbroken for ten days was found to be still moist enough to be eaten in the ordinary way.

BEST'S GERM MALT BREAD.

This malted bread is prepared from a mixture of germs and flour or whole-meal. The bread is very nutritious, and far superior to white bread as a food.

SECTION V.—THE DISEASES OF BREAD, INCLUDING ABNORMAL CONDITIONS

CHAPTER XXXVII

DISEASES OF BREAD

Fortunately in this country it is very rare to find diseased bread. But sometimes, in spite of the utmost care on the part of the baker, bread becomes diseased soon after removal from the oven.

Often the disease or abnormal condition is due to impurities which previously existed in the flour. Sometimes the flour used is perfectly healthy, and the disease originates in some of the other ingredients, or may be developed in the bread by external agents.

It will be convenient if those abnormal conditions of bread (sour bread, heavy bread, etc.), which can hardly be classified as diseases, are studied in this section.

The *effects* of such bread on the body will also be conveniently considered here.

Diseases due to Impurities in the Flour.

Ergot.—This disease is more especially characteristic of rye; but it also attacks wheat.

It is produced by a fungoid growth known as *Claviceps purpuræ.* It may be present in the flour as ergot of wheat, or as ergot of rye, when the flour has been adulterated with rye.

Ergot of rye produces very serious symptoms. It acts specially on the *uterus,* producing powerful muscular contractions. Gangrenous sores may also be produced if it be ingested in large quantities.

The disease is more likely to be found in rye bread than in wheaten bread.

M. Nocard has recently stated, in a report to the French Government, that ergot of wheat does not produce the same results as ergot of rye.

Mildew is produced by a fungus named *Puccinia graminis,* and is one of the most common diseases of flour. No injurious effects have been definitely traced to the ingestion of bread made from such diseased flour. But there can be little doubt that such bread is not so beneficial to the body as healthy bread, and should therefore never be eaten.

The flavour of bread made from mildewed flour is decidedly unpleasant.

Smut is also a fungoid disease due to the growth of *Uredo segetum* within the grains. When present it imparts a disagreeable odour to the flour, and a peculiar steel-gray colour to the bread.

It produces intestinal derangements, sometimes accompanied with diarrhœa.

Bunt, or pepper brand, also known as stinking rust, is caused by a fungus known as *Uredo fœtida.*

It attacks the internal portions of the grain, which, when opened, are found to be filled with a black foul-smelling powder.

No specific injurious effects have been ascribed to the presence of "bunt" in bread. But it is probable that it acts generally as an irritant to the alimentary tract.

Lolium Temulentum, or rye grass, when present in bread confers upon it a poisonous character. It acts chiefly on the nervous system, producing convulsions, paralysis, and vertigo. **Melampyrum Arvense** (purple cow wheat), **Trifolium Arvense**, and **Rhinanthus, major** and **minor**, impart characteristic colours to the bread, but do not produce any specific injurious symptoms.

The **Acarus Farinæ** is often present in inferior damp flours, and although it is not injurious, yet its dead body in the bread is decidedly objectionable.

Bacteria of various forms develop in flour during decomposition, but little is known concerning their effect on the body.

Many of the bodies described above find their way into the flour accidentally. The modern milling operations are carried on with such care that it is seldom indeed that impurities are intentionally allowed to creep in.

Disease due to Fungoid Growths in the Bread.

It will be convenient if a very brief sketch be given of a general type of fungus. Taking the *Penicillium* as a type, its history and structure may be stated as follows:—

It develops from a small spore, termed in this case a conidium.

Delicate branches named hyphæ, consisting of single chains of cells, develop and grow downwards.

The hyphæ interlace and form a loose structure known as the mycelium, and many branches descend still lower to form "submerged" hyphæ.

Branches, termed aerial hyphæ, also grow upwards, and these bear the spores known by the name of conidia. The upper portions of the aerial hyphæ are often named conidiophores, because they bear the conidia.

Mouldy Bread is undoubtedly produced by the growth of a fungus known as the *Eurotium herbariorum.*

It is the *acrospore* stage of this fungus which produces the disease. Formerly it was described as a different variety, under the name *Aspergillus glaucus,* but recently De Bary has conclusively shown that it is identical with the sporocarp stage of the *Eurotium.*

The ingestion of mouldy bread may produce derangements of the stomach, accompanied with sickness.

Musty Bread resembles mouldy bread in origin and general characters, but usually there is less mould to be seen, and the odour is slightly different.

It appears from the researches of Percy Smith

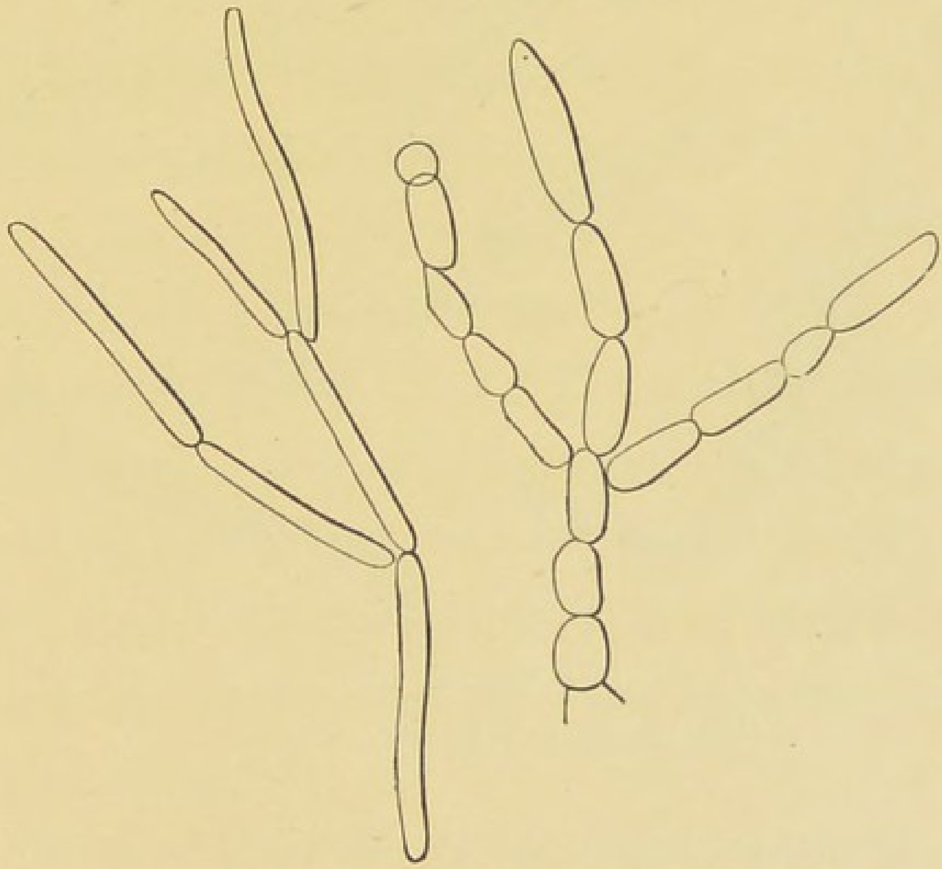

Fig. 22.—Aspergillus Glaucus.

that musty bread yields not only the *Eurotium herbariorum*, but another fungus, named the *Mucor mucedo*, and possibly other species.

The *M. mucedo* probably effects chemical changes in the constituents of the bread, producing bodies with disagreeable flavours.

Both the diseases just described are favoured by dampness and darkness. Flour and bread should therefore be stored in dry places.

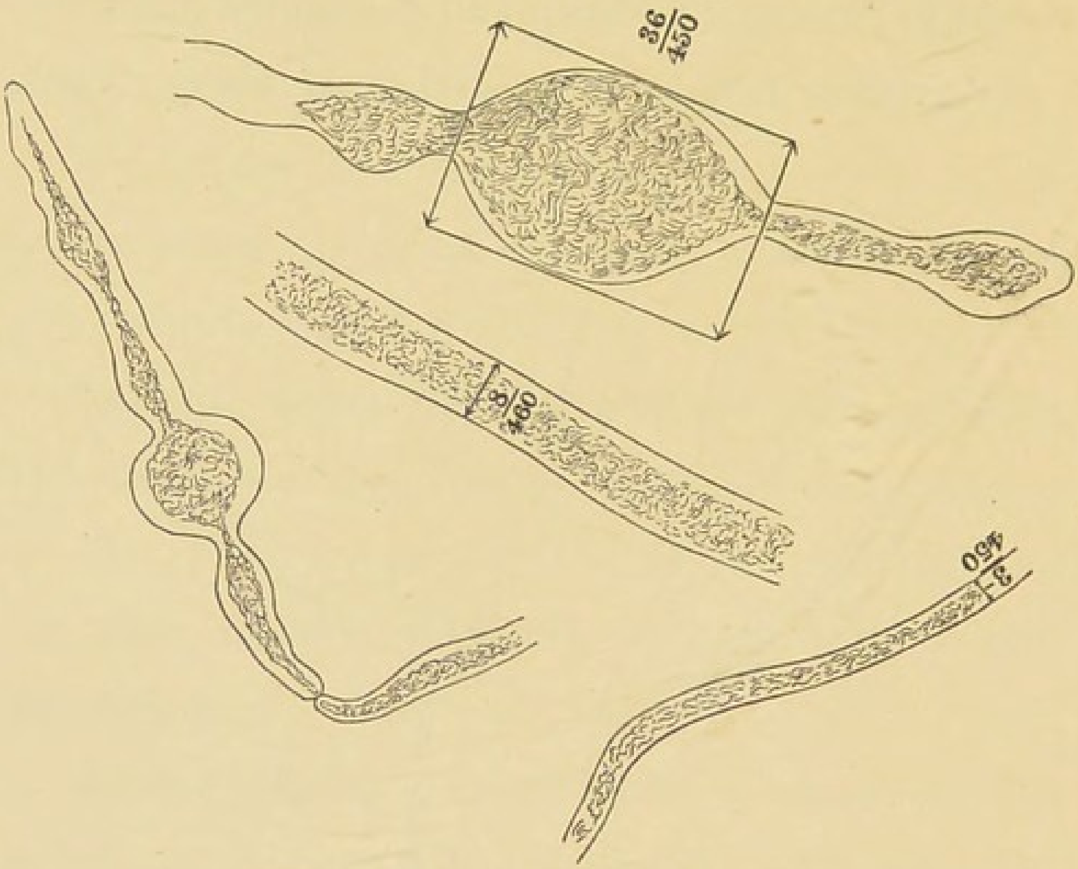

Fig. 23.—Mucor Mucedo. (Pasteur.)

Diseases Produced by Micro-Organisms.

Blood Rain is a peculiar condition of bread produced by the *Micrococcus prodigiosus*. The organisms consist of rounded or oval cells, which develop very rapidly, forming small red patches in the bread. It is not known to produce injurious effects on the body.

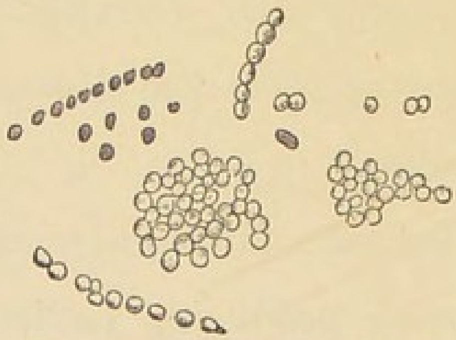

Fig. 24.—Micrococcus Prodigiosus.

Ropy Bread.—This disease of bread is not by any means uncommon. It resembles somewhat the condition in malt liquors known as "ropy" beer.

The bread is at first somewhat sodden and gummy, but after a time it develops a stringy character, and soon undergoes decomposition.

The disease is primarily due to an organism, though there is much difference of opinion as to the exact changes which occur. The starting fermentation has been ascribed to the micro-organism, which produces butyric acid, but the disease is probably partly due to changes which occur in the yeast, by which the cells are modified into a structure resembling a penicillium.

The best preventive of the disease is scrupulous cleanliness, and the use of flour and yeast of good quality.

Putrefaction.—This condition of bread is produced by the *bacterium termo.*

Happily it is so rare that individuals are obliged to eat such bread that it calls for no extended consideration.

Graham's disease is produced in the interior of loaves by the *bacillus mesentericus vulgatus.* It forms "centres" in the bread, producing brownish sticky

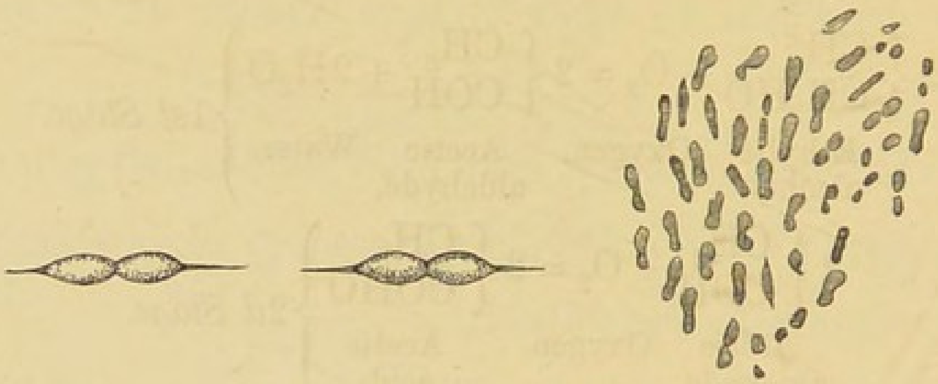

Fig. 25.—Bacterium Termo.

viscid masses with a very peculiar odour. It only flourishes in an alkaline medium, so that Scotch and Irish bread is seldom attacked.

Sour Bread is characterised by the presence of sufficient free acid to give a decided acid reaction and smell.

It appears that lactic acid is chiefly formed, though, according to some authorities, acetic acid may also be present.

Lactic acid is produced from dextrose by the action of the *B. Lactis,* according to the following equation:—

$$\underset{\text{Dextrose.}}{C_6H_{12}O_6} = \underset{\text{Lactic acid.}}{2C_3H_6O_3}$$

Acetic acid is produced from ethylic alcohol by oxidation, brought about by the intervention of the *mycoderma aceti.* The change may be represented as follows:—

$$2\left\{\begin{matrix} CH_3 \\ CH_2HO \end{matrix}\right. + O_2 = 2\left\{\begin{matrix} CH_3 \\ COH \end{matrix}\right. + 2H_2O \quad \text{1st Stage.}$$

Ethylic alcohol. Oxygen. Acetic aldehyde. Water.

$$2\left\{\begin{matrix} CH_3 \\ COH \end{matrix}\right. + O_2 = 2\left\{\begin{matrix} CH_3 \\ COHO \end{matrix}\right. \quad \text{2d Stage.}$$

Acetic aldehyde. Oxygen. Acetic acid.

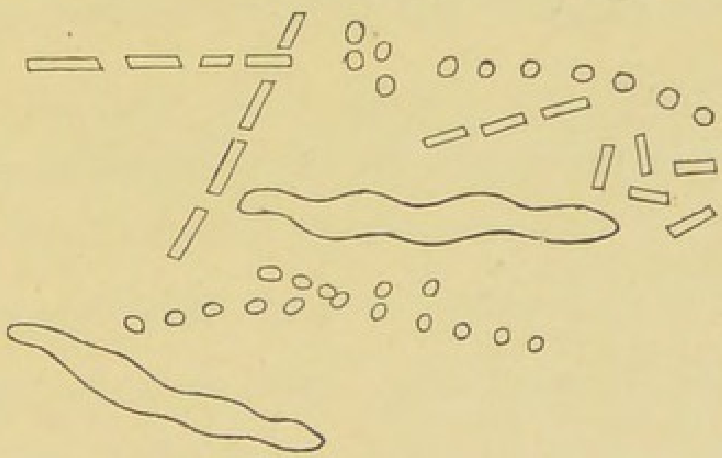

Fig. 26.—Mycoderma aceti.

The souring organisms develop when the conditions are more favourable for their propagation than for the growth of the yeast. Long, slow fermentations are favourable to the production of sour bread.

Quick and vigorous fermentation, together with scrupulous cleanliness, should prevent the occurrence of sour bread in ordinary cases. The acid present in the bread renders it less digestible.

Heavy Bread is characterised by a lack of vesicular structure.

It is produced by insufficient fermentation, or by using a very weak yeast.

The vesicular structure of bread is produced by the expansion of carbon-dioxide in the dough. If an insufficient quantity of gas be produced, or if the dough cannot hold the gas owing to the lack of gluten, the bread is not properly aerated, and turns out "heavy."

Heavy bread is not so easily digested as normal bread.

SECTION VI.—THE MEDICINAL PROPERTIES OF BREAD

CHAPTER XXXVIII

BREAD AS A MEDICINAL AGENT

A FULL and detailed consideration of the medicinal properties of bread does not legitimately fall within the scope of this work. But, pending the publication of the author's researches on this subject, the following brief statement may be made.

There can be little doubt that good bread possesses sufficient medicinal properties to form a most healthy food in many diseases. The action of bread in this direction depends on—

(1) The presence of fine particles of bran.
(2) The quantity of phosphoric acid and iron present.
(3) The relative digestibility of the constituents.
(4) The relative proportions of the constituents.

Bread containing fine particles of bran is especially useful in overcoming constipation and its attendant evils. Bread containing large proportions of phosphates and iron is beneficial in nervous diseases, anæmia, and in states involving the bad nutrition of bones and teeth.

Persons who suffer from indigestion are benefited by the use of bread containing a large proportion of *soluble* matter, while bread containing little starch and sugar is to be recommended in diabetes.

Obesity is regarded by many physicians as an actual disease. Others simply regard it as a sign of decay, characterised by the tendency of the cell units of the body to form fat rather than to perform the more laborious work of building up nitrogenous tissues.

Any treatment for this condition is aided by the use of coarse whole-meal bread rather than white bread. The reasons for this conclusion may be stated as follows:—

(1) The large percentage of waste gives a feeling of satisfaction in the stomach, and thus prevents over-eating.

(2) The bran particles increase the peristaltic movements of the intestines, which result in an increased waste in other foods.

Constipation is a condition of the body marked by insufficient peristaltic action of the intestines.

The *fæces* thus accumulate in the lower bowel for a longer period than is usual, and become hard owing to the excessive absorption of water by the blood vessels of the large intestine. The bowels do not act as often as they should, and the comparatively dry *fæces* pass away with difficulty.

The straining often acts on the veins and produces piles.

Constipation though not in itself dangerous leads to serious derangements of the body, and should be met with vigorous measures. Fine whole-meal bread usually favours any specific treatment for constipation, and may be taken with advantage by those who suffer from this condition.

Relaxation or Looseness of the Bowels is usually rarely met with. The individual who suffers from this condition would be benefited by the use of white bread.

Indigestion may be brought on by a multitude of causes. But from whatever cause it be produced, the sufferer obtains decided benefit by partaking of foods which contain a large percentage of matter in a soluble form.

Diastase bread, triticumina bread, malted breads, and bread made from dough which has been treated by special fermentable substances to quicken fermentation, are very beneficial in many cases of indigestion, for they contain considerable quantities of dextrin, sugar, and in some cases soluble albuminoids. Aerated bread, and bread made from salt or acid should be avoided by those who suffer from that form of indigestion characterised by an inertness of the digestive juices.

Aerated bread and other forms of unfermented bread are, however, very beneficial in those cases of indigestion brought on by stomachic fermentation. Many such cases have come under the notice of the author, which have been cured by the substitution of unfermented bread for the ordinary variety. The most common symptoms of this abnormal condition of the digestive tract are, eructation of gas, flatulency, furred tongue, and a bad taste in the mouth in the morning.

Anæmia is a disease characterised by either a dearth of red corpuscles or a lack of hæmoglobin.

Some kinds of anæmia are due to both these causes.

The disease is marked by pallor, and a want of energy in the various organs, due to the deficient supply of oxygen which they receive.

Anæmia requires a long course of specific treatment, which is aided by the use of fine whole-meal bread rather than white bread. The beneficial action of the fine whole-meal is probably partly due to the iron which it contains.

Rickets, a common disease of childhood, may be described as a condition in which the bones and teeth are insufficiently nourished. Many cases of rickets are accompanied with poor nutrition of other organs like the muscles.

Rickets is usually produced by wrong methods of feeding. If the foods given to young children are poor in phosphoric acid, lime, and magnesia, and are deficient in fat and proteids, rickets may be produced. It is very important to distinguish between rickets produced by a *lack* of mineral matter in the food and the kind brought on by an inability of the bones to take up the mineral matter from the blood, due probably to a deficiency of fat and nitrogenous food stuffs in the diet. The two varieties of the disease require widely different treatment. When the disease is due to a lack of mineral matter in the food, the use of fine whole-meal bread or frame food bread is to be recommended. Although wheat is poor in lime, yet it is rich in phosphoric acid, which may combine in the body with the lime of other foods to form the necessary phosphate of lime.

Decay of the Teeth.—The author has been informed by several well-known dentists that in many cases the use of fine whole-meal bread has been attended by a marked diminution of the decay.

Toast, if well carbonised, has a certain medicinal value, not only on account of its digestibility, but also owing to the charcoal present. In those conditions of the stomach marked by an accumulation of mucus and the products of fermentation, charcoal is very valuable. Being an absorbent and deodorant, it acts beneficially on the mucous coat of the stomach, by clearing off the accumulation of foul matter.

Charcoal biscuits and carbonised bread have the same effect, but they act much more powerfully than toast.

Fine whole-meal bread and frame food bread have a distinct medicinal value in cases of nervous debility, as well as in *atrepsia*—a condition brought on by a want of sufficient mineral matter in the food of a nursing mother.

The use of gluten bread in the treatment of diabetes, and the value of fine whole-meal bread to those who are *enceinte,* and to nursing mothers, have already been referred to in previous chapters.

APPENDIX

Metric Measure of Mass

10 Milligrams (mgrm.)	= 1 centigram (cgrm.).
10 Centigrams (cgrm.)	= 1 decigram (dgrm.).
10 Decigrams (dgrm.)	= 1 gram (grm.).
10 Grams (grm.)	= 1 decagram.
10 Decagrams	= 1 hectogram.
10 Hectograms	= 1 kilogram.

Useful Data.

1 Milligram	=	0·0154 grains.
1 Gram	=	15·4323 „
1 Grain	=	·0648 grams.
1 Gram	=	·03527 ounce (avoir.).
1 Ounce (avoir.)	=	28·35 grams.

The Heat and Work of the Body.

Since writing the paragraph on page 13 the researches of some eminent French physiologists have been published, which point to the conclusion that the energy of the muscle is at once converted into work, the surplus being manifested as heat, and not that the energy is first changed into heat and the heat into work.

According to the published figures 65 per cent of the energy is manifest as heat, and 35 per cent as work.

Fermentation in Bread.

The recently published researches of M. L. Boutroux in *Comptes Rendus*, cxiii. (1891), pp. 203-206, partially confirm the view of panary fermentation expressed on pp. 97-99 of this work. M. Boutroux inferred from his experiments that the fermentation of dough consists essentially of a normal alcoholic fermentation of the sugar pre-existing in the flour. He isolated three kinds of microbes from flour, viz.—

(1) A bacillus *a*, capable of dissolving gluten and converting starch into sugar.
(2) A bacillus *b*, which produces in flour and water a characteristic fermentation accompanied with an evolution of gas.
(3) A bacterium *c*, obtained from bran, capable of producing in bran and water a characteristic fermentation accompanied with an evolution of gas.

These microbes are parasitic on the starch grains.

Although these micro-organisms are present during the panification, they do not play a direct part in the production of the fermentation, but may assist up to a certain point by producing from the starch a fermentable substance, probably sugar.

M. L. Boutroux sums up as follows:—

"Panary fermentation consists essentially of a normal alcoholic fermentation of the sugar pre-existing in the flour. The dextrin of the flour may possibly participate also in this fermentation after being saccharified by a diastase. The yeast plays a double part: it produces the evolution of gas which makes the bread swell, and it prevents the development of the microbes. The result of the preservation of the gluten is that each bubble of gas produced in the dough is surrounded by an elastic membrane, which in baking becomes more tenacious, and thus imprisons the gas."

The author believes that M. Boutroux has attached too little importance to the work of the microbes in preparing yeast food. From his experiments and observations he has come to the conclusion that a portion of the gluten as well as the starch is broken down by the bacilli into bodies, which are either fermentable or act as stimulants to the yeast organisms. This view is supported by the fact that fermented bread contains less proteid material than unfermented bread. The author has never been able to obtain from fermented dough the same quantity of gluten which he obtained from an equal weight of flour.

M. Chicandard, in *Comptes Rendus*, cxiii. p. 612, maintains that M. Boutroux is wrong in his conclusions, and considers that panary fermentation consists essentially of a fermentation of the gluten brought about by the *Bacillus glutinis*.

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THE END

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