An elementary textbook of hygiene adapted to the requirements of the board of education, and certificate examinations / by H. Rowland Wakefield.

BLACKIE'S SCIENCE TEXT-BOOKS.

HYGIENE.

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AN ELEMENTARY TEXTBOOK
OF
HYGIENE

ADAPTED TO THE REQUIREMENTS OF THE BOARD OF EDUCATION, AND CERTIFICATE EXAMINATIONS

BY

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FOURTEENTH EDITION

BLACKIE AND SON LIMITED
50 OLD BAILEY LONDON
GLASGOW AND BOMBAY

PREFACE

THE present work is intended as an introduction to the study of Hygiene, and is adapted to the requirements of the Board of Education, as laid down in the syllabus for the First or Elementary Stage of the subject. At the same time, in order to extend its sphere of usefulness, additional chapters have been written upon questions relating to School Hygiene for the especial use of students in training, namely Chapters XVI., XVII., and XXIII. These chapters, together with those marked with an asterisk (which have to be studied by both classes of students), will be found sufficient for the Certificate examinations.

Science and Art students must also satisfy the examiners in elementary Human Physiology, and the admirable little work by Mr. V. T. Murché (Blackie) should be read in conjunction with the present one.

H. ROWLAND WAKEFIELD.

CONTENTS.

ELEMENTARY HYGIENE.

CHAPTER I.—FOOD.

Necessity for Food.—The human body is frequently compared to a steam-engine at work, and in some respects there is a similarity between the two. For example, no matter to what state of perfection an engine may be brought, unless a motive power be given to it that engine must for ever remain motionless. Of itself it has no *power of doing work*, or, in other words, it lacks *energy*. From whence, then, is the energy of a steam-engine derived? It is obtained from steam at high pressure, which we get by heating water by the combustion of some kind of fuel. Now energy must be supplied to the human body, and unless this be done it will have but little power of doing work, and, like the engine without steam, must sooner or later become motionless also. The source of the energy possessed by our bodies is the combustion or oxidation within us of the food we eat.

Moreover, the daily wear and tear of work in a machine involves a waste and destruction of the parts of which it is composed. Work, also, is done both by and in the body, and since *all work implies waste*, it follows that our bodies must be gradually wearing away.

Furthermore, the body is maintained during life at a nearly constant temperature of 98½° F. This bodily heat is derived from the oxidation of portions of our food, and its production is accompanied by the formation of certain waste matters, which are got rid of by our lungs, skin, and kidneys. Now, as waste and decay thus take place continually, it follows that if the body is to be sustained, new material in the shape of food must be constantly supplied to make good the loss.

But where the waste is comparatively little, as in childhood, the amount of food which is taken at this period is more than sufficient to repair the loss, and so some of the extra food is utilized in increasing the size of the various organs of the body, especially the muscles. Lastly, food is required to maintain the bodily heat.

Summarizing what has been said, we find that food is required:—

1. To supply material for building up the body.
2. For the repair of the body.
3. For the maintenance of bodily heat.
4. For the production of energy.

Classification of Foods.—In determining the necessary food-stuffs which we require, we may proceed along two different lines. In the first place, there is no single food—except for the young, milk—which is capable of fulfilling all the above requirements. But since milk does supply all the wants of a child for the first year of its life, some idea of the constituents of a diet for an adult may be gained from its composition, although the proportions may not be the same. The following is the percentage composition of human and cow's milk:—

	Human Milk.	Cow's Milk.
Water (Mineral),..................	88·0	86·87
Albuminates (Nitrogenous),...	2·97	4·65
Fat (Hydrocarbons),............	2·90	3·50
Sugar (Carbohydrates),.........	5·97	4·28
Salts (Mineral),..................	·16	·70

From these analyses it would appear that our diets should contain representatives of the nitrogenous foods, fats, carbohydrates, and mineral foods.

Exactly the same classes of foods are indicated if we attack the question by examining the composition of the human body. Of the seventy elements well known to chemists, some fourteen enter into its composition, and these are found combined together, forming in many instances chemical compounds of a highly complex character. These compounds of the body may be divided into two great classes:—the *Inorganic*, representing water and the saline ingredients; and the *Organic*, including albuminates, fats, and carbohydrates.

Tabulating the classes of food, with their chief examples, we have:—

I. NITROGENOUS FOODS.

Name.	From whence obtained.	Composition.
Albumin, ...	Eggs, Meat, &c.............	Nitrogen combined with Carbon, Hydrogen, and Oxygen.
Legumin, ...	Peas, Beans, Lentils........	
Casein, ...	Milk, Cheese................	
Glutin, ...	Wheat-flour.	
Fibrin, ...	Meat, Oatmeal.	
Gelatin, ...	Animal Matter of Bones.	

II. HYDROCARBONS (FATS).

Name.	From whence obtained.	Composition.
Olein,..................	Common to both Animal and Vegetable foods.	$C_{57} H_{104} O_6$.
Palmitin, ...		$C_{51} H_{98} O_6$.
Stearin,..............	Peculiar to Animal Foods.	$C_{57} H_{110} O_6$.

III. CARBOHYDRATES.

Name.	From whence obtained.	Composition.
Starch, ...	Arrow-root, Rice, Sago, &c.	$C_6 H_{10} O_5$.
Sucrose, ...	Cane-sugar, Beet-root......	$C_{12} H_{22} O_{11}$.
Glucose,..............	Fruits.	$C_6 H_{12} O_6$.
Lactose,..............	Milk..........................	$C_{12} H_{24} O_{12}$.

IV. MINERALS.

Name	From whence obtained	Composition.
Common Salt,.......	Contained in or added to Food.	Na Cl.
Phosphate of Lime,	Milk, Meat..................	$Ca_3 P_2 O_8$.
Carbonate of Lime,	Hard Water.	$Ca CO_3$
Salts of Potash,.....	Fresh Vegetables, Seeds.	Various; but all contain Potassium combined with Carbon, Hydrogen, and Oxygen in different proportions.
Oxygen, ...	Obtained from the Air.....	O.
Water, ...	Taken as a beverage and found in all foods.	$H_2 O$.

Nitrogenous Foods.—The nitrogenous foods are also known as *proteids*, *albuminoids*, and *flesh-formers*. They are composed of carbon, hydrogen, oxygen, and nitrogen, with smaller quantities of sulphur and phosphorus. Their general percentage composition will be seen from the following:—

Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.
51·5 to 54·5	6·9 to 7·3	21·0 to 23·5	15 to 17	2 to 3

The type of the proteid foods is the *albumin* found in eggs. It is soluble in cold water, but when heated becomes solid and opaque, and is no longer soluble in water. *Myosin* is the proteid or albuminous body which exists in solution in the juice of muscle. *Serum-albumin* is found in the fluid part of blood. During the coagulation of blood there is developed another nitrogenous body called *fibrin*. *Casein* is the albuminous constituent of milk and cheese. *Legumin* is a similar substance found in peas, beans, and lentils. In cereals, such as wheat, the proteid is called *glutin.* *Gelatin* is obtained from the animal parts of bones and connective tissue by prolonged boiling.

Functions of Nitrogenous Foods.—Nitrogenous foods are required for the construction of new tissue, either for the purpose of building up the various organs, especially the muscles, or for repairing the bodily waste. For a long time it was supposed that the force exerted by the body was due to the oxidation of the nitrogenous matters in the tissues; and that such oxidation resulted in the production of heat, which was transformed into muscular energy. If this were really the case, then the excretion of waste nitrogenous matters, such as urea, would be proportional to the amount of energy put forth; that is, with increased work there should be an increased elimination of urea, and with less work there should be less urea expelled. It has been shown, however, by Moleschott, Voit, and Dr. Ed. Smith that muscular exertion is not attended by any notable increase in the amount of urea expelled by the kidneys; and that the main source of animal energy is the oxidation of non-nitrogenous substances in the blood. It is the excretion of carbonic acid gas and water which increases with the exercise, and these are the products of the oxidation of such materials. It is true, however, that when more proteid food is ingested than is required for the repair of the waste of the tissues, the excess is directly oxidized in the body, and thus yields some heat and energy. It is also surmised from certain observations that some of the excess may be even transformed into fat.

The Hydrocarbons or Fats.—These consist of carbon and hydrogen, with a little oxygen, and are obtained from both the animal and vegetable kingdoms. They are lighter than, and perfectly insoluble in, water; but soluble in ether and benzol. The amount of fat present in the human body is estimated at 6 lbs., and is found in almost all the organs and tissues, especially the brain, which contains 8 per cent; spinal cord, about 23·5; and adipose tissue, 82·7 per cent.

The principal kinds of fat we take as food are the fat of meat, butter, suet, lard, and dripping. In many parts of the world, vegetable fats in the form of oil are much used, as olive-oil, palm-oil, &c. Oils consist chiefly of *olein* ($C_{57}H_{104}O_6$). It is a colourless liquid, and the solidity of fats depends upon the greater or less amount of olein present in them. The most abundant of the solid constituents of fats is *stearin* ($C_{57}H_{110}O_6$), which is the chief fat of mutton suet. *Palmitin* ($C_{51}H_{98}O_6$), found abundantly in palm-oil and cocoa-nut oil, is the principal solid constituent of butter.

Fats are as necessary to the well-being of the body as the nitrogenous materials; for the body is not so well nourished by the food if fats are absent.

Functions of Fatty Foods.—It has been pointed out that whilst muscular exercise is not attended by any notable increase in the amount of urea eliminated, there is a marked increase in the excretion of carbonic acid gas and water. This was clearly shown by Pettenkofer and Voit in their experiments on a man in the Munich laboratory. He was allowed to enjoy complete rest on some days, and made to work for several hours on others. The results obtained were as follows:—

	Elimination in grammes.	
	Rest-day.	Work-day.
Carbonic acid gas, ...	911·5	1284·2
Water, ...	828·0	2042·1
Urea, ...	37·2	37·0

Now this carbonic acid gas is principally due to the oxidation of the non-nitrogenous materials in the blood; but what is of far greater importance, is, that their oxidation is attended with the production of heat, as is generally the case in chemical action. Of all the non-nitrogenous foods, the fats are the greatest heat-givers, as will be readily understood by a study of their composition. In all fats the amount of oxygen present is far too small to oxidize the whole of their carbon and hydrogen; so that in the blood there will be not only the carbon for its oxygen to combine with, but also the excess of hydrogen, which means of course an additional supply of heat. Hence one great use of fatty foods is the maintenance of the heat of the body. It is for this reason that fat is so largely consumed by the dwellers in Arctic regions. Their next important function is the production of energy, which enables us to perform work. There is reason to believe that fat also aids the digestion of other foods, so that the body is better nourished by food when the fats are present.

When more fat is consumed than is required for these purposes, the excess is deposited in various parts of the body, constituting a storehouse, which may be drawn upon at any future time. But the whole of the fatty constituents of the body are not derived in this manner; for it is certain that a portion proceeds from the disintegration of albuminous compounds, and probably from amylaceous foods as well.

The Carbohydrates or Amyloid Foods.—Under the head of carbohydrates or amyloids we include the various *starches*, *sugars*, and *gums* which enter largely into the composition of foods of vegetable origin. They consist of carbon, hydrogen, and oxygen, the last two elements being present in the same proportion as in water.

Starch ($C_6 H_{10} O_5$) is found widely diffused throughout the vegetable kingdom. It is abundant in potatoes, and is the principal constituent of arrow-root, rice, sago, tapioca, &c. To the naked eye it appears as a white powder, but under the microscope it is seen to consist of white grains or granules, differing in form in different plants, and often marked with concentric rings (fig. 1). Its presence in a food may be easily detected by free iodine, with which it forms a deep blue compound. Starch is insoluble in cold water; but when heated with water


Fig. 1.—Potato Starch Granules.

the granules swell up and burst, forming the well-known paste. It can be very readily obtained by washing wheat-flour in a muslin bag. A milky fluid passes through, which, if allowed to stand, deposits the starch as a white powder at the bottom.

Sugar is another widely diffused substance. The principal varieties are:—1. Cane-sugar or sucrose ($C_{12} H_{22} O_{11}$), which abounds in the cells of the sugar-cane, beet-root, sugar-maple, &c. 2. Grape-sugar or glucose ($C_6 H_{12} O_6$), found in many fruits, and often seen as small creamish-coloured particles in raisins. It is about one-third as sweet as cane-sugar. 3. Milk-sugar or lactose ($C_{12} H_{24} O_{12}$), the sweetening principle of milk.

Functions of Amyloid Foods.—Within the body both starches and sugars help to produce and maintain its heat, but not to the same extent as fatty foods. They are probably also a source of fat; for it has been shown that bees, although fed entirely upon pure sugar, are still able to produce wax, a kind of fat, for their comb. It is also found that fat is abundantly formed when ducks, geese, pigs, and oxen are fed on a diet rich in carbohydrates.

The Mineral Foods.—Water is one of the most important mineral foods. Besides being taken as a drink, it is found in nearly all the foods we eat, as will be seen from the following table, which gives the percentage of water in the articles of food named:—

Mushrooms,	96	Fish,	78	Veal,	63
Cabbages,	92	Potatoes,	75	Bread,	38
Turnips,	90	Eggs,	74	Peas,	13
Milk,	88	Beef,	72	Butter,	7
Pears,	84	Cream,	66	Maize,	6

Water plays an important part in the animal economy. It enters into the construction of all the tissues, and assists in the removal of waste products. As a solvent it greatly aids digestion, and, forming as it does 79 per cent of the blood, acts as a carrier of the food to all parts of the body. By its evaporation it also serves to regulate the temperature of the body.

Common salt (chloride of sodium), although regarded merely as a flavourer by many, is really necessary for our existence. It furnishes the chlorine for the production of the hydrochloric acid of the gastric juice, and its sodium enters into the composition of the salts of bile. As a condiment it increases the flow of the saliva. About 200 grains of salt are required daily by an adult; but a large proportion of this is in the food we eat.

Carbonate of lime is found in the hard water we drink. Phosphate of lime is obtained from milk, meat, &c. Both are required for the construction of the bones and teeth.

The salts of potash are obtained from fresh vegetables and fruits, and assist in purifying the blood. The principal salts are the citrate and tartrate; and it is believed that the continued absence of them from our diets is the cause of scurvy.

The oxide of iron is found in most foods, and sulphur in the yolk of eggs.

CHAPTER II.—NITROGENOUS FOOD-STUFFS.

I. NITROGENOUS ANIMAL FOODS.

Flesh of Animals.—One of the main sources of our food is the flesh of various animals, which is characterized by the large amount of nitrogenous matter it contains. It is therefore admirably adapted for building up and repairing the structure of the body. The percentage of water is also high, varying from 50 to 70 per cent. Thus, when freshly-cut beef is dried over a hot-water bath, it shrinks so much from the loss of water, that four pounds of it will only yield about one pound of dried flesh. The proportion of fat varies considerably, and it is noticed that when the quantity of water is great the proportion of fat is small, and *vice versa*. The percentage composition of butcher's-meat will be seen from the following table:—

	Lean Beef.	Fat Beef.	Lean Mutton.	Fat Mutton.	Fat Pork.	Veal.
Water, ...	72·0	51·0	72·0	53·0	39·0	63·0
Nitrogenous, ...	19·3	14·8	18·3	12·4	9·8	16·5
Fat, ...	3·6	29·8	4·9	31·1	48·9	15·8
Saline, ...	5·1	4·4	4·8	3·5	2·3	4·7

The flesh of animals may be divided into two classes—red meat and white meat. Of red meats, beef, mutton, pork, game, wild fowl, and salmon are the chief examples. The white meats include the common fowl and turkey, rabbits, most fishes, &c. As a rule they are more digestible than red meat.

If a piece of lean beef be washed in clear water, the blood it contains will be removed and a white mass of muscular or fibrous tissue will remain. If this be then dried and left in ether until the fat has been dissolved, the fibrous mass will be more compact, and consist chiefly of a substance called myosin. Under the microscope a piece of meat is seen to consist of bundles of long fibres, which are bound together in various ways to form muscles of various shapes and sizes.

Although it is quite possible to live upon vegetable foods alone, as is shown by the number of "vegetarians" at the present day, still it is found by those engaged in laborious occupations that their stamina is not maintained to the same extent when fed upon a purely vegetable diet, as when a moderate amount of animal food is included.

Characteristics of Good Meat.—The muscle of all meat should be firm and elastic to the touch, of a bright uniform colour, and should have a marbled appearance from the little lines of fat interspersed with the lean. The odour of freshly-cut meat should be slight but pleasant, the juice reddish, and the lean fine-grained and free from any foreign particles imbedded in it. The lean parts of mutton are paler than those of beef, and the flesh of young animals paler than that of old ones.

Beef.—Beef as a rule contains less fat, and bulk for bulk is more nutritious than either mutton or pork. Its quality depends upon the age, sex, breed, and feeding of the animal. Beef is said to be at its best when cut from the carcass of a four-year-old ox. Ox beef is the most strengthening and nutritious of all animal foods, and is therefore highly suitable for those engaged in severe physical labour. Delicate persons, however, find it difficult of digestion, so that when beef has to be given to invalids, it is customary to supply it in the form of beef-tea.

Mutton.—Mutton has a more delicate flavour and is more easily digested than beef; hence it is better adapted for the needs of persons of sedentary occupations, as well as invalids. South Down and Portland mutton are considered the best; the Leicester is also a good but larger breed.

Pork.—Of all meats, pork is one of the most difficult to digest; but its digestibility depends in a large measure upon the age and breed of the pig. It is frequently preserved for future use, either by curing with salt, or by putting it into a liquor made of salt, saltpetre, and water, known as brine; or by partly salting and drying, and afterwards smoking it over a wood fire. It is then known as bacon, except in the case of the legs, which are cured separately and sold as hams. It cannot be too strongly impressed that pork should always be sufficiently cooked, for, as will be seen in a later chapter, pigs are frequently subject to disease.

Veal.—Veal is less nutritious than and not so easily digested as beef or mutton. Its delicate colour is obtained by gradually bleeding the calf—an act which is not only reprehensible, but which deprives the meat of much of its saline matters. These are frequently re-supplied by serving it with a good gravy made from gravy-beef, or with "Liebig's Extract." On account of the want of fat, roast veal is generally served with ham or bacon.

Lamb.—Lamb is more watery and less nutritious than mutton. The fat should be firm, and the lean a clear faintish white and firm also. Lamb will not keep long after it is killed.

Fish.—Fish may be divided into two classes according to the manner in which the fat is distributed within them. In some it is mainly found in the liver, as in the cod, whiting, haddock, sole, skate, flounder, hake, ling, turbot, &c. These are known as *white fish.* In the second class, or *fat fish*, the fat is diffused throughout the flesh. To this class belong the herring, mackerel, eel, salmon, sprat, pilchard, lamprey, &c. They are not quite so digestible as the white fish, but are considered more satisfying. According to Payen, the percentage of fat in soles is 0·248, in whiting 0·383, conger-eel 5·021, mackerel 6·758, and eels 23·861. It is customary to make up for the deficiency of fat in white fish by the addition of a fatty substance, such as white sauce.

Since fish contains almost the same amount of nourishing material as butcher's-meat, it forms an important article of diet. It is not so stimulating as meat, and for this reason is very valuable as a food for the sick.

Choosing Fish.—In choosing fish the following points should be borne in mind. Fresh fish have bright eyes and gills, and the flesh is stiff and firm. If the scales can be rubbed off easily it is generally a sign that the fish is somewhat stale. Fish also, which have been kept long in ice, have not the same flavour as fresh fish. Lastly, short and thick fish are preferable to the long and thin ones.

Shell-fish.—As a rule shell-fish, such as crabs, lobsters, whelks, mussels, &c., are very indigestible. Oysters, if taken raw, are very digestible, but become tough and hard when cooked. Mussels are notoriously unwholesome, and are best avoided.

Poultry and Game.—These include the flesh of the common fowl, ducks, geese, turkeys, pheasants, rabbits, &c. They have usually a small proportion of fat, but are rich in phosphates. Unless very young they are not tender. The flesh of the common fowl and turkey is more tender, and possesses a more delicate flavour than that of ducks and geese. Game is valued for its special flavour.

Eggs.—The eggs of most birds can be used as food, but those of the domestic hen are most extensively employed, and amongst nitrogenous foods are the most useful and handy. The shell consists chiefly of the carbonate of lime, and serves as a protection to the inner parts. It is very porous, and for this reason, eggs which have been kept some time become bad from the entrance of the external air laden with putrefactive germs. This may be prevented by smearing new-laid eggs with a solution of gum-arabic, and then, when dry, placing them in bran or saw-dust. Lard or butter may be used for the same purpose. Bad eggs may be easily recognized from good ones by putting them into a solution composed of one ounce of salt and half a pint of water. The bad ones float, while the good ones sink. Bad eggs will even float in pure water.

The white of egg, so called because when heated it coagulates or sets into a white solid substance, consists almost entirely of water in which is dissolved a small quantity of albumin. It also contains a small proportion of fat, and about one per cent of phosphate of lime.

The yolk contains less water, but more albumin; and in addition a considerable amount of fat or oil rich in phosphoric acid. Its yellow colour is partly due to the presence of sulphur, and it is this substance which blackens a silver spoon when left in an egg by uniting with the silver to form a sulphide. Hence it is usual to gild the bowls of silver egg-spoons, since sulphur has no effect upon gold. The offensive odour of a rotten egg arises from the combination of the sulphur with hydrogen, the product being sulphuretted hydrogen or rotten-egg gas.

According to Church the composition of an egg, neglecting the shell, is as follows:—

Constituents.	White.	Yolk.
Water,	84·8	51·5
Albumin,	12·0	15·0
Fat, &c.,	2·0	32·0
Saline,	1·2	1·5

Milk.—Milk is one of the most important animal foods. It is the sole nourishment provided for the young of all animals which suckle their young, and because it contains all the four classes of food necessary for the health and growth in the earlier periods of life, may be regarded as a model and typical food. But although milk alone forms the sole sustenance of the young, it is not adapted to the adult.

In England we generally get our milk from the cow; but in other countries that of goat, ass, sheep, camel, and bison is largely used. All kinds of milk are composed of the same ingredients, though the relative proportions differ in each kind, as will be seen in the accompanying table:—

	Human.	Cow.	Ass.	Goat.	Mare.	Sheep.
Water,	88·0	86·87	91·17	87·54	88·80	82·27
Nitrogenous,	2·97	4·65	1·79	3·62	2·61	7·10
Fat,	2·90	3·50	1·02	4·20	2·50	5·30
Sugar,	5·97	4·28	5·60	4·08	5·59	4·33
Saline,	0·16	0·70	0·42	0·56	0·50	1·00

From this table it will be seen that there is a great variation in the proportions of the nitrogenous materials, which in human milk is little more than half of that of cow's milk; the amount of saline matters and water also varies considerably.

When milk is left undisturbed for a few hours—varying from four to eight—an oily fluid called cream rises to the surface. If a drop of this be examined under the microscope it will be found to consist of a number of small globules of fatty matter inclosed in a thin pellicle or membrane. Good milk ought to give from ten to twelve per cent of its volume of cream.

If the cream be removed from the surface, the fluid left is called *skim-milk*, and consists of water in which are dissolved the sugar (lactose) and salts. On the addition of rennet or any weak acid, skim-milk is separated into a solid called *curds*, and a liquid, *whey*. The curd, when dried, salted, and pressed, constitutes cheese, and consists of *casein*, which represents the nitrogenous portion of milk. The whey contains the soluble salts and sugar.

Lactometers.—A lactometer (L. *lac*, milk, *metron*, a measure) is an instrument used to test the quality of milk. It consists of a glass stem with a bulb at one end weighted with mercury to enable it to remain upright in the liquid under examination. If the specific gravity of water be taken as 1000, that of good milk ought to be 1029. Hence if water has been added to the milk, the lactometer will sink to a greater depth than it would in good milk alone. But if the cream be removed from the milk, which has then a higher specific gravity, and water be then added to bring the milk to its original density, the lactometer will not reveal this kind of fraud.

Condensed Milk.—Condensed milk is that which has had the greater part of its water removed by gentle boiling. It may be of two kinds, depending upon whether cane-sugar has been added or not. The milk thus obtained is a thick opaque syrup, and is preserved in hermetically-sealed tins. That which has had about 30 per cent of sugar added will keep good for some time after being exposed to the air; the other kind will not keep for more than three or four days after opening.

Cheese.—When milk is kept too long it becomes sour and coagulates. The souring is due to the formation of lactic acid, which precipitates the casein or curd from the other constituents of the milk. The same result can be brought about in perfectly fresh milk by the addition of a small quantity of any acid, and advantage is taken of this fact in the making of cheese, which is chiefly the curd of milk.

In making cheese the coagulation is caused by the addition of *rennet*, which is prepared from the inner membrane of the fourth stomach of the calf. Fresh milk is first heated to a temperature of 80° F., and then the rennet is added, together with a little colouring matter, which is generally *annatto*. In a short time the milk curdles; the curd is then separated from the whey and washed, and is afterwards carefully pressed and dried.

Many different varieties of cheese are obtained according to whether the proportion of cream is increased or diminished. The cheese made from whole-milk, that is, fresh milk which has not been skimmed, is known as Cheddar. When more cream is added to whole-milk, a very rich cheese, like Stilton, is obtained. The Cheshire cheeses are the produce of milk from which an eighth or a tenth of the cream has been removed, while the Dutch, American, and Parmesan cheeses are made from skimmed milk alone.

Cheese is a highly nitrogenous food, but usually difficult of digestion, especially when toasted. It is eaten for two very different purposes—either as a part of the regular food, or in small quantities after dinner as a relish or as an aid to the digestion of other foods. Various chemical changes take place in cheese, either from age, as in "ripening," or from imperfect manufacture. The blue and green mould seen on old ripe cheeses is due to *Aspergillus glaucus*, a low form of vegetable life. The "jumpers" or maggots are the larvæ of the cheese-fly—*Piophila casei;* while the cheese-mites (*Acarus domesticus*) are produced from the eggs of a certain insect.

Gelatin.—Gelatin is obtained from bones, cartilage, connective tissue, &c., by prolonged boiling. The bones should be well broken, and then placed in water in a digester, and kept at a temperature of about 150° C., in order to extract most of the gelatin. It is readily soluble in warm water, and being easily digested by the stomach has long been very popular as invalids' food. But since it has been shown that animals cannot live upon it alone, nor even when mixed with non-nitrogenous foods, it is evident that it is of little value. Not that it is entirely destitute of nutritive value; for when it is added to a diet previously deficient in albuminates, animals will continue to flourish.

Isinglass, prepared from the inner membrane of the floating bladder of the sturgeon, is an example of the purest form of gelatin. *Glue*, a very impure variety, is obtained by boiling the hoofs and horns of animals.

II.—NITROGENOUS VEGETABLE FOODS.

The most important nitrogenous vegetable foods are those derived from the grains of the *cereals* and certain leguminous seeds, designated *pulse* foods. The cereal foods, such as wheat, oats, barley, &c., contain a large quantity of starch, a nitrogenous substance peculiar to them called glutin, and mineral salts, especially phosphate of lime. The leguminous seeds used as food in this country are peas, beans, and lentils. They contain a smaller proportion of starch than cereals, but considerably more nitrogenous matter, termed legumin or vegetable casein. From their extremely dense and solid character they are not so easily digested as cereals, and consequently require thorough cooking to ensure their perfect digestion.

Wheat.—Of the cereal foods, the one most generally useful is wheat. When crushed and sifted it is roughly separated into two parts—bran and flour. The bran is chiefly the outer covering of the grains, and contains a large amount of nitrogenous and mineral matter. Wholemeal and brown meal contain both bran and flour, and are used for making brown bread, which is more nutritious but less digestible than white bread. Many persons also find that the particles of bran act as an irritant to the walls of the stomach and intestines, causing a slight laxity of the bowels. For this reason it is sometimes recommended by medical men as a remedy for constipation. But it must not be forgotten that as the food is thus hurried along the intestinal canal, the whole of the nutritive matters cannot be extracted and absorbed from it.

Bread.—In making bread on a small scale the flour is put into an earthenware pan, and after making a well in the middle of it, a mixture of lukewarm water, yeast, and a little salt is poured in. These are then well mixed together with the flour, more lukewarm water being added as required. The whole mass is kneaded into dough and set aside in a warm place for three or four hours, during which time fermentation takes place, and bubbles of gas (carbonic acid gas) are set free in the dough, which is thus rendered light and porous. The dough is then made into loaves and placed in the oven. Here the heat of the oven first increases the fermentation, and consequently the "rising" of the dough; but as soon as the temperature has nearly reached that of boiling water the yeast is killed, and fermentation ceases.

The cause of the fermentation is due to the peculiar action of the yeast-plant upon the flour, whereby a portion of the starch of the flour is first converted into grape-sugar, and then into alcohol and carbonic acid gas. As this gas cannot readily escape, it forms a number of bubbles in the dough, which in this way is made light and porous.

The spongy character of bread may be also brought about by chemical means, as by the use of baking-powders. These consist essentially of a mixture of tartaric acid and bicarbonate of soda. As soon as the mixture is wetted, chemical action takes place, and large quantities of carbonic acid gas are evolved, producing the same effect upon the dough as that obtained by the fermentation of sugar.

Dr. Dauglish patented another method for raising bread in 1856. In this process no ferment is used, but the flour is worked into dough with water highly charged with carbonic acid gas, which of course tends to raise and lighten it as before. Bread made in this way is known as "aerated bread," and is to be recommended on the score of cleanliness, as it is entirely made by machinery.

Macaroni and *Vermicelli* are preparations of certain kinds of wheat rich in glutin. The wheat is first ground into meal, and made into a paste with hot water. It is then pressed through gauges to give it the pipe-form in which it is bought. *Semolina* is the heart of the wheat grain crushed to powder.

Oats.—Oats are hardier than wheat, and will consequently ripen in colder climates. They are rich in nitrogenous matter; but as this is not of an adhesive nature, like the glutin of wheat-flour, it is impossible to make oatmeal into bread without the addition of wheat or rye flour. In some countries, as Scotland, oatmeal forms an important article of diet, and is made either into porridge or into oatmeal cakes.

Barley.—Barley is hardier than either wheat or oats. It contains less nitrogenous matter than either of them, and is not so nourishing. Pearl-barley is made by first removing the husks of the barley grains, and then rounding the latter by a process of rubbing. Patent barley is pearl-barley ground to powder. On the Continent barley is extensively used for making bread, but in this country its principal use is for the manufacture of *malt*. For this purpose the barley is made to germinate by means of moisture and warmth. During the process there is developed within the grain a peculiar ferment called *diastase*, which has the property of changing the starch of the grains into sugar.

Rye.—Rye is also extensively used on the Continent; but it makes a very sour, dark-coloured bread, and those unaccustomed to it find it a very laxative food. Before being made into bread, the rye grains should be thoroughly examined, as they are particularly liable to the attack of a fungus called the ergot of rye, which may produce severe symptoms, and even fatal consequences.

Maize or Indian Corn.—Maize is not suited for bread-making in consequence of the deficiency of glutin. In America maize meal is made into cakes called "Johnny cakes," while the young corn-cob is frequently boiled and used as a vegetable. Not only is it rich in nitrogenous matters, but the proportion of fat is also large—hence maize is an important article of food. *Corn-flour* and *hominy* are preparations of maize.

Pulse or Leguminous Foods.—The principal varieties of pulse employed as food are peas, beans, and lentils. They are distinguished from all other vegetables by their large amount of nitrogenous material known as *legumin*, excelling in this respect even beef, mutton, and fish. But as the whole of their nitrogenous constituents are not available as nutriment, they are dietetically inferior to many other foods. They must at all times be well cooked; but even then they are difficult of digestion, the dried form of peas and beans being more so than green ones. They are also a prolific cause of flatulency. Still they are very important articles of diet, and are best taken with fatty foods, broad beans and bacon forming an excellent dish.

CHAPTER III.—NON-NITROGENOUS FOOD-STUFFS.

I. NON-NITROGENOUS ANIMAL FOODS.

Butter.—Butter is a light and easily digested kind of fat. It is prepared by churning either cream or whole-milk; the latter yields rather more butter, but the process entails considerably more labour. The cream is best obtained by allowing the milk to stand in shallow pans and keeping it at a temperature of 60° F. It is then removed by skimming once or twice a day, and stored in an earthenware jar until a sufficient quantity is collected. The same temperature should also be maintained during churning if good butter is to be obtained.

In good samples of butter, the fat varies from 86 to 92 per cent, and consists mainly of palmitin and olein. The odour and flavour of butter are due to the presence of small quantities of other fats, especially *butyrin*. There is also present from 3 to 5 per cent of casein from the milk taken up with the cream. The best butter contains least; because the decomposition of the casein is the cause of butter becoming rancid. The amount of water in butter varies from 8 to 10 per cent; but in some kinds as much as 22 per cent may be met with. When the amount exceeds 15 per cent the butter is considered to be adulterated.

The addition of a little salt to butter not only increases its flavour, but is useful as a preservative. Sometimes a considerable amount of salt is added in order to hide a slight rancidity.

Butter-milk, the liquid left from the preparation of butter, is very nourishing and easily digested; it ought to be more largely used as a food than it is at present. In Ireland it is taken with potatoes.

Devonshire Cream is obtained by straining the milk, fresh from the cow, into large metal pans which are allowed to stand in a cool dairy for twelve hours in summer and twenty-four in winter. The milk is then scalded over a slow fire, and skimmed the next day.

Lard.—Lard is prepared by cutting the fat of the pig into small pieces, and then melting these in iron vessels heated by steam. As the fat melts, it is poured into bladders which have been well cleaned. Pure lard has no smell, and almost no taste. Its chief constituent is olein.

Butterine, Margarin, and Oleo-margarin.—These are names given to the various substitutes for butter. They are all made from animal fat, beef-fat being the principal. The process of manufacture consists in first removing the stearin of the fat, and afterwards churning the remaining constituents with milk to give them the flavour of butter.

As a rule they are very wholesome, and are undoubtedly excellent substitutes for butter, from which they differ but little in composition, as will be seen from the following table:—

Constituents.	Butter.	Oleo-margarin.
Water,..................	9·4	10·5
Nitrogenous,..........	1·4	—
Fat, ...	86·5	87·
Milk-sugar,............	·8	·7
Salts,....................	1·9	1·8

Dripping.—Dripping is the fat obtained by roasting meat. Beef-dripping contains less stearin than mutton dripping.

II. NON-NITROGENOUS VEGETABLE FOODS.

Arrow-root.—Arrow-root is the starch obtained from the tubers of a West Indian plant, *Maranta arundinacea.* East Indian arrow-root is obtained from the *Curcuma angustifolia.* The tubers, when twelve months old, are dug up, well washed, and beaten to a pulp. This is thrown in clean water and thoroughly washed, after which the fibrous portions are carefully wrung out and thrown away. The milky liquor which remains is poured through a sieve, and allowed to stand until the arrow-root sinks to the bottom. The clear water is then poured off, and the sediment spread out on sheets and sun-dried.

Arrow-root contains 72 per cent of starch. Alone it is not very nutritive; but when made up with milk, it forms a very palatable and nutritious food, and is highly serviceable for invalids.

Sago.—Sago is prepared from various species of palm-trees, known as sago-palms. The trees are cut down, split open, and the pith removed and washed in water to extract the starch. This is then half-dried, and forced through a sieve to give it a ball-like appearance. After further drying over a fire it is ready for use.

Sago is an easily digested and wholesome food. With milk, in the form of light puddings, it is an excellent food for invalids and children.

Tapioca.—Tapioca is another starchy food. It is prepared from the roots of the *Manihot utilissima*, a native of tropical America. The roots are washed, and then strongly heated to get rid of a bitter poisonous substance which they contain. They are again washed and reduced by a kind of rasp to a pulp, which is afterwards dried on plates over a fire.

Tapioca is a wholesome, nutritious food, and very easy of digestion. It is used for puddings, and for thickening soups.

Corn-flour.—Corn-flour is the starch of maize, from which the nitrogenous material and peculiar flavour have been removed by various processes. It is a good substitute for arrow-root.

Tous-les-mois.—Tous-les-mois, a variety of arrow-root, is the starch of a West Indian plant, the *Canna edulis.* Of all the starchy foods, the granules of tous-les-mois are the largest, being no less than $\frac{1}{200}$ of an inch in diameter, while those of rice are only about $\frac{1}{5000}$ of an inch.

Salep.—Salep is the dried roots of several kinds of orchids. It is imported from Persia and Asia Minor, and used as food in Eastern Europe.

Potato.—The potato is an enlargement of the underground stem of a plant known as the *Solanum tuberosum.* It is one of the most useful of vegetable foods, and forms the chief article of diet of the poorer classes of the Irish. Potatoes grown in a light dry soil are more mealy when boiled than those grown in damp heavy ground. They contain about 2 per cent of nitrogenous matter; 19 per cent of carbohydrates, of which the chief is starch; 75 per cent of water; a little fat and saline matters.

Cane-sugar.—Cane-sugar, the form most extensively used in this country, is obtained from the sugar-cane (*Saccharum officinarum*), which belongs to the natural order of grasses, *Graminaceæ.* For the extraction of the sugar, the canes, which contain about 18 per cent of sugar, are cut before they flower, and as near to the ground as possible; because the lower parts of the stem contain most sugar. The leaves and top are then cut off, and the canes are passed between rollers to press out the juice. This is heated to about 140° F., and a small quantity of milk of lime is added in order to prevent it from fermenting. The juice is then boiled down in copper pans to a certain consistency, when it is passed through filters, and again evaporated to a thick syrup. This is poured into shallow pans to crystallize, after which it is placed in casks with perforated bottoms to drain. In this way the crystals of moist or brown sugar are separated from the uncrystallizable part, which is known as molasses or treacle. The *refining* of sugar is to remove the colouring matter and other impurities. "The raw sugar is dissolved, and again boiled with lime and filtered. The filtered liquor is then decolorized by flowing through a thick bed of animal charcoal, and the colourless filtrate evaporated down to the point of crystallization, under diminished pressure, in vacuum-pans. The concentrated juice is then either allowed to crystallize in moulds, giving loaf-sugar, or the small crystals are freed from the syrup in rapidly revolving sieves."

Grape-sugar or Glucose.—Glucose is another variety of sugar found in grapes and sweet fruits. It is well seen as little whitish-coloured granules in raisins, and the familiar thickening of honey when kept for a length of time is due to the crystallization of the grape-sugar of which it mainly consists. It is also known as *dextrose,* from its power of deflecting to the right a ray of polarized light, when passed through a solution of it. In honey it is found mixed with the isomeric form of *levulose,* or "left-handed glucose." This is an uncrystallizable colourless syrup, and is more soluble than dextrose in water and alcohol. Dextrose is found in small quantities in the blood, and white of egg, and is the kind of sugar largely excreted with the urine of diabetic patients. Dextrose may be prepared by boiling starch with dilute sulphuric acid, and afterwards neutralizing the acid with chalk, and evaporating the liquid to a syrup, from which the sugar crystallizes as it cools. It may also be separated from the levulose of honey by washing with dilute alcohol.

Herbaceous Vegetables.—Under this head are included cabbages, spinach, lettuce, celery, asparagus, and many other vegetables, which form an essential part of our diet. Although containing some nitrogenous matter, they are not looked upon as nitrogenous foods proper, because the percentage of flesh-forming material is so very low, in some cases, as in beet-root, amounting to only ·4 per cent. Their great value lies in the salts which they possess, for the continued use of a diet from which fresh vegetables are entirely absent leads to the diseased state of the body known as scurvy. They all agree in possessing a large proportion of water, and a small amount of the carbohydrates, of which the chief is sugar. Too much stress cannot be laid upon the importance of having all vegetables as fresh as possible. Stale ones are not good for food, and no amount of cooking will make them digestible.

Some vegetables, such as the onion, leek, shallot, and garlic, possess peculiar essential oils, for which they are mainly used to flavour other foods. Salads, such as mustard and cress, lettuce, endive, radishes, water-cress, &c., are very useful as antiscorbutics, but unfortunately many of them are very indigestible.

Fruits.—The great value of fruits depends upon the free acids and saline ingredients which they possess, and which give to them their well-known aperient and antiscorbutic properties. The kind of acid present varies with different fruits; the commonest are malic, citric, and tartaric. In all fruits the amount of nitrogenous material is very small, varying as a rule from ·4 to ·7 per cent. The non-nitrogenous substances found in fruits include sugar, starch, gum, and pectin. The starch is chiefly found in unripe fruit, but in the process of ripening it is converted into sugar. Hence the latter will vary in amount with the degree of ripeness.

Fruit should be fully ripe if it is to be taken raw. If unripe, it must be cooked before it is eaten; otherwise it may be the cause of severe diarrhœa. For the same reason all unsound fruit should be avoided.

The cucurbitaceous fruits (*marrows, cucumbers, pumpkins,* &c.) are used rather as vegetables than as fruits. They all contain a large amount of water, and, with the exception of cucumbers, are of easy digestion.

CHAPTER IV.—CONSTRUCTION OF DIETARIES.

Necessity for a Mixed Diet.—From a consideration of what has been said respecting food in the previous chapters, it will be seen that the co-operation of the various classes of food is essential in order to secure the several objects for which food is taken, and that the proportion of proteids, hydrocarbons, &c., or proximate principles as they are termed, varies considerably in different articles of food. No single food—except, for young children, milk—is able to support life. Animals fed on a purely carbonaceous diet, such as sugar, starch, fat, &c., die in a few weeks; and the same result occurs when they are fed on pure albuminoid material, as the white of egg. Hence we are driven to the conclusion that in order to support life there must be a proper admixture of different kinds of foods, so that a deficiency of any particular food-stuff will be compensated for by other foods in which it is abundant. A similar conclusion is arrived at by our daily experience. Thus we instinctively take cheese with bread; bacon with beans; melted butter with fish; milk with rice, sago, &c.; vegetables with meat; and so on.

The necessity for a mixed diet is also shown by our longing for a variety of food; not in the sense of a great number of courses at one and the same meal, but a proper change from day to day. No matter how palatable a food may be in the first instance, its continued use soon produces a nauseating effect, and may, moreover, lead to derangements of digestion.

Whether animal food should form a part of our diet will always remain a debatable question. The advocates of vegetarianism maintain that there is no necessity for its use, since the vegetable kingdom can supply us with all the food-stuffs we require. They point out that many vegetables contain as much proteid matter as lean meat, and are therefore capable of taking its place. But it must be borne in mind that the nutritive value of a food does not depend upon the percentage of nitrogenous materials present in a food, but upon how much is assimilated or converted to the uses of the body. Now with a purely vegetable diet there is always a larger quantity of undigested refuse than there is from a like amount of animal food; that is, there is a greater assimilation of the latter kind of food. From other considerations as well, the moderate use of animal food certainly seems desirable; but its excessive use cannot be defended.

Construction of Dietaries.—The next point to be considered is the quantity of each of the food-stuffs required daily in order to keep the body in a condition of healthy vigour. Numerous experiments have been made with the object of determining the proportion of the several food-stuffs necessary to form the most *economical diet;* that is, one in which there is a proper apportionment of the food-stuffs according to the wants of the body. Of course such determinations can only be approximate, inasmuch as there are several circumstances, as age, sex, state of health, &c., which modify our daily requirements.

Now we have seen that a certain amount of wear and tear of the tissues is continually going on within the body; that this amount is practically constant; and that the loss is replaceable by nitrogenous foods. Moreover, we have seen that the temperature of the body and the energy which it puts forth are derived principally from the oxidation of the fats and carbohydrates. But since the excreta eliminated by man represent the oxidized condition of the food ingested, it is evident that if a man be kept under observation for some time, the daily loss of urea and uric acid by the kidneys, and of carbonic acid gas by the lungs and skin, can be ascertained. When these are known, the nitrogen and carbon of the urea and uric acid, and the carbon of the carbonic acid gas, can be then calculated. So that if we are provided with tables of analysis of the various foods, it is an easy matter to construct a diet which shall contain an amount of nitrogen and carbon equivalent to that lost. It will be necessary also to make an allowance for any indigestible residue, since all food is only partially assimilated.

It has been estimated that a male adult, when not engaged in active work, requires:—

Albuminates,	2·5	ounces.
Fats,	1·0	„
Carbohydrates,	12·0	„
Salts,	0·5	„
Total water-free food,	16·0	„

From experiments upon himself, Professor Ranke found that in order neither to gain nor lose weight when doing no work, he had to take:—

Albuminates,	3·5	ounces.
Fats,	3·5	„
Carbohydrates,	9·0	„
Total water-free food,	16·0	„

The above are regarded as mere subsistence diets only. Of the many standard diets given for the adult man engaged in moderate work, that of Professor Moleschot[*] is the one generally accepted, and is as follows:—

Albuminates,	4·59	ounces.
Fats,	2·96	„
Carbohydrates,	14·26	„
Salts,	1·06	„
Total water-free food,	22·87	„

In this table the food is given as water-free; but there is always from 50 to 60 per cent of water in ordinary food. Putting the average percentage, say, at 50, then the 22·87 ounces of dry food will become 45·74 ounces of moist food. Add to this another 60 ounces of water taken in some form or another as a beverage, and the diet is complete.

Such a diet is calculated to yield 316 grains of nitrogen and 4860 grains of carbon.

But speaking generally, we may say that the diet for a person doing a fair day's work should contain 300 grains of nitrogen, and 4800 grains of carbon. In other words, the proportion of the nitrogen to the carbon should be as 1 : 16.

For an adult man engaged in laborious work, as, for example, a navvy or outdoor labourer, the average daily water-free diet would be:—

Albuminates, ...	6·0 to 7·0	ounces.
Fats, ...	3·5 to 4·5	„
Carbohydrates,...	16·0 to 18·0	„
Salts, ...	1·2 to 1·5	„
Total water-free food,	26·7 to 31·0	„

According to Dr. Letheby, the requirements of an adult man during idleness, ordinary work, and hard work are as follows:—

Diet should contain	Grains of Nitrogen.	Grains of Carbon.
1. For idleness, ...	180	3816.
2. For ordinary work, ...	307	5688.
3. For hard work, ...	391	6823.

Calculation of the Value of a Diet.—In order to calculate the value of a diet, it is necessary to determine (1) the percentage of dry albuminoid material, of dry fatty material, and of dry carbohydrates in the various foods present; and (2) the number of grains of nitrogen and carbon which these foods contain.

By means of the following table given by Dr. Parkes, the first part of the problem can be easily solved. For example, suppose a diet contains 6 ounces of lean beef. According to the table, 100 ounces contain of

Albuminates, ...	20·5 ounces.
Fats, ...	3·5 „
Carbohydrates, ...	None.

Proceeding by rule of three, if 100 ounces of lean beef contain 20·5 ounces of dry albuminates, how much will 6 ounces contain? The answer will be found to be 1·23 ounces. By the same method we find that the dry fat amounts to ·21 ounce. So that 6 ounces of lean beef contain:—

Albuminates, ...	1·23 ounce.
Fats, ...	·21 „

TABLE FOR CALCULATING DIETS (PARKES).

ARTICLES OF FOOD.	IN 100 PARTS.				
	Water.	Albuminates.	Fats.	Carbohydrates.	Salts.
Uncooked lean meat (best quality),	74·4	20·5	3·5	—	1·6
Uncooked fat meat,	63·0	14·0	19·0	—	3·7
Cooked meat (roasted and boiled), and no dripping lost,	54·0	27·6	15·45	—	2·95
Fat pork,	39·0	9·8	48·9	—	2·3
Dried bacon,	15·0	8·8	73·3	—	2·9
White fish,	78·0	18·1	2·9	—	1·0
Poultry,	74·0	21·0	3·8	—	1·2
Bread (white),	40·0	8·0	1·5	49·2	1·3
Rice,	10·0	5·0	0·8	83·2	0·5
Oatmeal,	15·0	12·6	5·6	63·0	3·0
Arrow-root,	15·4	0·8	—	83·3	0·27
Peas (dry),	15·0	22·0	2·0	53·0	2·4
Potatoes,	74·0	2·0	0·16	21·0	1·0
Carrots,	85·0	1·6	0·25	8·4	1·0
Cabbage,	91·0	1·8	0·5	5·8	0·7
Butter,	6·0	0·3	91·0	—	variable.
Eggs,	73·5	13·5	11·6	—	1·0
Cheese,	36·8	33·5	24·3	—	5·4
Milk,	86·8	4·0	3·7	4·8	0·7
Sugar,	3·0	—	—	96·5	0·5

Having obtained the amount of dry albuminates, fats, and carbohydrates in ounces, the number of grains of nitrogen and carbon which these materials contain can be found by using the following table:—

	Grains of Nitrogen.	Grains of Carbon.
1 ounce of dry albuminates contains	69	233
1 ounce of dry fatty material contains	0	336
1 ounce of dry carbohydrates contains	0	194

Thus, in the six ounces of beef in the previous example, there will be from the 1·23 ounces of dry albuminates—

	Grains of Nitrogen.	Grains of Carbon.
1·23 × 69	84·87	—
1·23 × 233	—	286·59

and from the ·21 oz. of fat—

·21 × 336	—	70·56
Total,	84·87	357·15

If we bear in mind that a well-arranged diet should contain 300 grains of nitrogen and 4800 grains of carbon, it will be found that such a proportion can only be obtained by an appropriate combination of various foods. For example: Suppose a man attempted to live on bread alone. According to Payen, 1000 grains of bread contain about 10 grains of nitrogen and 300 of carbon. So that to obtain the 300 grains of nitrogen he would have to eat 30,000 grains of bread, or more than four pounds. But in this amount there would be 9000 grains of carbon, or nearly twice the quantity actually required. Or suppose he took nothing but meat. To obtain the necessary amount of nitrogen 1½ lbs. would be sufficient; but he would have to consume about 4½ lbs. in order to get the proper quantity of carbon. But in doing so he would take three times the amount of nitrogen needed. In order, therefore, to avoid an excess of either element, he must properly combine the two; and by taking ¾ lb. of meat and 2 lbs. of bread, his daily requirements will be satisfied exactly.

Varying Need of Food.—The absolute quantity of food required daily depends upon so many circumstances that it is impossible to frame a standard diet applicable to every case. The principal variations in diet are due to climate, age, sex, constitution, and habits of the individual. "Brain work, body work, indoor work, and outdoor work, all introduce modifications in the daily requirements of the nutritive organs."

Effects of Excessive or Deficient Diet.—The great influence which a well-balanced and sufficient dietary has upon health cannot be over-estimated. The tendency of the present day is to habitually eat too much—a practice traceable to the excessive use of condiments, stimulants, &c. That over-feeding is answerable for many of the "ills that flesh is heir to," every medical practitioner will corroborate. A single excess will only lead to a temporary derangement of the digestive system; but if a continued excess be taken, with little or no exercise, it is not digested, but undergoes putrefactive changes in the alimentary canal, resulting in indigestion, disordered bowels, headache, sleeplessness, giddiness, &c. With the addition of alcoholic drinks, gout may arise.

When a deficiency of food, either general or of any one of the necessary food-stuffs, is long continued, a loss of weight takes place, because the body, unable to obtain sufficient material from the food taken, has to draw upon the tissues themselves to carry on the vital functions. Thus a slow state of starvation is going on, and will end, sooner or later according to the condition of the body to begin with, in death. The free use of water will prolong the period. The fatty materials throughout the body are the first to be used up, the glandular organs being next. The parts which suffer least are the bones, eyes, and nervous system.

When to Eat.—With reference to the times at which meals should be taken, and the interval which should elapse between each, it is extremely difficult to lay down any dogmatic rules, because we are to a great extent the creatures of circumstances. But we should always make the strongest endeavour to take our food at fixed times, with proper intervals between, for the digestive system is easily put out of order by irregularity of meal-times. When the diets are well arranged, three meals a day are regarded as sufficient for the healthy adult. Children should not have less than four.

For those engaged in an active busy life—especially if out of doors—it is well to take a good breakfast before commencing the work of the day; but for those leading quiet sedentary lives, light nutritious food is best. An interval of five hours should then elapse before dinner is taken. This should be the most substantial meal of the day, since it has to make good the loss caused by the morning's labour, as well as to provide the energy for the work still to be done. After another interval of five hours a third meal is necessary. But unless this is a fairly substantial meal, a light supper—say of oatmeal porridge and milk—should be taken one and a half hours before bed-time.

Nothing should be taken between meals; and the common practice of many parents of giving food to children whenever they ask for it must be strongly condemned. The digestive organs, like all the other organs of the body, need rest; and this cannot be obtained if food is introduced too frequently.

How to Eat.—1. All food (unless it is in such a state that it requires no further reduction) must be thoroughly masticated. The importance of this will be understood when it is stated that there is not a more fruitful source of dyspepsia than imperfect mastication. Therefore eat slowly and chew the food well.

2. Do not drink large quantities of water, or any other fluid, at meal-times, because the digestive juices will be so diluted as to render them almost useless. Strong alcoholic drinks are apt to stop digestion altogether. Tea should be taken at the end of a meal, and not sipped from time to time during its progress. The popular

"meat-tea" is highly objectionable, because the *tannin* of the tea renders the meat indigestible.

3. Do not read or attempt to learn anything while eating, for mental pre-occupation interferes with digestion, and in proportion to its intensity. It is much better to engage in a lively talk or a pleasant chat over a meal.

CHAPTER V.—CONDIMENTS.

Condiments.—Under this head are included a variety of substances which are added to our food for the purpose of either making it more palatable, or of assisting its digestion by stimulating the digestive organs to increased action. They are not foods in themselves, but stimulants, and as such require to be used in moderation. To those in good health they are not at all necessary, except, perhaps, with very insipid foods. The mere entrance of food into the alimentary canal ought to be a sufficient incitement to cause an increased flow of saliva and gastric juice. But to those with defective appetites, or in whom digestion is slowly performed, they are of great value. With the exception of salt, children should not be permitted to use them at all; hunger alone should prompt them to eat.

The condiments which we employ may be divided into:—

1. Common salt.
2. Acids: *Vinegar*, *lemon-juice*, *lime-juice*, &c.
3. Pungent substances: *Mustard*, *pepper*, *ginger*, *horse-radish*.
4. Aromatics: *Nutmegs*, *mace*, *cinnamon*, *cloves*, *allspice*, *caraway*, *mint*, *parsley*, *thyme*, *marjoram*, &c.

Salt.—The composition and importance of common salt have been dealt with under the head of mineral foods. It is the chief condiment in daily use, and in this country is obtained by evaporating the brine obtained from springs at Droitwich in Worcestershire, and at Nantwich, Northwich, and other places in Cheshire. Its quality is known by its whiteness, its fine crystalline character, and the perfect clearness of its solutions in water.

Vinegar.—Vinegar is a vegetable acid. It consists principally of water and acetic acid, of which there is about 5 per cent in pure samples. There are also present very small quantities of various substances which give the special flavours to vinegars, as well as varying amounts of colouring matters generally added by the manufacturers. The addition of the one-thousandth part by weight of sulphuric acid is permitted by law in order to prevent decomposition. Such addition is quite unnecessary, and its presence can be readily detected by the formation of a white precipitate on the addition of a few drops of *barium chloride*. If it be known that a vinegar contains sulphuric acid it should be rejected, because the latter acid tends to form insoluble salts of lime. The principal modes of preparing vinegar are: (1) by the oxidation of alcohol, (2) by the destructive distillation of wood. In the first process alcoholic liquids, such as beer or wine, are exposed to the action of the air at a temperature of about 77° F. for a fortnight, when the alcohol is converted to vinegar. The process by which this is accomplished is termed *acetous fermentation*, and is now known to be due to the action of a peculiar vegetable growth—*Mycoderma aceti*, which first absorbs oxygen from the air, and then gives it up again to the alcohol. The best vinegar is prepared on a large scale in France from wine, and is known as *wine vinegar*. In England it is made from beer or malt-wort, and is called *malt vinegar*.

The second process produces *wood vinegar* or *pyroligneous acid*. Wood is heated in large iron retorts connected with condensers. The products of this destructive distillation consist of wood spirit, acetic acid, water, and tarry matters, from which the acetic acid is afterwards separated by various chemical processes.

Vinegar is either used alone, or in combination with sauces and pickles. It is capable of preventing the decomposition of both vegetable and animal substances, and is therefore largely employed in the preparation of pickles, and on a smaller scale for preserving fish in hot weather. When taken in moderation it allays thirst, checks excessive perspiration, and aids digestion; in large quantities it is undoubtedly injurious, as it interferes greatly with the digestive processes, so that the body is not properly nourished. For this reason it is taken as a remedy for corpulency.

Lemon and Lime Juice.—These are valued for their antiscorbutic properties. The lime is a variety of the lemon, but is much smaller. It is not cultivated to any great extent in Europe, but in the West Indies it is highly esteemed. Both lemon and lime juice are imported to this country for the manufacture of citric acid, which closely resembles tartaric acid in appearance.

Mustard.—The pale-yellow flour of mustard is prepared from the seeds of two well-known English plants, *Sinapis nigra* and *S. alba*, the black and white mustard. In the dry state mustard has little or no smell, but when moistened it gives forth a most pungent and penetrating odour which is very irritating to the eyes and nose. This pungent character is due to a volatile acrid oil which did not previously exist, but which was developed on the addition of water from a substance called *myronic acid.*

As a condiment mustard is useful in promoting an appetite and aiding digestion. It should, however, be taken only in small quantities, as an excessive use of it is likely to lead to liver complaint. In domestic surgery mustard is of great value. Mixed with water it forms a safe and very effectual emetic in cases of poisoning, and applied as a poultice will frequently relieve the most intense pain.

Horse-radish.—Horse-radish is the root of a plant to be seen growing in most English gardens. It resembles mustard very much in flavour, on account of the presence of an essential oil identical with that formed in mustard by the addition of water. It should be grated or scraped as fine as possible, and served with vinegar. As a condiment it is not so wholesome as mustard, for it is apt to adhere to the walls of the stomach and produce very serious results.

Pepper.—Pepper is the fruit of a climbing plant, the *Piper nigrum* (Fig. 2), which grows almost exclusively in tropical countries. The berries or pepper-corns, of which there are from 20 to 50 in each bunch, are gathered before they are ripe, and dried in the sun. This gives them their well-known black and wrinkled appearance. Such berries when ground to powder produce *black-pepper*. *White-pepper* is made from the same fruit, but the outer husks are removed before grinding. The essential constituents of pepper are a volatile oil which is more irritating than that of mustard, and a peculiar substance called *piperine*. The best black-pepper comes from Malabar; that usually sold in the shops is a mixture of inferior sorts, such as Penang and Sumatra, the latter being the cheapest kind.

Fig. 2.—Black-pepper (*Piper nigrum*).

Long-pepper is the fruit of a similar plant, the *Piper longum*, and is imported into England from Bengal. It is a favourite in some culinary preparations, as in making pickles. *Cayenne pepper* is more irritating than ordinary pepper. It is made from the pods of the *Capsicum annuum*, commonly known as chillies.

Ginger.—This well-known spice is the dried root-stock of the *Zingiber officinale*, a plant extensively cultivated in the East and West Indies, India, and China. It is not only useful as a condiment, but also as a medicine, acting as a carminative. It is best taken by persons of relaxed habits. The sweetmeat called "preserved ginger" is made by boiling the green shoots in simple syrup.

Curry-powder.—Ordinary curry-powder consists of a mixture of *turmeric*, *black-pepper*, *coriander seeds*, *cayenne*, *fenugreek*, *cardamoms*, *cumin*, *ginger*, *allspice*, and *cloves.* These are all well ground together, and then kept in a well-stoppered bottle until required for use. It is a very hot stimulating condiment in use in hot climates.

Cinnamon.—Cinnamon is the inner bark of the cinnamon laurel, *Cinnamomum zeylanicum*, which is cultivated in Ceylon, Borneo, Sumatra, and the coast of Malabar. After the bark has been removed it is dried in the sun, and this causes it to roll up into the long sticks we are so familiar with.

Nutmegs and Mace.—Nutmegs are the seeds of the *Myristica moschata* (fig. 3), a small tree indigenous to the Moluccas, but now extensively cultivated in the tropical parts of America. Surrounding the nutmeg is a sort of network covering or arillus, which, when dried, is known as *mace.* Fresh mace has a blood-red colour, and is prepared for the market by first drying it in the sun for some days and afterwards flattening it. Both spices have a hot biting taste and an agreeable odour, due to an aromatic oil.

Fig. 3.—Nutmeg (*Myristica moschata*).

Cloves.—Cloves are the dried flower-buds of a beautiful evergreen tree which grows in the West Indies and Zanzibar. They contain a volatile oil—the oil of cloves, and are principally used for flavouring apple-tarts, puddings, and pies.

Allspice.—Allspice, also known as *pimento* and *Jamaica pepper*, is the berry of the *Eugenia pimenta*, a tree grown in the West Indies and South America. It received the name allspice because its aroma resembled that of cloves, cinnamon, and nutmeg mixed together. It may be bought either whole or ground, and is used in a similar manner to other peppers.

Caraway Seeds.—Caraway seeds are largely imported from Holland, and are much used for flavouring confectionery, cordials, &c. They are the seeds of the *Carum carui*, a plant somewhat similar to the carrot and parsnip.

Coriander Seeds.—Coriander seeds are highly aromatic and much used in cooking. The plant (*Coriandrum sativum*) from which they are obtained is largely cultivated in France.

Vanilla.—Vanilla is an extract from the pods of an orchidaceous plant, the *Vanilla aromatica* or *planifolia* (fig. 4). It is generally used in the form of an essence for flavouring creams, ices, chocolate, and other confectionery; it is also highly prized as a perfume. The best vanilla comes from Mexico; but cheaper and inferior kinds are now sent from Mauritius, Guadeloupe, and Demerara.

Fig. 4.—Vanilla.

Onions, Leeks, Shallots.—Onions, leeks, and shallots are both condiments and foods. As condiments they are very useful for flavouring soups and many made-dishes. Many persons object to the use of them entirely on account of the unpleasant odour which they impart to the breath. This arises from the strong-smelling and volatile oil which they contain. If the water, however, in which they are boiled be thrown away and renewed two or three times much of their oil is dissipated, and they become milder in consequence. The young onions are frequently eaten raw. *Shallots* or *eschalots* are a very mild kind of onion. They should be dug up in the autumn and well dried; they will then keep for several months.

Other Condiments.—Of the remaining condiments, the principal are *mint*, *thyme*, *marjoram*, *sage*, *parsley*, *fennel*, and *garlic*. They all contain a volatile oil, and are much used for flavouring dishes. With the exception of fennel and garlic, they may be dried and kept in well-corked bottles for winter use. For those who like it, fennel is served in melted butter with mackerel.

CHAPTER VI.—NON-INTOXICATING BEVERAGES.

Beverages.—A beverage is any agreeable liquor used for drinking purposes. The most important natural beverage, and, indeed, the only one required, is water; and yet man has prepared and daily used from the earliest times a great variety of artificial drinks, several of which are, unfortunately, too freely indulged in. When taken in moderation and at proper times, their beneficial effects cannot be over-estimated. It is their abuse which is to be condemned.

All beverages may be arranged under two heads: those that are non-alcoholic or unintoxicating, as tea, coffee, cocoa, &c.; and alcoholic or intoxicating, as beer, wines, and spirits.

Tea, Coffee, Cocoa.—Tea, coffee, and cocoa resemble each other in several respects. All three contain a nitrogenous substance, called the *active principle*, upon which their stimulative properties partly depend. The active principle of tea is called *theine;* that of coffee, *caffeine;* and of cocoa, *theobromine.* Caffeine was discovered in coffee-berries in 1820, and theine in tea in 1827; and eleven years later it was found that the two substances were identical. Their composition is represented by the formula $C_8H_{10}N_4O_2, H_2O$. Theobromine ($C_7H_8N_4O_2$) was discovered in cocoa in 1841.

Theine (caffeine) has no smell, and only a slightly bitter taste. It amounts in tea to about 2 per cent, and in coffee 0·8 to 1 per cent. In moderate doses it accelerates and strengthens the heart's action and respiration. Theine acts as a stimulant and tonic to the nervous system, producing a feeling of refreshment and invigoration, for which it is valued by most brain-workers. It also increases the action of the skin and kidneys, diminishes the tendency to sleep, and frequently relieves headache. Taken in excess it produces nervous excitement, tremor of the muscles, restlessness, and palpitation. Theobromine acts in a similar manner.

Tea, coffee, and cocoa also contain an aromatic volatile oil, to which they owe their distinctive flavour and aroma. This oil does not exist in either when freshly gathered, but is developed during the drying and roasting processes to which they are subjected before being sent to market. The headaches and giddiness of tea-tasters, and the attacks of paralysis to which those employed in packing and unpacking chests of tea are liable, are said to be due to the action of this oil. The Chinese rarely use tea before it is a year old, the idea being, it is believed, to allow some of the oil to escape.

There is also found in tea and coffee an astringent substance, which gives the well-known bitter taste to the infusions when they are allowed to "stew." In the case of tea it is known as *tannin*, and forms from 13 to 20 per cent of the dried tea-leaf. In coffee it is called *caffeic* or *caffeo-tannic acid*, but its amount is much less than the tannin in tea. The presence of tannin can be shown by the black discoloration on the addition of a solution of sulphate of iron to an infusion of tea. Caffeo-tannic acid does not produce this effect with a similar solution. Whenever present, the tannin exists in very small quantities in cocoa.

In addition to the three principal constituents just described, a great variety of other substances, such as albuminoids, gum, dextrin, fat, &c., are also found in tea, coffee, and cocoa, but, with the exception of the fat, are of no moment to our subject. In cocoa the fat, known as cocoa-butter, amounts to 50 per cent.

Tea.—Tea is the dried leaf of the tea-plant, *Thea sinensis*, of which there are three principal varieties, known to botanists as *Thea viridis* and *T. bohea*, native to parts of China and Bengal, and *T. assamica*, native to Assam. The plant is an evergreen flowering shrub, and is believed to be a native of Bengal, from whence it was introduced into China in the sixth century of the Christian era.

The tea plants are raised from seed which is sown in March; having been kept in moist earth through the previous winter. When a year old, the young trees are planted out in rows about three or four feet apart, and by cropping the main shoots their upward growth is kept down to about three feet, the trees in this way being made to grow bushy. As a rule the young bushes are allowed to grow unmolested for two or three years, the gathering of the leaves not commencing till about the fourth year. Three or four crops are then taken each year, the first at the beginning of spring, the second in May, the third in June, and the last in August. The leaves of the first gatherings make the best tea, those of the later crops being more bitter and woody.

In preparing the tea for the market the treatment which the leaves undergo depends on whether green or black tea is required, the difference between the two being simply one of preparation. For green tea the leaves are spread out on flat bamboo trays for one or two hours to slightly dry them. The leaves are then thrown into roasting-pans, heated over a brisk wood fire, and rapidly moved about. This causes them to make a crackling noise and to become moist and flaccid; at the same time they give off considerable vapour. After remaining in this state for a few minutes they are removed from the pans, rolled into balls by the hand, and returned once more to the roasting-pans. Here they are kept in rapid motion by the hand, and in about an hour or an hour and a half the leaves are thoroughly dried and are of a dullish green colour. The better kinds of green teas are known as Hyson, Twankay, and Gunpowder.

In the preparation of black tea the leaves are at first allowed to lie in heaps for several hours, during which a kind of fermentation takes place, and the leaves assume a dark colour. They are then dried, rolled, and roasted over slow charcoal fires. The chief kinds of black tea are the Congou, Souchong, Oolong, Pekoe, and Caper.

In some parts of South America a peculiar infusion, called Maté or Paraguay Tea, is made from the dried leaves of the Brazilian holly (*Ilex paraguayensis*). Its constituents are similar to those of ordinary tea.

The composition of tea, according to König, is as follows:—

	Per Cent.
Water,	11·49
Theine,	1·35
Essential oil,	·67
Tannin,	12·36
Nitrogenous substances,	21·22
Fat, gum, &c.,	10·75
Other non-nitrogenous substances,	16·75
Woody fibre,	20·30
Ash,	5·11

It must be understood that this is not the composition of every kind of tea, but of only one sample. Other analyses show that there is a great variety in the composition of the different teas. These differences are principally due to the mode of drying the leaves, the age of the plant and leaf, the variety of plant from which the leaves are obtained, and the season when they are gathered.

The Value of Tea as a Food-stuff.—Guided by the above analysis alone it would appear, from its high percentage of nitrogenous substances, that tea was of considerable value as a food-stuff; whereas it is really valueless. This will be readily understood when it is borne in mind that the infusion is made with boiling water, which renders the albuminoid materials insoluble.

It has been estimated that in half a pint of tea, made from a large tea-spoonful of dried tea, only 37 grains of the materials of the leaf are extracted, of which 7½ grains are tannin, 2½ grains theine, and 6 mineral; the remaining 21 grains consisting chiefly of gummy, sugary, and nitrogenous bodies. So that practically there is no nutriment in a cup of tea beyond that of the milk and sugar added.

As a beverage tea stands unrivalled; and its introduction into this country has certainly aided in promoting temperate habits. It is both stimulating and exhilarating, but does not cause any after depression as the alcoholic drinks do. But unfortunately these very qualities lead to its excessive use, in which case it becomes a prolific source of indigestion, with all its mischievous consequences. To the sick patient a little tea is very refreshing, and is frequently the only thing which he can take.

Tea should not be taken during fasting, nor sipped after every mouthful of food, especially when meat forms a part. For this reason the popular "meat-tea" should be avoided. Tea is best taken at the end of a meal. When used as a stimulant by those engaged in intellectual work, it should be taken in moderation.

How to make Tea.—In making tea, we must first warm the pot by letting some boiling water stand in it for two minutes. Pour this out and immediately put the tea in, the amount depending upon the quantity of infusion required. Close the lid, and let it stand for another minute; then pour upon it the *boiling water*, and allow it to infuse for not more than five minutes under a "cosy." If the tea has to be kept for a length of time, it should always be poured into a second pot; because the longer the tea-leaves are infused the darker and more bitter will the tea become, on account of the greater quantity of tannin extracted. The water employed for making tea should be, if possible, soft; but when hard water is of necessity used, it should be boiled for some time to soften it, or a pinch of bicarbonate of soda may be added to it.

Coffee.—Coffee is prepared from the seeds of the coffee-shrub, *Caffea arabica*, a native of Abyssinia, from which country it was introduced into Arabia at the beginning of the fifteenth century. The coffee plant belongs to the same natural order (*Cinchonaceæ*) which supplies us with *ipecacuanha*, *quinine*, and *Peruvian bark*. The tree is an evergreen, and, when full-grown and in healthy condition, reaches a height of 15 to 20 feet in some countries, but only averaging 8 or 10 feet in others. Its leaves are dark and glossy, and its flowers white and fragrant, but quickly fading. The fruit, which resembles a cherry, contains two hard oval seeds, surrounded by a tough integument or skin. After the pulp has been removed, the seeds, with their coverings attached, are dried in the sun. The skins are then removed by heavy rollers, arranged in such a manner as not to crush the seeds. The berries obtained from the plantations situated on hilly districts have a better flavour than those from the plains below. But all kinds of coffee-beans improve in flavour by keeping, and it is said "that the worst coffee produced in America will, in from ten to fourteen years, become as good and acquire as high a flavour as the best."

The composition of coffee is given by Church as follows:—

Water, ...	5·0 per cent.	Gum, colouring matter, &c.,	34·4 per cent.
Theine (caffeine),	0·6 ,,		
Tannin, ...	4·0 ,,	Fibre, ...	36·4 ,,
Nitrogenous, ...	15·0 ,,	Saline, ...	4·6 ,,

Before being used for domestic purposes the berries are first roasted and then ground. During roasting the berries swell, and lose about 20 per cent of their weight. They become of a chestnut-brown colour, and exhale a delicious odour arising from the development of a volatile and aromatic oil, which also gives the coffee its flavour. The roasting, however, requires to be conducted with great care; if overdone, the aroma is destroyed and a burnt flavour is produced instead. After the coffee has been roasted it should not be left exposed to the air, as it loses all its aroma in a short time.

An infusion of coffee is prepared in the same way as tea. Many people prefer boiling their coffee in order to give some "body" to it. By doing so, however, its delicate aroma is dissipated. A better plan would be to boil the "grounds" of a previous brewing, and then pour this hot decoction over a fresh supply of coffee, thus obtaining both body and flavour.

The effects of coffee upon the human system are similar to those of tea. It exerts a stimulating action upon the nervous system, quickens the heart's action and the rate of breathing, and increases the amount of carbonic acid expelled. It increases the secretion of the kidneys, and has a relaxing effect upon the bowels. Unlike tea, it does not promote perspiration, but rather dries the skin. It has been said that both tea and coffee diminish tissue change; but careful experiments have shown that this is inaccurate.

Coffee is of great value to those engaged in laborious occupations, as it invigorates without producing a subsequent depression; while its great power of causing wakefulness makes it highly serviceable in cases of alcoholic and opium poisoning.

Chicory.—The addition of a small quantity of chicory to coffee is considered an improvement by many. It imparts a darker colour as well as greater flavour to the infusion. It is prepared from the root of the *Cichorium intybus*, a plant resembling a dandelion, but having blue instead of yellow flowers, and largely cultivated in Germany, Holland, and Belgium. It grows wild in our own country in many places, and is known as the wild succory or wild endive. The root, which is similar to that of the parsnip, is sliced and roasted until it is of a chocolate colour, and afterwards ground. For those who like the addition of chicory, a mixture of two ounces of chicory and one pound of genuine coffee will be found most suitable.

Cocoa.—Cocoa is prepared from the seeds of the *Theobroma cacao*, a tree indigenous to tropical America, and now grown chiefly in Brazil, Guiana, and Trinidad. The cocoa-tree is an evergreen, growing to a height of 15 or

20 feet, and having drooping bright green leaves. The fruit is of the shape of a vegetable marrow, only more elongated and pointed at the ends, and contains a sweetish pulp in which from 20 to 50 seeds are embedded in three parallel rows. As soon as collected the seeds are taken from the pod, and either covered with sand or buried in the earth until a fermentation ensues. This has the effect of developing an aromatic odour, and at the same time removing a portion of their natural bitterness. The seeds are then spread out to dry in the sun ready for exportation.

On their arrival in this country the cocoa-beans are placed within revolving iron cylinders and carefully roasted to develop their full aroma. When this has been effected they are spread out on large trays to cool, and are then ready to be "broken down," as it is technically termed. To do this, the roasted beans are passed through a machine which gently breaks off the thin husks and sets free the glossy kernels, known as *cocoa-nibs*. These have a deep brown colour, and contain about 50 per cent of fat called cocoa-butter.

The "prepared cocoa" is obtained by grinding the nibs between hot granite rollers. This reduces them to a creamy fluid, from which the fat or cocoa-butter is afterwards removed by a special process, leaving the cocoa perfectly dry. The best cocoa consists solely of the ground nibs, but the inferior sorts contain a proportion of the husk. Chocolate is prepared by mixing the finely ground nibs with sugar and various flavouring substances, especially vanilla. It is, however, often considerably adulterated.

König gives the following as the mean composition of the cocoa-bean:—

Water, ...	3·25 per cent.	Other nitrogen free matters, ...	12·35 per cent.
Nitrogenous matters,	14·76 „	Cellulose,...	3·68 „
Fat, ...	49·0 „	Ash, ...	3·65 „
Starch, ...	13·31 „		

From this table it will be seen that cocoa differs from tea and coffee in containing a large proportion of nutritive material, which makes it a very valuable food-stuff. For it must be borne in mind that we do not make an infusion of cocoa as we do of tea and coffee; but mix it with boiling water and drink the whole, thereby introducing all its constituents into the body. For those with whom tea and coffee disagree, cocoa is a most agreeable alternative. The large quantity of fat which it contains, however, causes it to be somewhat indigestible with some people. In such cases, the cocoas containing very little fat, as the homœopathic, should be tried. The action of the theobromine is similar to that of the theine of tea and coffee, but of not so pronounced a character.

Aerated Waters.—Aerated waters are either natural, as those of Seltz, Vichy, and Spa; or artificial, as soda-water, potass-water, lithia-water, lemonade, &c. They all agree in being highly charged with carbonic acid gas, and in many, there is a variable amount of alkaline salts dissolved.

CHAPTER VII.—INTOXICATING BEVERAGES.

Properties of Alcohol.—Alcohol is the active agent which gives all the intoxicating beverages the property by which they are known. It is a limpid colourless liquid, having an agreeable odour and a strong pungent taste. It is highly inflammable, and burns with a bluish sootless flame to carbonic acid gas and water. On exposure to the air it evaporates very rapidly. Alcohol is a great solvent, and is much employed in the preparation of varnishes, perfumes, &c. As its congelation only occurs at a temperature of − 203° F., it is much valued for filling thermometers exposed to intense cold.

In chemistry the alcohols form an important group of organic compounds, the commonest of which are:—

Methyl alcohol (CH_4O), commonly called wood-spirit.
Ethyl alcohol (C_2H_6O), or spirits of wine.
Amyl alcohol ($C_5H_{12}O$), or fusel-oil.

Methyl alcohol is obtained by the dry distillation of wood. Ethyl alcohol, or spirits of wine, is the form which is meant when alcohol is spoken of as a beverage. Amyl alcohol, popularly known as fusel-oil, is a constituent of the commoner brandies, whiskies, &c.

Ordinary alcohol is obtained by the vinous fermentation of sugar. When a sugary solution, such as the juice of ripe grapes, is freely exposed to the air and kept at a temperature of about 70° F., a chemical action ensues which results in the decomposition of the grape-sugar and the formation of carbonic acid gas and alcohol. The process by which this change is accomplished is known as fermentation, and is due to the action of a minute fungus (*Torula cerevisiæ*) derived from the air. When once fermentation has begun, the presence of the air is no longer necessary.

On account of its strong affinity for water, alcohol, as it is usually prepared, contains a considerable quantity of it. In order to obtain the pure, or as it is called, *absolute alcohol*, the spirit must be distilled with some substance having a still stronger affinity for water, such as quicklime or potassium carbonate. When spirits are first distilled they invariably contain a disagreeable oil, known as fusel-oil, together with other impurities. By repeated rectifications these may be removed, and the resulting spirit is then said to be *rectified*. But the strongest spirit that can be prepared in this way will still contain about 10 per cent of water. *Proof-spirit* consists of alcohol 49·24 and water 50·76 by weight.

The beverages which contain alcohol may be arranged as (1) malt liquors, (2) wines, and (3) spirits; and the percentage of alcohol in those commonly employed will be gathered from the following table:—

Brandy,	55·3	per cent.
Whisky,	54·3	,,
Rum,	53·6	,,
Gin,	51·6	,,
Sherry,	22·9	,,
Port,	21·9	,,
Madeira,	19·1	,,
Champagne,	11·7	per cent.
Claret,	8·0	,,
Edinburgh Ale,	8·5	,,
Burton Ale,	5·9	,,
Porter,	5·4	,,
Lager Beer,	5·1	,,
Table Beer,	1·5	,,

Beer.—Beer, in its various forms of ale, porter, stout, &c., is brewed from malt and hops. The barley is first made to germinate by being steeped in water, and then placed in warm rooms. After ten or twelve days the further growth of the barley grains is arrested by drying gently in a kiln. It is now known as malted barley. If a moderate heat is employed, the malt has a pale colour, and is used for brewing the pale ales; but if the heat has been considerable, the malt is dark coloured owing to a portion of the sugar being converted to *caramel*, and is used for making porter and stout. The germination develops a peculiar ferment, *diastase*, which has the property of converting starch into sugar ($C_6H_{12}O_6$). The malt is placed by the brewer in his mash-tun together with warm water, and allowed to stand, after which the liquor is strained to free it from the malt husks. The "wort," as the liquor is now called, is then boiled with hops to give it a bitter flavour, and afterwards cooled as rapidly as possible by being run into shallow wooden vessels or coolers. When it has reached a temperature of about 54° F. it is transferred to the fermenting vat, where, after the addition of a sufficient quantity of yeast, it is left to ferment for some days. During this fermentation, as before remarked, the sugar of the wort decomposes into alcohol and carbonic acid gas; the former remaining in the beer, and the latter mostly escaping into the surrounding air. Before, however, this change is complete, the yeast is removed by skimming, and the beer is then drawn off into casks for use.

The quality of the different beers brewed varies according to the kind and quantity of the malt used, the nature and quantity of hops added, and the extent that fermentation has been allowed to proceed. Bottled ales are generally more alcoholic than those on draught. Their sparkling character arises from the free carbonic acid gas produced by a secondary fermentation after bottling. All beers contain a small percentage of acetic, lactic, and succinic acids in addition to carbonic acid.

Wine.—Wine is the fermented juice of the grape. In wine-making the grapes are first crushed, and the expressed juice, or *must* as it is termed, is either allowed to ferment in contact with the skins, or is drawn off to ferment separately. In the latter case a white wine is produced, irrespective of the kind of grape employed, because the colouring matter of red grapes resides in the skins only, and is insoluble in water. It is, however, soluble in alcohol. Hence if a red wine be desired, it will be necessary to allow the juice and skins to ferment together, so that the colouring matter may be extracted as the formation of alcohol proceeds.

The fermentation of grape-juice is not induced by the addition of a ferment, as in the case of beer, but arises spontaneously from the decomposition of its albuminous material. As soon as fermentation commences the juice becomes cloudy, and gives off bubbles of gas; but in a few days the liquid begins to clear by the settling of a sediment or "lees," at the same time losing its sweetness. If the process has proceeded until all the sugar has been converted to alcohol and carbonic acid gas, a *dry* wine is obtained, of which Bordeaux and Burgundy are examples. Should the transformation be not complete, a portion of the sugar remaining in the wine, it is then known as a *sweet* wine. Sparkling wines owe their character to the presence of much free carbonic acid gas in consequence of being bottled before fermentation has ceased.

The bouquet or aroma of wine is due to the presence of various ethers, especially *œnanthic ether*, which are developed at the expense of the alcohol. Thus very old wines, although possessing a finer bouquet, are of a lesser alcoholic strength than new ones of the same class. Several free acids are also found in small quantities, the principal being tartaric acid. Much of this acid crystallizes in the casks in the form of bitartrate of potash, commonly known as *cream of tartar*. The "crust" of old port and other wines consists chiefly of this substance.

The composition and quality of the wine produced depend upon several conditions. Of these the chief are the variety and ripeness of the grape, the climate of the country, the time of gathering, soil, &c. It is a common practice, however, to fortify wines by the addition of alcohol.

Spirits.—Spirits are obtained by the distillation of a previously fermented liquor. The liquor to be distilled is poured into a vessel called a *retort*, and boiled. The vapour which passes off is collected and condensed in a *receiver*, kept cool by being continually surrounded by cold water. The spirit at first collected contains a considerable quantity of water; but by successive distillations—or rectifications as it is called—much of this is removed. The reason of this is that alcohol boils at a lower temperature (173° F.) than water, and therefore tends to come away as vapour before the water does.

Brandy is supposed to be prepared by distilling wine. Its quality depends upon the kind of wine employed; that obtained from white wine having the finest flavour. *Whisky* is the spirit distilled from malt-wort. *Rum* is prepared from fermented molasses; while *gin* is distilled from barley and rye, and flavoured by means of juniper berries.

Other Fermented Beverages.—Among the remaining fermented beverages, those known as *British wines* hold a prominent position. They include *currant*, *gooseberry*, *orange*, *mulberry*, and *elderberry* wines, with numerous others. They all agree in being of lower alcoholic strength than the grape wines (unless fortified), as these fruits contain little saccharine matter. They are, however, rich in free acids, and it becomes necessary to add some sugar to mask their presence. *Cider* and *perry* are the fermented juices of apples and pears.

A similar variety of fermented beverages is found in use with other nations. Foremost among these is the favourite drink of the Tartars, *koumiss*, an alcoholic and effervescing beverage prepared from mare's milk. It is said to be of great value in wasting diseases, and is highly spoken of by Russian physicians. A similar beverage is now largely prepared in this country from cow's milk.

The Hindoos and Malays delight in their *arrack*, the distilled spirit obtained from fermented rice liquor. *Chica*, or maize-beer, has been in use among the South Americans from early times. Among the lower classes of Central Mexico the favourite drink is *agave-wine*, the fermented sap of the American aloe. The rye-beer of the Russian, and the palm-wine of the African may be quoted as other examples.

Effects of Alcohol.—Upon the moral and social aspect of this question we shall not dwell, as it scarcely falls within the province of a work of this nature; but shall consider it only from a physiological point of view. That water is the natural drink of man, and that no other liquid is capable of taking its place, is at once apparent from a consideration of its uses in the body. The fact that in the body of a man weighing 154 lbs. there are no less than 109 lbs. of water, is alone a sufficient proof that the substitution of alcohol for that constituent must lead to some disturbance in every organ in the body. That this is so we are only too painfully familiar.

It is commonly believed that the physiological effects of alcohol only differ in degree according to the amount taken. This, however, is certainly not the case, as large doses produce almost exactly the reverse effects of small ones. Thus in small quantities it acts as a general stimulant, in large quantities as a narcotic. But what are we to consider as a moderate quantity? From the investigations of Drs. Parkes and Anstie it appears that 1½ ounces of absolute alcohol can be taken in twenty-four hours without any of it appearing in the urine. As this amount is as much as can be disposed of without harm, we may regard it as the limit of moderation. The equivalent of 1½ ounces of alcohol would be about a pint and a half of the lighter ales; half a pint to a pint of the lighter wines and stronger beers; and about three ounces of brandy.

When alcohol is swallowed, it passes from the stomach into the blood, and is thence carried throughout the body. Its precise destination, however, has not been determined by physiologists; but many believe that it is equally distributed, and does not accumulate in the liver and nervous tissue only. There has also been much debate about the way it is disposed of in the body. Lallemand and Duroy, because they could detect its presence in the urine, maintained that it passed from the body unchanged; but the experiments of Anstie, Dupré, and others have shown that this is not so, and that a considerable quantity does disappear in the system, but in a manner not yet known.

The habitual consumption of large quantities of alcohol tends to produce a morbid condition of the body in general, and especially of the nervous system. In the stomach a chronic inflammation is excited in the mucous membrane lining that organ, and digestion is either wholly or partially arrested. There is no longer an appetite for food, and the body in consequence is insufficiently nourished. This manifests itself in emaciation, but more commonly by a fatty degeneration of most of the organs of the body. From the stomach the blood carries the alcohol to the liver, where, from its peculiar structure, alterations of a very serious nature occur. These are either in the form of an enlargement of the organ from a deposition of fat, or of an overgrowth of fibrous tissue between the lobules. In the latter case the overgrowth compresses the liver cells to such an extent that they are unable to perform their work properly, and atrophy of them ensues; at the same time, by obstructing the passage of the blood from the stomach and intestines through the portal vein, the blood-vessels in these organs become gorged with blood. The consequence is that the pressure of the blood upon the walls of the capillaries causes its serum to escape into the cavity of the peritoneum—the smooth membrane surrounding the organs of the abdomen,—and dropsy of the abdomen occurs.

Upon the heart and blood-vessels alcohol also has its effect. It increases the force and frequency of the heart's action, and thus the heart is called upon to perform more work than it would otherwise do. The flow of blood through the body is consequently quickened, with the result that the blood-vessels are rendered fuller than usual. This result is brought about in the following manner:—The bore of the blood-vessels depends upon the state of contraction of the muscular fibres with which their walls are supplied, the amount of contraction being regulated by the sympathetic nerves. Now, owing to the paralysing effect which alcohol has upon these nerves, the walls of the blood-vessels relax, and so the latter become distended with blood, as shown by the redness and flushing of the skin. In the case of the regular tippler, this dilatation of the vessels of the surface becomes permanent, producing the characteristic red tint, especially about the nose.

In some cases of disease the effects of alcohol upon the heart are totally different from those in health. Thus in many cases of fever and heart-disease it lessens the frequency, while at the same time it increases the force of the heart's action. Hence, in the hands of a medical man, it may be a powerful instrument for good.

The action of alcohol upon the nervous system may be said to be twofold: it at first excites, and then depresses. The stimulating effects of alcohol are seen in the freer discourse, the rapid flow of ideas, and general excitability of those under its influence; or in the quarrelsome and combative spirit so frequently displayed. These effects are partly due to the increased flow of blood to the brain (for the activity of an organ mainly depends upon its blood-supply), and partly to the direct action of the alcohol upon the nerve-centres. Sooner or later, however, a reaction sets in, and the first effects are followed by exhaustion, which is the more prolonged and intense as the previous excitement has been greater. The brain now begins to lose its powers, as indicated by the confusion of ideas and indistinctness of speech, together with an unsteady gait.

When large quantities of alcohol are consumed, its narcotic influence upon the nervous system is very marked; a total collapse of all control over the voluntary movements ensues, and the individual falls insensible to the ground, "dead drunk." The frequent repetition of such excessive debauches finally leads to the terrible nervous disease known as *delirium tremens*, owing to the presence of too much blood in the vessels of the brain. To this list of cerebral disorders, brought on by alcoholic indulgence, the thickening of the membrane of the brain, the loss of memory, dulness of perception, and insanity may be added.

The kidneys also participate in the general disturbance, and become diseased from changes analogous to those occurring in the stomach and liver. They shrink, and become tough and fibrous.

Before dismissing this part of our subject, a word must be said upon the hereditary effects of alcohol. There is not the least doubt in the minds of medical men that many of the changes wrought in the system by the action of alcohol are transmitted to the offspring, and manifest themselves either in defective bodily structure or in certain depraved instincts.

Is Alcohol a Food?—There has been much conflict of opinion among scientific men upon the dietetic value of alcohol. Some believe that it acts like a carbonaceous food, such as sugar and starch; while others as strenuously maintain that it is in no sense a food. Alcohol, as we have seen, consists of carbon, hydrogen, and oxygen only. There is no nitrogen present; and therefore the absence of this element shows it to be incapable of repairing tissue waste. Its carbon and hydrogen, however, are capable of oxidation, and it was for this reason that Liebig regarded alcohol as a "respiratory" food. But the researches of Perrin, Lallemand, and Duroy seemed at one time to have proved that alcohol was not broken up in the system, but was eliminated unchanged. Their conclusions, however, have been shown to be utterly wrong by the labours of Anstie, Parkes, and Wollowicz, who have found that as much as 1½ ounces of alcohol can be disposed of within the body. Nothing, however, is definitely known of the changes which it undergoes; but it is reasonable to suppose that it becomes oxidized, and may thus be a source of heat and energy. Out of the body alcohol readily changes to acetic acid; and it is upon these grounds that Dr. Parkes believes that the same occurs within the system. If such is the case, then the acetic acid, by combining with the soda of the blood, would eventually lead to the formation of a carbonate, which would be expelled with the urine. "If this view be correct, the use of alcohol in nutrition would be limited to the effects it produces —first as alcohol, and subsequently as acetic acid, when it neutralizes soda, and is then changed into carbonate" (Parkes).

From the experiments of Dr. Hammond upon himself, it would appear that alcohol can replace food to some extent. Thus he found that, with a diet which was insufficient to maintain his weight at the normal, the addition of alcohol more than compensated for the deficiency of food, and that he actually gained in weight. But whether the increase was due to the alcohol really taking the place of food, or to its retarding the metamorphosis of the tissues, is doubtful. If it arose from the latter cause, then alcohol can scarcely be regarded as a food on that account. Even granting that alcohol is a food, which is very doubtful, its substitution for the ordinary food substances is a risky practice, to say the least.

Does Alcohol Warm the Body?—It is the generally received opinion that alcohol makes us warm, and thus enables us to withstand prolonged exposure to cold; but all experience proves that it has no such property. Arctic explorers are singularly unanimous against the use of alcohol as a preventative against cold; and Alpine guides are so convinced of its worthlessness for such purposes, that they will not allow those in their charge to take any. The bodies of drunken men grow colder instead of warmer, and Dr. W. B. Richardson has shown that in the advanced stages of alcoholism there is a reduction of temperature from 98° to 96°.

The glowing sensation of warmth which follows the drinking of a little spirit is only superficial, and is due simply to the increased circulation of the blood that it causes. Under ordinary circumstances the effect of cold upon the skin is to contract the cutaneous capillaries, and thereby greatly reduce the circulation of the blood through them. Hence much less heat is lost by conduction and radiation, the skin itself being a bad conductor. When, however, large quantities of alcohol are consumed, the vaso-motor nerves are more or less paralysed, and the blood-vessels, no longer able to respond to the stimulus of cold, allow a freer circulation to occur at the surface, and thus the body is exposed to a greater loss of heat. It is obvious, therefore, that the immoderate use of alcohol must greatly diminish the power of resisting cold.

Is Alcohol at any time desirable?—The injurious effects which follow the too free use of alcoholic drinks have led many men to condemn their use altogether. They certainly ought not to be taken until adult age is reached; and if then, only in very moderate quantities. Under no circumstances should they be given to children; for they not only tend to their present injury, but are apt to lead to a craving for alcohol, which may have the most baneful results in after-life. Women are more susceptible to their influence than men, and should therefore take much less, if any.

On the other hand, however, alcohol is very useful in many forms of disease, and people have been known to be kept alive for a considerable time upon nothing but wine and spirits. But to those in robust health and in the prime of life it may be safely affirmed that it is quite unnecessary.

CHAPTER VIII.—PREPARATION AND PRESERVATION OF FOOD.

Objects of Cookery.—Food, as we have seen, is taken to enable us to do work; to keep our bodies warm; and to maintain the growth and repair of the body. Except among, perhaps, a few "savage" tribes, food is only eaten by man after it has undergone the preparatory process of cooking. The art of cooking forms an important part of our subject on account of its influence on health, and we do not exaggerate when we say that many fatal disorders originate in badly-cooked and ill-assorted foods. It is, therefore, not surprising to find that increased attention is being given to this matter by school-boards and other educational bodies.

The objects we have in view in cooking are as follows:—

1. *To soften,* and to some extent *break up the food,* thereby rendering it more easily digested.

2. *To make the food more palatable.* The appearance of raw meat, for example, is very repulsive to our tastes.

3. *To effect certain changes in the food.* Thus, the connective tissue in meat is changed to gelatin, starch to sugar, &c.

4. *To warm the food.* Warm food is more readily digested, and therefore nourishes the body more quickly, than cold.

5. *To destroy any parasites* which may be present in the raw food, and thus effectually removing some important causes of disease.

The Eight Modes of Cooking.—As so many different kinds of food are called into daily use, and as no one culinary treatment is suitable to all classes of foods, there must be different ways or modes of cooking them. Some of these are best adapted for animal foods, and others for vegetables.

The processes employed in preparing food for digestion are:

1. Roasting.
2. Boiling.
3. Baking.
4. Broiling.
5. Frying.
6. Steaming.
7. Stewing.
8. Soup-making.

In cooking meat by the first six methods our aim is to prevent the juices inside the meat from coming out, and this is done by coagulating the albumen on the surface as quickly as possible; in stewing and soup-making, the meat is put into cold water so that the juices may run out to make the soup or stew all the richer.

Roasting.—When a joint is to be roasted, we must have a clear bright fire to start with, and to secure this the fire must be made up quite an hour before the joint is "put down." We have already learnt that there is a certain proportion of albumen in meat, and that it is coagulated when subjected to heat. Hence if we wish to retain as much as possible the juices of the meat, we should endeavour as quickly as possible to form an envelope or casing of coagulated albumen in the meat. This can be done by placing the meat within a few inches of the fire for ten minutes, after which the meat should be drawn back to about 12 or 15 inches and cooked very slowly. The joint must be kept constantly in motion, to prevent one part being burnt while another is still uncooked, and frequently basted. It is a good plan to place the dripping-pan in front of the fire, with the dripping or lard in it, a quarter of an hour before the meat is put down, and to pour some of the hot fat over the joint immediately it is placed in front of the fire. As a rule, a quarter of an hour should be allowed for every pound of meat in the joint to be roasted, and a quarter of an hour over; should there be much gristle, longer time is required.

During roasting, the heat not only coagulates the albumen, but converts the connective tissue into gelatin, which, by dissolving, loosens the muscular fibres, and thus enables the gastric juice to act more readily upon them. Moreover, a very agreeable odour, due to the formation of a peculiar substance called *osmazome*, is also produced. The loss of weight during cooking varies from 20 to 35 per cent. The loss is chiefly water.

Boiling.—Boiling, like stewing, is a most economical form of cooking. To boil meat, we first plunge the joint into boiling water for five minutes to coagulate the albumen to a depth equal to the thickness of a sixpence. The pot is then put aside in a warm part, where, however, it does not quite boil, but simmers at about 170° F. If the temperature exceeds this point, the muscular fibres shrink, and become hard and indigestible. If no thermometer be at hand to guide us, the proper temperature necessary to cook the meat may be obtained by adding three pints of cold water to every gallon of boiling water after the meat has been in for the first five minutes. Soft water should be used for boiling, or where it cannot be obtained a little preliminary boiling with the addition of a pinch of carbonate of soda will do instead.

Meat should never be soaked in water before cooking, as by so doing we lose some of its salts and nourishing properties. Salted meat, however, must be put into cold water in order to remove the excess of salt. If such meat were put into hot water and boiled it would become tougher than hard-boiled fresh meat.

But no matter how carefully we boil meat, a portion of its juices and salts will escape into the water, and for this reason the water must never be thrown away, but poured into a clean pan or *stock-pot*, for with the addition of vegetables, &c., it will make good soup on a future day. The boiling of meat requires the same time as roasting.

Fish should be carefully placed in a fish-kettle, with sufficient cold water to cover them, and then made to boil as quickly as possible. With large fish from six to eight ounces of salt should be added to every gallon of water, and about four ounces for the smaller kinds. Directly the water begins to boil, a scum will be seen rising to the surface. This must be skimmed off at once, as otherwise it will cling to the fish when removed from the kettle, and give to it an unpleasant flavour.

For boiling vegetables, the following points should be attended to:—

1. Carefully trim them, by cutting off decayed leaves or any injured parts.
2. Wash all green vegetables, except peas and beans, in salt water, to remove any slugs, caterpillars, &c.
3. Boil in soft water, or in water to which carbonate of soda has been added.

Potatoes are best cooked with their skins on, except when baked under meat, because there is a layer of nitrogenous material underneath the skin, and this is lost if they are peeled before boiling. Peas and beans are also better boiled in their pods. Haricot beans should be soaked in cold water over-night.

Baking.—Meat baked in the ovens of the old-fashioned open fire-grates has a decidedly different flavour to that roasted in front of the fire. This is due to the fact that the vapours arising from the baking meat cannot escape, but are burnt on the heated sides of the oven and are partly re-absorbed by the meat; whereas in roasting these vapours pass up the chimney immediately. This objection to baking, however, has been entirely overcome by the introduction of ovens fitted with ventilators, whereby a current of air can always be made to pass through them, and thus to carry away the objectionable odours.

The meat to be baked should be put on a small wire table in the baking dish to keep the meat from getting sodden, and then placed in a very hot oven in order to rapidly coagulate the albumen at the surface.

Baking, however, is more convenient for pastry, or batter puddings and potatoes when put under the meat. This mode of cooking is also adopted in jugging hare, making beef-tea, gravies, &c. From the annexed table will be seen the loss in weight which meat undergoes by the three methods of cooking just described:—

4 lbs. of beef lose by boiling, 1 lb.; baking, 1¼ lbs.; roasting, 1¼ lbs.
4 lbs. of mutton „ „ 14 oz.; „ 1¼ „ „ 1 lb. 6 oz.

Broiling.—Broiling or grilling is roasting on a small scale on the top of the fire. It is a process which requires considerable practice to perform well. The chops or steaks must be placed on a clean *hot* gridiron over a bright smokeless fire, and turned every two minutes. Care must be taken, in turning them over, not to burst the casing of the albumen, for then the juice of the meat would run out. For this reason a fork or skewer must not be used. Steak-tongs may be employed for the purpose, or failing these the blades of two table-knives are good substitutes. It is advisable to use a fluted gridiron, for we are thereby enabled to catch a little of the melted fat.

Frying.—As generally practised in this country, frying is of two kinds, which we may describe as *wet* and *dry* frying. In the former method the food to be fried is completely covered with *hot*, but not, as is often wrongly stated, *boiling* fat. The temperature at which fat will brown food well is 350°; but that at which it boils is about 600°, a sufficient degree of heat to burn any food placed in it. In the absence of a thermometer the best way to find out whether the fat is at the proper temperature is to throw into it a piece of bread; if the latter becomes nicely browned in rather less than a minute, the fat is at the right heat.

Having dried the fish and dredged it with flour, or dipped it in a beat-up egg and afterwards in bread crumbs, it is then put into the hot frying-basket and plunged into the heated fat, and allowed to brown for five minutes. With meat, the pan should be taken off the fire and stood on the hob until it is thoroughly cooked, which may be in about ten minutes, according to the size of the piece.

In the second mode of frying, only sufficient dripping or lard is used to keep the food from sticking to the pan and getting burnt. This method is adopted with all those foods containing much fat, as sausages, &c.

Of the eight modes, frying is about the worst. If performed at too high a temperature the fibres are made dense and tough, and the fat is decomposed into empyreumatic and other offensive acids which are difficult of digestion, and particularly irritable to weak stomachs.

Steaming.—Potatoes, especially some varieties, are much better steamed than boiled. It should be borne in mind that raw potatoes contain a peculiar nauseous substance which is in great part destroyed or dissipated in cooking; a portion, however, remains in the water, and for this reason such water should never be used for stock. The same thing occurs in steaming; hence no other food should be cooked in the sauce-pan underneath the steamer.

Stewing.—Stewing is the most economical way of cooking, for by its use nothing of the food is lost or wasted, and as very little fire is wanted for stewing there is a saving of fuel. Moreover waste is prevented, because every bit of food, be it coarse or dry pieces of meat, gristle, bone, or the trimmings of the best joints, can in this way be utilized.

The object of stewing is to extract the goodness or nutriment from the food. For this purpose the meat, cut up into convenient pieces and seasoned, is put into a stew-pan and barely covered with *cold* water. The stew-pan is then covered closely, and placed where it will get gradually warm but never boil. The best stews are those done slowly at a low heat.

When the fibres are a little tough, as in the meat from a beast recently killed, it is a good plan to add a little vinegar to the meat in the stew-pan. This loosens and softens the fibres, thus making the meat more digestible.

Bones, containing as they do considerable gelatin, should be broken into small pieces and stewed in a Papin's digester, the liquor being used as stock for soup.

Soup-making.—Like stews, soups are both nourishing and wholesome, and may be prepared economically. Soups can be made either from fresh meat, or the liquor, called *stock*, in which a joint has been boiled, with the addition of vegetables and the odds and ends of any food left from previous meals. A stock-pot should be kept in every home for saving such scraps of food.

When soup is made from fresh meat—beef is the best—the meat should be cut into small pieces and allowed to simmer over a gentle fire, the scum being removed as it rises. Vegetables, such as carrots, parsnips, and celery, are then added, and the cooking continued until the latter are tender.

Preservation of Food.—All kinds of food when left exposed to the air soon begin to decompose and putrefy. This arises chiefly from the action of aerial germs, which rapidly multiply when allowed to come in contact with the food. To avoid this, various methods of *preserving* have been introduced, the principal of which are: (1) drying or desiccation; (2) the application of great cold (refrigeration); (3) the addition of chemical agents (antiseptics); and (4) by heat and air-tight cases.

It is by the latter method that the large quantities of meat and fish, which we get from Australia and America, are preserved. This process, known as *tinning* or *canning*, consists in filling tin cans with the meat and then hermetically sealing them.

"It requires no argument to show that the preservation of food is a matter of great public importance, for it not only enables us to provide against actual wants in periods of unusual scarcity, but it also affords the means of equalizing the distribution of food at all times, so that the excess of one country may be used in supplying the deficiency of another" (Letheby).

CHAPTER IX.—COOKING APPARATUS.

The Materials employed for Kitchen Utensils.—The principal materials used in the construction of kitchen utensils are metal, glass, and pottery-ware. For some purposes metallic utensils are quite unsuited, owing to their injurious effects upon the food and the consequent influence on health. Of the metals employed, silver is undoubtedly one of the best, as being the least acted upon by any of the food-stuffs. The cost of the metal, however, excludes the use of silver vessels in most homes; but where preserves are made on a large scale they might profitably be used.

Utensils made of copper or brass ought to be lined with tin to protect them from the action of vinegar or the acids of fruit. When left in contact with vinegar, copper forms a highly poisonous substance called *verdigris;* hence great care should be taken to prevent accidents. Tin is too soft to be used by itself. What are commonly called tin vessels are really made of sheet-iron, and simply coated with tin to prevent the iron rusting. Lastly, but certainly not the least important, comes iron. This is one of the safest materials employed. Rusting, perhaps, is its only objectionable feature, and iron vessels will therefore require more cleaning.

Glass vessels are of great use for storing preserves, pickles, dried herbs, &c. Stew-jars and other earthenware utensils require to be well glazed, as otherwise acids and oily substances are sure to penetrate them, and will then impart their flavour to anything put in them afterwards.

Cooking Apparatus.—In order that food may be properly prepared, every kitchen should be supplied with the requisite apparatus suitable to the various modes of cooking. Cooking apparatus may be divided into *cooking ranges* and *kitchen utensils.* The ranges may be the open-fire range, the closed range or kitchener, stoves to burn coal, coke, or charcoal, and gas-stoves.

Open-fire Grates.—Open-fire grates are much more extensively used in this than in any other country. This is due to their more cheerful appearance and the important part they play in ventilation. Against these advantages it must be mentioned that they consume an inordinately large amount of fuel, and in these days of dear coals this is an important consideration. At the lowest estimate, seven-eighths of the heat generated in open-fire grates passes uselessly up the chimney. Moreover, they are the cause of considerable dust and smoke, as well as inconvenience in cooking. How often has the temper of the housewife been sorely tried by the upsetting of a saucepan upon the fire. Still, many prefer these open ranges because meat can be roasted in front of the fire, a mode of cooking held dear by the English.

Closed Ranges or Kitcheners.—When properly attended to, there can be no doubt as to the superiority from every point of view of the closed ranges over the open ones. They are more economical and decidedly cleaner. A large number of dishes can be cooked at the same time, and the sauce-pans do not get a thick coating of soot as when used over an ordinary fire. An important feature of closed ranges is their usually large ovens, which, when well constructed, will bake a joint of meat in such a manner that even the most sensitive palate will fail to detect the difference between it and one roasted before the fire.

Many ranges are also fitted with boilers, so that hot water may be had when wanted. Boilers should always be filled before the fire is lighted, and afterwards never quite emptied for fear of their cracking when cold water is poured in. A plate-rack over the range is also very useful for warming the dishes and plates previous to being sent to the table.

The flues should be swept out every morning when the grate is cleaned.

Cooking Stoves.—Cooking stoves of various kinds are now coming into very general use on account of the increased price of coals. In some of these, attempts have been made to combine the cheerfulness of the open grate with the advantages of the closed range. The American cooking stoves are of this description. One great advantage with these stoves is that they require very little setting in the chimney-opening. They usually comprise a large-sized oven and a hot plate, heated by means of a small anthracite fire.

Gas-stoves.—Coal-gas has long been used as an illuminant of our dwellings, but of late years it has also been employed for cooking purposes, and with marked success. The better class of gas cooking stoves are made of enamelled steel, as in the "Eureka," which not only renders them more durable, but also very cleanly, as they can be wiped down with a wet cloth, and made absolutely clean every day. To enable the oven to be still further cleaned, the shelf-slides, instead of being riveted to the sides of the oven, are arranged on loose frames which swing out, so that there are no crevices in which grease or dirt can lodge.

On the top of the stoves are properly constructed hot-plates, heated from beneath by several burners arranged in ring form, and many are also fitted with a special arrangement for grilling. They can be provided with a movable boiler when desired.

Whenever these stoves are employed they must not stand out in the room, as is now too frequently the case; they should be fitted into an ordinary grate recess, so that all the products of combustion may escape up the chimney.

Cooking Utensils.—A great variety of cooking utensils are now employed to lessen the labours of the cook; but as many of these are to a great extent unnecessary, only the more important will be described. It scarcely need be pointed out that all cooking utensils should be kept scrupulously clean, and should never be put away dirty.

Dripping-pan and Basting-ladle.—During roasting, a dripping-pan must be placed under the joint to catch the melted fat which drops from it. Some dripping-pans are constructed with a well in the centre, into which the fat runs through the holes around it, the object being to free the dripping from any ashes that may fall into the pan. The basting-ladle should have a long handle, and should be half-covered with metal gauze, so that if any ashes should get into the fat, they will be prevented from being poured upon the meat.

As it is necessary that the joint should be constantly turning whilst it is before the fire, a contrivance called a *bottle-jack* is commonly used. More frequently a hank of worsted and a meat-hook are employed. This plan necessitates constant watching, so as to give the worsted a turn when the revolving slackens. All draughts must be excluded from the meat, and for this purpose we employ a screen of some sort. It may be made of bright metal, when it is commonly called a *hastener;* but an excellent substitute is a small clothes-horse placed around the fire, with the household linen requiring to be aired spread upon it.

Sauce-pans are employed for boiling and stewing. They are made either of tinned copper, iron with or without a lining of tin or enamel, and tin. The enamelled iron sauce-pans are very good, and with care may last for years. Those lined with tin must be used with care. Food should not be allowed to stand in them for long, as the tinning frequently contains lead; and moreover, unless they are kept well filled when upon the fire the tin is apt to melt and run to the bottom. Tin saucepans are very useful, and though not so durable as iron ones, are more easily mended.

Baking dishes are generally made of earthenware. For baking fruit-pies those made with a flange inwards as well as outwards are very useful, as they prevent the syrup from boiling over. Many cooks prefer those made of iron, enamelled on the inside, on account of their durability.

Frying-pans are either deep or shallow. Deep frying-pans are used principally for cooking fish, and for this reason are called "fish fryers." They are generally fitted with a wire basket, so that the fish may be removed when done without much fear of its being broken.

The *gridiron* is an important article in the list of kitchen utensils, and, when properly used, is an excellent means of cooking chops and steaks, &c. The gutter gridirons, or those made with fluted bars, are the best, as much of the fat which would otherwise fall in the fire is saved. It is advisable to keep two gridirons, one for chops and steaks and the other for fish.

For broiling in the front of the fire, a *Dutch oven* is employed.

A *digester* is a valuable utensil in a house. It is a kind of iron sauce-pan, made with a closely-fitting lid which can be fastened to the body of the sauce-pan, to prevent the too great escape of steam, so that substances may be boiled under pressure. To guard against accident, the lid is supplied with a safety-valve.

CHAPTER X.—WATER.

Necessity for Water.—Scarcely a day passes but that we are forcibly reminded of the inestimable value of water, and we have only to picture a day at home without it to fully realize its importance. It is required not only for drinking, but for cooking, cleansing, and other domestic purposes; it is employed in all the manufactures; in towns for flushing sewers, cleansing streets, extinguishing fires, and other public purposes; and is a ready means of communication between different countries. Of the many blessings bestowed on man, water is one of the greatest.

Composition and Properties of Water.—The chemical composition of water was first discovered in 1781 by Henry Cavendish, who found that the union of two volumes of hydrogen with one of oxygen resulted in the formation of water. Since then numerous careful experiments have been conducted by many eminent chemists, and the results have fully confirmed Cavendish's discovery.

Water is very widely diffused. It forms about three-quarters of the total weight of all animals and plants; it is always present in the air; and covers at least three-fourths of the entire surface of the world.

When pure it is inodorous, tasteless, transparent, and colourless, except when viewed in large quantities, when it appears of a beautiful blue colour. Water is the greatest solvent known, and for this reason is never found chemically pure in nature.

Hard and Soft Water.—The water employed for domestic purposes is described as "hard" or "soft," according to the difficulty or otherwise of producing a lather with soap. The hardness is due to the presence of mineral matters in solution, and the softest water is the one which contains the least quantity of these salts.

In its descent through the air, the rain absorbs a quantity of carbonic acid gas, and this carbonated rain-water, as it percolates through the rocks, has the power of dissolving certain mineral constituents, of which carbonate of lime is the chief. But as this carbonate of lime is easily removed by boiling, the hardness of such water is said to be *temporary*. Water, however, which contains sulphate of lime in solution is called *permanently* hard; since the calcium salt cannot be got rid of without employing other equally objectionable substances.

Although the drinking of moderately hard water is not injurious to health, it is certainly not so useful for many household purposes. Green vegetables do not keep their colour when boiled in hard water, and tea is not so good when made with it. The quantity of soap required to wash clothes in hard water is much greater than when soft is used; and the harder the water, the more soap it will take. It is said that half the soap manufactured in England is wasted annually through using hard water.

Sources of Water:

1. *Rain-water.*—The rain is an important source of our water supply. It is very soft—too soft, indeed, to be palatable. In country places where there are very few houses, it is generally very pure; but in or near large towns, on the contrary, it is contaminated by the impurities which it washes out of the air, and is decidedly unfit to drink.

2. *Springs.*—When rain-water falls to the ground, a portion of it sinks into the soil until it reaches some impervious stratum, as clay, through which it cannot pass. Here it may collect in pools, but as is more frequently the case, will run along the top of this stratum, for it is rarely

we find strata perfectly horizontal, and sooner or later will issue as a spring at the surface of the ground. Such springs are very common in hilly districts, and the supply of water depends directly upon the rainfall. In its passage through the rocks the rain dissolves various mineral matters, especially carbonate of lime. In fact some springs, as at Matlock for example, are so highly impregnated with calcium carbonate that they become petrifying waters. As a rule spring-water, although hard, is an excellent drinking water.

3. *Surface Wells.*—Surface wells are those which only extend to a depth of twenty feet or so, and consequently collect the water which has only passed through a few feet of soil. Although such water is usually very clear, it must always be regarded with suspicion, for it is so liable to be contaminated with sewage.

In country places it is a common thing to find a cesspool in close proximity to the well, and unless the former has been rendered thoroughly water-tight, some of its contents are sure to find their way into it. Well-water is usually hard, from the same cause as spring-water.

4. *Artesian Wells.*—These wells have derived their name from the town of Artois in France, where they have been so long employed. An ordinary surface well is first made and then lined with brickwork, thoroughly set in cement, to prevent the subsoil water percolating into it. Borings are then made from the bottom through the rocks until a water-bearing stratum is tapped, when the water rushes up the bore-hole with varying force into the surface well.

There are many such wells in the neighbourhood of London, some of which penetrate the chalk to a great depth. Their supply of water is derived from the rain which falls upon the chalk hills north and south of London.

Many Artesian wells are over 1000 feet in depth. There is one at Grenelle, near Paris, 1800 feet deep, and another at Kissingen 1878 feet. The character of the water from such wells varies considerably. As a rule it is sparkling and pleasant to drink from the excess of carbonic acid gas which it contains; on the other hand, it may be so highly charged with saline matters as to be undrinkable. The water from the well at Grenelle is quite alkaline from the presence of the carbonates of sodium and potassium.

5. *Rivers and Lakes.*—Rivers and lakes, when not polluted with the sewage of towns, yield an excellent supply of water. In the upper courses of rivers, the water as a rule is very wholesome and pleasant, but inasmuch as many rivers are the means of carrying away the refuse of the towns and factories upon their banks, the water in their lower courses ought not be used for drinking purposes. Of lake-water that obtained from mountain lakes with free outlets is usually of an excellent quality; and that of Loch Katrine in Scotland, with which Glasgow is supplied, of Bala in Wales, and Thirlmere, afford good illustrations. The comparative merits of the various kinds of water will be seen from their classification as given in the sixth report of the Rivers Pollution Commissioners.

Wholesome	1. Spring water.	Very palatable.
	2. Deep well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious	4. Stored rain water.	
	5. Surface water from cultivated lands.	Palatable.
Dangerous	6. River water to which sewage gains access.	
	7. Shallow well water.	

Quantity of Water required.—It has been estimated that an average-sized man loses by means of the lungs, skin, and kidneys about 80 ounces of water every twenty-four hours; and as this loss has to be made good, it follows that about four pints must be taken daily. Of this quantity about one pint is obtained from the solid food we eat, the remaining three pints being taken as drink. To this we must add the water required for cooking, washing, and other domestic purposes, as well as that for horses, street watering, flushing of sewers, manufactories, &c. Expressing the total daily amount for all purposes in gallons per head of the population we have:—

	Gallons.
Domestic supply,…	12
For general baths,…	4
Water-closets,…	6
Unavoidable waste,…	3
Total house supply,…	25
Town and trade purposes (including animals) in non-manufacturing towns,…	5
For manufacturing towns,…	5
	35

In hospitals an allowance of at least 40 to 50 gallons per inmate should be made, on account of the greater amount used for washing and bathing.

Storage of Water.—In rural districts the supply of water is chiefly obtained from wells and springs. A good coping should be built around the mouth of a well to prevent any contamination from surface washings during rain, and where there is much subsoil soaking the well should be lined with brickwork set in cement to stop the flow.

In large towns the supply from wells alone is inadequate; and it therefore becomes necessary to provide receptacles sufficiently large in which enough water may be stored to last the inhabitants for several months. This provision is frequently undertaken by private companies; but in some towns, as Manchester and Birmingham, it is managed by the corporation. For collecting and storing water an artificial lake or reservoir is constructed as near the town as possible, and at such an elevation, whenever practicable, that the water may be distributed to the houses by gravitation. Where this cannot be accomplished, the water must be pumped from the collecting reservoir into tanks at a higher level, from which the water is afterwards sent to the various parts of the town.

In hilly or mountainous districts the reservoirs are made by simply constructing a dam across the valley or ravine through which a river flows; the water then collects in the upper part. Such reservoirs may be made to hold twice as much by cutting down the sides perpendicularly. All reservoirs should be large enough to hold sufficient water to supply a town for two or three months. Their embankments should be of great strength and perfectly water-tight, and should, as far as possible, be covered in and ventilated.

From the collecting reservoir the water passes either directly into the service-pipes, or else at first into smaller reservoirs called *service-reservoirs*, and then into the service-pipes. Service-reservoirs should always be covered in, and large enough to hold a few days' supply.

Cisterns.—In those towns where the houses are only supplied with water for a few hours daily, it is necessary to store sufficient water for household purposes in water-tanks or cisterns. These are made either of stone, slate, galvanized iron, lead, zinc, or brick lined with cement. Of these, galvanized iron is considered by some the best material for cisterns. Slate is certainly very good, but unless the junctions are set in good cement, they are apt to leak. Lead is objectionable on account of the solvent action of water on it; but when it is employed it should not be disturbed for fear of displacing the crust of carbonate of lead which forms upon it in time, and which protects the lead beneath from the further action of the water.

In all cases where cisterns are in use they should be easy of access, so that they may be easily cleaned out from time to time. They should be covered with a well-fitting lid, and so arranged with regard to closets that no gases can pass into the water. For this reason the overflow pipe should not pass directly into any part of the water-closet apparatus, but should always be made to deliver into the open air. On no account ought the water for drinking purposes to be obtained from the same cistern which flushes the water-closets.

Delivery of Water.—The water which has been collected in the reservoirs is brought to the town by main pipes made of cast-iron, from which it is carried to the houses by leaden pipes. The supply of water to houses may be on one of two systems, *constant* or *intermittent.* In the constant service the main pipes and their branches are always full of water, so that a supply can be obtained at any time from the tap within the house. By the intermittent service the water is only turned on for a few hours once or twice a day. Of these systems the constant service is by far the preferable. With this system there is no necessity for storing water in cisterns, except for water-closets, and for the supply of kitchen boilers; and in cases of fire a ready supply of water is always at hand. Moreover the pipes last longer, as they are not so liable to rust as when they are sometimes filled with water and sometimes with air.

The objections to the intermittent system are (1) that it necessitates the use of cisterns, water-butts, &c., to store water in; and these, unless frequently cleaned out, are apt to get foul. (2) Their overflow-pipes frequently communicate with the drain or some part of the sewerage arrangements. (3) The foul air and water from the soil or defective drains are liable to find their way into the pipes in the intervals when they are not filled with water. (4) In cases of fire, a supply of water cannot be obtained until the turncock arrives. (5) It is not conducive to cleanliness on account of the supply being limited.

CHAPTER XI.—WATER (*Continued*).

Impurities in Water:

1. *Gases dissolved in Water.*—Of the gases dissolved in water, the oxygen and nitrogen obtained from the atmosphere are the chief. Since oxygen is the more soluble of the two, it is found dissolved in a greater proportion in water than in air, the proportion of the nitrogen to the oxygen being as 1·87 is to 1. Carbonic acid gas is also present, and very frequently in considerable quan-

tities. Its presence is largely due to the oxidation of organic matter, and it is on this account that the water from churchyards is so often clear and sparkling.

These gases as a rule can scarcely be regarded as impurities, for without them water is tasteless and insipid. This can be easily proved by tasting water which has been boiled and allowed to cool. During the boiling the dissolved air is expelled.

Where water is contaminated by sewage, the amount of oxygen is likely to be less on account of some of it being used in oxidizing the organic matter. Unless the reservoirs are covered in when near manufacturing towns, sulphurous acid gas and other vapours evolved from the processes that are carried on will also be found in the water.

Sewer gas will also find its way into water, as, for example, when the overflow-pipe of a cistern communicates with the soil-pipe.

2. *Mineral Impurities.*—The mineral impurities are derived from the soil through which the water passes, and hence their nature will depend to a large extent upon the geological formation of the district. Of the mineral impurities carbonate of lime is of most frequent occurrence, the sulphate of lime coming next. A moderate quantity of the former salt is certainly not injurious to health; but the latter, together with its nitrate and chloride, as well as the sulphate and chloride of magnesium, are liable to produce diarrhœa in those who drink water containing them.

Common salt (chloride of sodium) is also found in ordinary water, but as a rule in very small quantities. Sometimes it is found in much larger quantities, as in the case of water drawn from wells near the sea-coast, or in the neighbourhood of salt-bearing rocks. With these exceptions, water which contains beyond the merest trace of salt must be regarded with suspicion, as it indicates a probable pollution of the water from an admixture of sewage.

Nitrates, especially the nitrate of ammonia, and nitrites are invariably found in very small quantities in all natural waters. Whenever present they must be viewed with suspicion, as they are frequently derived from the oxidation of the nitrogenous matters of sewage. Hence, although sewage may be poured into a river, the water taken from a point considerably lower down in its course may be found to contain only nitrates and nitrites, owing to the oxidation which has taken place. Thus their presence usually points to a previous contamination. In fact, it has been suggested that their amount should be taken as indicative of the quantity of impurity which has gained access to the water. But it must be borne in mind that the water from many deep wells, although not contaminated by sewage, contains considerable quantities of nitrates, and the value of such a test is therefore greatly diminished.

Of the metallic impurities present in water, iron and lead are the principal. Iron gives an inky or chalybeate flavour to the water, and although harmless in small quantities, still the use of such water is objectionable; tea made with it is generally very dark and even black. Lead is generally derived from the cisterns in which the water is stored, or the pipes through which it flows. The more highly oxygenated and purer waters, as well as those containing organic matters, act most rapidly on lead. The carbonic acid contained in hard waters forms a comparatively insoluble lining of carbonate of lead on the inside of pipes, and thus protects the lead beneath from any further action of the water. Water, however, containing a great excess of free carbonic acid gas may dissolve this.

3. *Organic Impurities.*—Important as the preceding impurities undoubtedly are, they are as nothing when compared with those which are termed "organic." For although it cannot be said that hard waters have a marked effect upon health, yet it is universally admitted that water containing organic matter, especially if it is of animal origin, is particularly injurious to health.

The organic impurities may be of vegetable or of animal origin, and may be either dissolved in the water, or suspended in it, that is, floating about.

Vegetable organic matter often lends a brownish colour to the water, as seen in the water from moorlands; and although it may have an unpleasant taste, yet from this cause alone there need be no alarm when such impurities do not exceed two grains per gallon. A greater amount may lead to diarrhœa or ague.

It is the animal organic impurities which render water unfit to drink. They are derived from sewage, and find their way into the water by soaking through the soil from cesspools, sewers, privies, pig-sties, and manure heaps; or else are washed into the water during heavy rains. Moreover, sewage is frequently poured directly into rivers; and cases have come to light where it has been even poured into a well from which the drinking water was obtained, the well thus having to perform a double duty.

The organic matter of animal origin is generally nitrogenous, that is, one of its constituents is nitrogen. In fact this element may be found in water in four different ways. 1. As *free gas*, derived from the atmosphere by solution. 2. As *nitrates* and *nitrites*, representing the completely oxidized organic matters. 3. In combination with hydrogen, as *ammonia*, pointing to sewage contamination. 4. In combination with carbon, hydrogen, and oxygen as *unchanged organic matter*.

The presence of ammonia in water is always suspicious, and almost certainly indicates a pollution by sewage. Whenever it is found in excess, it is highly probable that urinary contamination has occurred; for *urea* (CON_2H_4), one of the chief constituents of urine, is readily converted by a process of fermentation into carbonate of ammonia. If common salt were also present such a suspicion would be further confirmed.

Reference has already been made to the oxidation of the nitrogenous matters of sewage in water, and their conversion into nitrates and nitrites, but where this change has not taken place, the water is totally unfit for domestic purposes, as the *unchanged organic matter* is especially dangerous. Various methods have been devised for estimating the quantity of such matter in water, as, for example, by determining the amount of ammonia it would yield when submitted to chemical treatment. The ammonia obtained in this way has been called for convenience *albuminoid ammonia*, because albumin and other nitrogenous bodies of the same class are productive of ammonia when similarly acted upon.

But what is to be most dreaded is the use of water contaminated with sewage in which the germs of certain diseases, like cholera and typhoid fever, may exist. It is now believed on all hands that the various infectious diseases are propagated by minute organisms called *bacteria*. When introduced into the system these bacteria rapidly multiply, and are always found in the excreta of the sick. So that, should the sewage containing such excreta find its way into drinking-water, then those persons who partake of it will in turn be stricken down with the same.

Sources of Impurities.—The impurities found in water are classified according to their origin, thus:

1. *Those derived at the source.* These will depend upon the geological character of the strata through which the water has passed, together with the proximity of highly cultivated and manured lands, churchyards, &c.

2. *Impurities received in transit from source to reservoir.* These have been divided into "sewage" and "manufacturing;" the former including all solid and liquid excreta, waste water, and all the impurities of dwellings, the latter including the refuse of factories.

3. *Impurities of storage.* Surface wells may receive the surface washings and soakings of the soil. Uncovered cisterns are exposed to dust, and when near water-closets may absorb sewer-gas. Metallic salts may be also dissolved from the sides of the cisterns.

4. *Impurities of distribution.* Lead and iron may be dissolved from the pipes through which the water flows. Sewer-gas, and coal-gas from leaky pipes, may be drawn into the water-pipes.

Impure Water as a Cause of Disease.

I. *Effects of Mineral Impurities.*—Diarrhœa is occasionally produced by drinking water containing suspended mineral matters. This is shown in the hill diarrhœa of certain parts of India, which is due to the presence of fine scales of mica suspended in the water.

Although it has never been proved beyond doubt that hard water containing only a moderate amount of mineral matter is unwholesome, still it is held by many that the habitual use of excessively hard water may lead to complications. Calculus has long been supposed to be the result of drinking lime-waters; but the evidence on this point is not conclusive. Water containing magnesian salts is said to be the cause of the swelling of the thyroid gland in the throat known as "goitre;" but here again the evidence is contradictory. For although it does prevail in some magnesian limestone districts, yet in other similar districts it is quite unknown, while cases of goitre have occurred where this formation is absent. Recent researches seem to point to iron pyrites as being the cause of it.

II. *Effects of Organic Impurities.*—Although the chemist may be able to estimate the amount of organic matter present in water, still he is unable by any special test to disclose its real nature, and to say whether it will act as a fever or a cholera poison; and "since at the present time we cannot differentiate between those excrementitious matters which cause disease, and those which do not, it is clearly safest to condemn as a supply a liquid which has been proved to be contaminated by a something, which, for aught we know, contains the seed of typhoid fever or of cholera" (Blyth).

It was first pointed out by Dr. Snow in 1849 that cholera poison could be distributed by drinking-water, and from the various outbreaks which have occurred since then, sufficient evidence has been obtained which puts the question beyond the region of doubt. Thus, in 1854 the mortality from cholera was very high in the southern districts of London. The inhabitants were supplied with water by two rival companies; the one deriving its water from Thames Ditton, and the other from the Thames at Battersea. The result was, that in 26,000 houses supplied with comparatively pure water by the Lambeth Company, the deaths amounted to 294; whilst in 40,000 houses supplied with foul Thames water by the Southwark Company, the deaths were 2284. Now these houses were in the same district, often side by side, and therefore very similar in other respects; yet in those receiving the purer water of Thames Ditton, the death-rate from cholera was only 3·7 per thousand, whereas in the others it was as much as 13 per thousand.

When the cholera visited Glasgow in 1832, and again in 1854, the inhabitants were supplied with impure water from the Clyde, and the number of deaths from cholera in these years was 2842 and 3886 respectively. By the time the next outbreak occurred, in 1866, a pure supply of water had been obtained from Loch Katrine, but this time the number of cholera deaths was only 68.

With typhoid fever, the evidence is equally conclusive, and it has been said on good authority that in 80 cases out of every 100 typhoid fever is the result of drinking polluted water. For many years this fever was very prevalent in the convict prison of Millbank. Prior to the year 1854 the water supply of the establishment was derived from the Thames, and during this time the death-rate was terrible, being in 1849 as much as 82 per 1000. In the August of 1854 the Thames water was abandoned, and a new supply was obtained from an Artesian well. At once the health of the convicts began to improve in a remarkable manner, and at last the disease entirely disappeared from within its walls. This is not a solitary case, but only one of many others that could be given.

Malarious fevers were formerly believed to be solely due to breathing the air of marshes; but from recent inquiries it appears that they may be propagated also by drinking marsh waters. With regard to the production of diphtheria and scarlet fever by drinking-water, there are a few cases on record which have been attributed to the use of foul water, but at present the evidence is not quite of a positive character.

Occasionally the eggs of several kinds of intestinal worms, and even small leeches, are swallowed, and have been known to lead to serious results.

Microscopic Examination of Water.—Among the suspended organic matters in water, there are always many small plants and animals. Considerable light has been thrown upon the nature of these micro-organisms by the labours of Koch, Pasteur, Frankland, and others. They belong to a great variety of species, and include many kinds of *infusoria*, *diatoms*, *desmids*, *bacteria*, and animals of the worm family. From the numerous investigations which have been made, it appears that whilst the surface waters, such as rivers, abound in microbial life, the water of springs and deep wells which has undergone filtration through the soil is remarkably free. It is therefore obvious that the water in its descent through porous strata is deprived to a large extent of those organisms which it had at the surface.

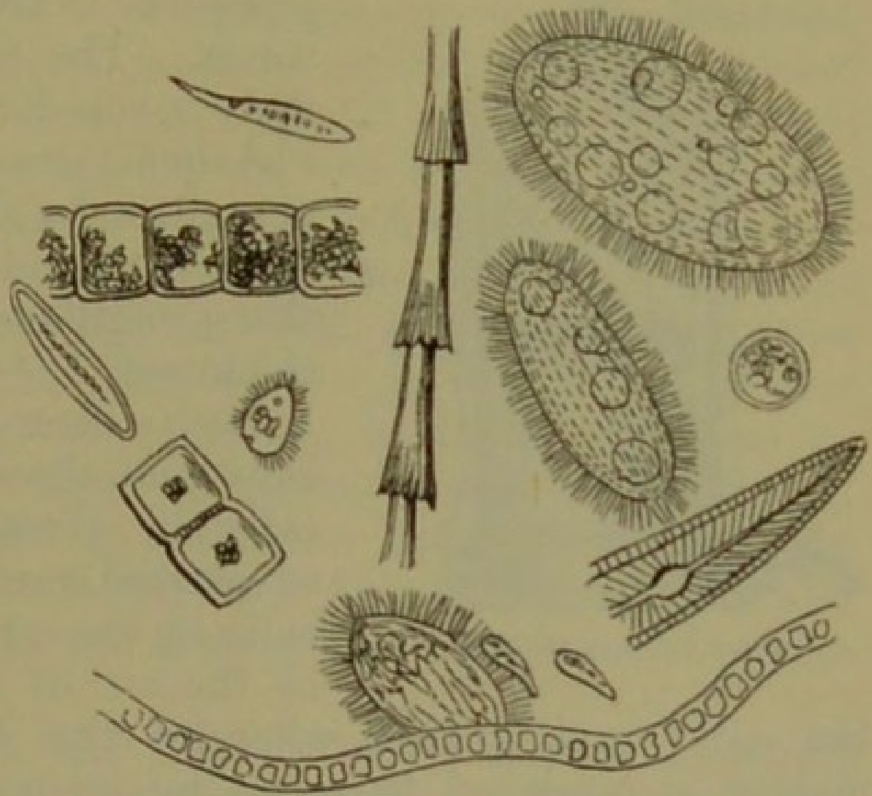

Fig. 5.—Some Animal and Vegetable Structures found in a Drop of Thames Water.

The Purification of Water.—When the water-supply of a district is obtained by pumping from deep wells, no filtration is necessary before discharging it into the service-reservoirs; but when the supply is derived from rivers, mountain streams, or gathering-grounds, steps must be taken to free it of those suspended materials which are invariably present. Usually this purification is accomplished by first collecting the water in settling reservoirs where the more bulky materials subside, and then passing it through filter-beds consisting of sand and gravel. Each filter-bed is a kind of tank or reservoir, on the paved bottom of which are placed a series of perforated pipes for conveying away the water. The pipes are immediately covered with small stones, and then comes a layer of coarse gravel to the thickness of about three feet, and finally a layer of sharp angular sand two feet in thickness.

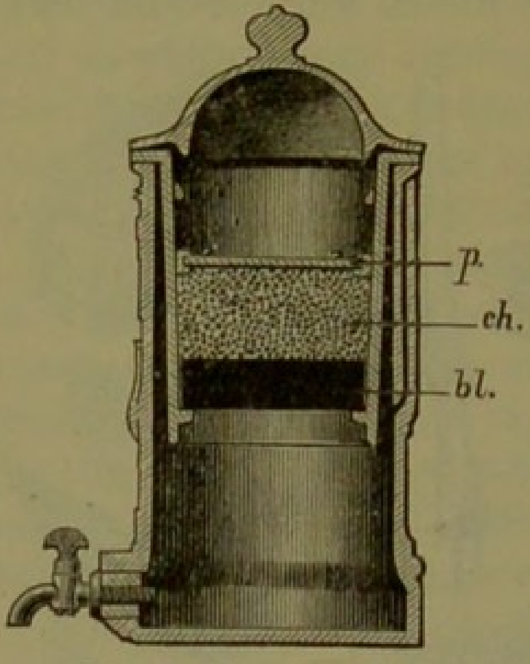

Fig. 6.—Cleansible Filter.

Such a filter-bed acts mechanically and chemically—mechanically by arresting the various suspended matters, and chemically by the action of the oxygen of the air in the interstices of the sand and gravel, whereby the dissolved organic matter is rendered harmless by its conversion into nitrates and carbonates. In order, however, that each filter-bed may have its maximum effect the water must be admitted slowly and uniformly, and should never be permitted to exceed a depth of two feet. Each square foot of such a filter-bed allows about 75 gallons of water to pass in twenty-four hours. The clogging which naturally ensues after the filter-bed has been at work for a time necessitates a periodical cleansing. This is effected by scraping away the surface sand with its sediment to a depth of about half an inch. When, by such removals, the efficiency of the filter is likely to be affected, fresh sand is added until the original thickness of the bed is restored. In all large water-works there are several filter-beds, so that their thorough cleansing and aeration are easily achieved.

Domestic Filters.—These are employed for filtering water on a small scale; but too much reliance must not be placed upon them. In fact, it may be said that in all our large urban centres, as Glasgow, Liverpool, Birmingham, &c., where the public are supplied with excellent potable waters, there is no necessity for any further filtering. Until recent years, the principal filtering medium employed in domestic filters was *animal charcoal*, or a combination of that material with other substances, such as *carbo-calcis* (a mixture of animal charcoal and lime), *carferal* (a mixture of charcoal and iron), or *silicated carbon* (a mixture of carbon and silica). One of the older forms of charcoal filters is shown in Fig. 6. The filtering-media consist of a block of carbon (*bl*) and a layer of granulated charcoal (*ch*), the whole being kept in position by a porous earthenware plate (*p*). As to the value of animal charcoal as a filtering medium, there can be no doubt, in the light of recent experiments, that it stands condemned. It has been proved beyond question that it acts as a culture bed for micro-organisms, and is therefore useless for destroying the germs of water-borne diseases.

In this country, the more recent experiments which have led to these discoveries have been those conducted by Dr. H. H. Johnston at the Public Health Laboratory, Edinburgh, and by Professor Sims Woodhead (Cambridge) and Dr. Wood for the *British Medical Journal.* Briefly stated, the object of both sets of investigations was to discover to what extent the various filters in common use removed bacteria from water. A sample of water was taken, and after estimating the number of bacteria already existing in each cubic centimetre of the water, a known number of other bacteria were added, and the water placed in the filter. In the course of a day or two some of the filtered water was drawn off and examined; and in every case where charcoal formed the filtering medium it was found that an enormous increase in the number of bacteria had taken place.

A Germ-proof Filter. — The only filter which proved itself germ-proof was that known as the Pasteur-Chamberland Filter. For the purpose of sterilizing water, Pasteur had for some time employed unglazed porcelain; and it occurred to his assistant, M. Chamberland, to use this material for domestic filters. Several different types of the filter are now in the market, of which two are shown in Fig. 7. One of these (A) takes the form of a tap filter. It consists of an outer metallic case (*a*) within which is a cylinder of specially-prepared unglazed porcelain (*b*), and open at its lower end only. The outer case is attached by its upper end to the tap, whilst through the lower end passes a glazed porcelain nozzle which is connected with the cylinder inside. On opening the tap, the water immediately fills the outer case, and, after passing through the porcelain cylinder, leaves by means of the nozzle. B represents another

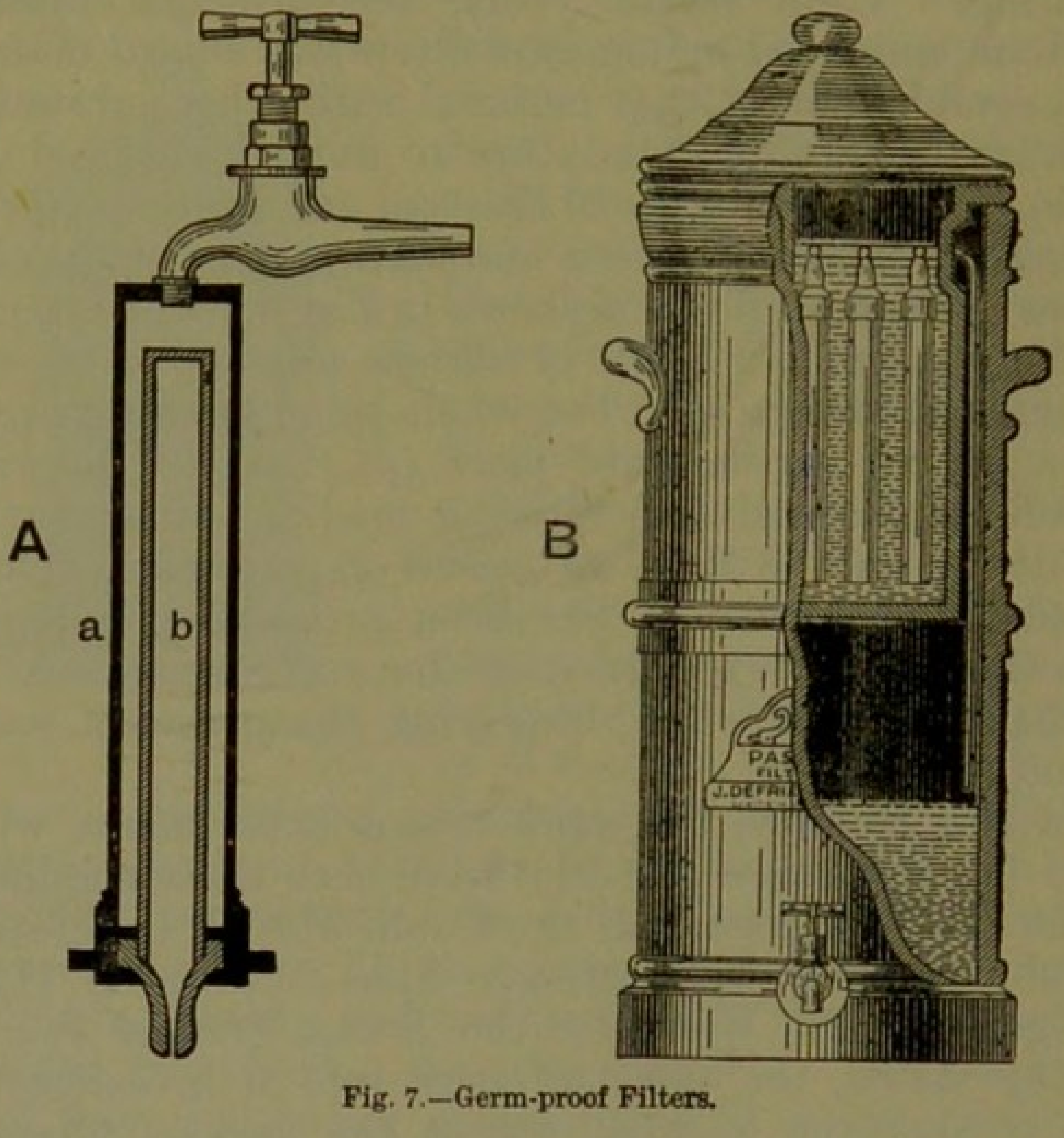

Fig. 7.—Germ-proof Filters.

form of the filter; but as the pressure in this case is only that due to the head of water in the upper chamber, it is necessary to employ a number of filter tubes.

Another type of this class of filter is the Nordtmeyer-Berkefeld. In general appearance it is similar to that of the Pasteur-Chamberland; but the filtering medium consists of hollow rods of a diatomaceous earth known as *Kieselguhr*.

The characteristics of a good filter are:—

1. That every part of the filter shall be easily got at, for the purposes of cleaning and renewing the medium.
2. That the medium have a sufficiently purifying power, and be present in sufficient quantity.
3. That the medium yield nothing to the water that may favour the growth of low forms of life.
4. That the purifying power be reasonably lasting.
5. That there shall be nothing in the construction of the filter that shall be capable of undergoing putrefaction, or of yielding metallic or other impurities to the water.
6. That the filtering material shall not be able to clog, and that the delivery of the water shall be reasonably rapid. (Parkes.)

Boiling.—Boiling is a ready and effectual method of purifying water. This plan not only serves to get rid of the calcium carbonate, which in settling carries down with it any organic matter that may be present, but also expels hydrogen sulphide and other gases which may be dissolved in water. But what is of far greater import is the fact that the germs of water-borne diseases cannot withstand the temperature of boiling-water for five minutes. Hence all suspected water should be boiled before drinking.

Characteristics of Good Water.—A good drinking water should be clear, transparent, sparkling, and very palatable. It should be free from organic matter, thoroughly aerated, and not too hard.

* CHAPTER XII.—THE ATMOSPHERE.

The Necessity for Air.—The necessity for air is clearly shown in cases of drowning, choking, &c., and can be experimentally proved by placing a small animal in a bottle, and then removing the air by an air-pump. In both of these cases a proper supply of pure atmospheric air is prevented, and what is called *asphyxia* comes on, due to the deprivation of oxygen and the accumulation of carbonic acid gas in the blood. Drowsiness and headache are common complaints with people living in overcrowded and stuffy rooms. Death from the deprivation of food is a matter of days; but deprivation of air kills in a few minutes.

Oxygen, moreover, is required to oxidize the various food-stuffs introduced into the body, in order to maintain its proper supply of energy and heat. Although oxygen enters into the composition of most of the foods, its amount is insufficient for their complete combustion. We are therefore compelled to introduce into the body a further quantity of oxygen, and this is accomplished by breathing.

Composition of Air.—The air we breathe completely surrounds our earth, and extends, it is believed, to a height of about two hundred miles. By suitable means it can be proved that the air has weight, and in virtue of this weight exercises a pressure upon all objects on the earth's surface equal to about fifteen pounds on every square inch.

Ordinary air is a mixture, and not a chemical compound, of its constituent gases, nitrogen, oxygen, and carbonic acid gas. In 10,000 parts of such air, 7900 are nitrogen, 2096 oxygen, and only four carbonic acid gas. In addition to these there are minute quantities of ozone, ammonia, and other gases, and variable amounts of water vapour and suspended matters.

Oxygen.—Oxygen is a colourless, transparent, inodorous, and tasteless gas. It is the most abundant of all the elements in nature, forming about 50 per cent of the weight of the earth, and about 21 per cent of the air. Substances which burn in air burn with much greater brilliancy and rapidity in oxygen. All kinds of organic matter when left exposed to the air undergo a process of oxidation, whereby they are reduced into simpler bodies. For this reason oxygen is regarded as a great purifying agent. A very remarkable modification of oxygen is sometimes found in small quantities in the atmosphere. It may be described as condensed oxygen, and is known as *ozone.* It may be produced by passing a series of electric discharges through oxygen; hence its presence in the air after a thunderstorm. It is also found on the tops of mountains and in the air near the sea.

Nitrogen.—Nitrogen, like oxygen, is a gas void of colour, taste, and smell. It does not burn, and will not support combustion. Nitrogen does not combine readily with bodies, and is a very inert substance. Its sole use in the atmosphere appears to be the dilution of the oxygen, for in an atmosphere of pure oxygen animals would live too rapidly, and very soon die. Nitrogen is not a poisonous substance, and animals die when plunged into this gas simply from the want of oxygen.

Carbonic Acid Gas.—Carbonic acid gas, or carbon dioxide, is always present in the air in the proportion of about four parts in 10,000. This is largely increased where great numbers of persons are gathered together, unless there be good ventilation. It is a very heavy gas, and for this reason collects at the bottom of disused wells, pit-shafts, and brewers' vats. Unlike nitrogen, carbonic acid gas kills an animal put into it because it is poisonous; and will, if in sufficient quantity, kill an animal, although plenty of free oxygen may be present.

Water Vapour and Ammonia.—A variable quantity of water vapour is always present in the air. This vapour is continually rising from the earth's surface, especially from water, and is given out with the breath of all animals. The amount of vapour present at any time depends upon the temperature of the air; the warmer the air the greater quantity it will hold. The last important constituent of the air is ammonia, which is given off from all decaying organic matter. It exists in excessively minute quantities, not more than one part in 1,000,000 parts of air. Nevertheless it has its use, and is the principal source of the nitrogen of plants.

Impurities in the Atmosphere:

(*a*) *From the Respiration of Animals.*—Inspired air may vary considerably as to temperature, moisture, and some of its gaseous constituents; but expired air is always from 95° to 97° F., is saturated with aqueous vapour, and contains definite proportions of nitrogen, oxygen, and carbonic acid gas, as will be seen from the following table:—

COMPOSITION OF AIR.

	Before Respiration.	After Respiration.
Nitrogen,	7900	7900
Oxygen,	2096	1630
Carbonic acid gas,	4	470
	10,000	10,000

The amount of carbonic acid gas expired averages about 4·35 per cent at the ordinary rate of respiration, making about 16 cubic feet per day, or an amount equal to the oxidation of eight ounces of carbon. But the amount exhaled in a given time is liable to variation from several causes, the chief of which are age, sex, diet, temperature, and exercise. It increases in both sexes to about 35 years, and then diminishes. Men eliminate more than women. Its exhalation is greatly increased by external cold and diminished by heat. Exercise also increases the amount, and so does additional food. It is increased again by the freshness of the air we breathe; and one of the mischievous effects of impure air is that the elimination of carbonic acid is diminished. Quickened breathing increases the amount, but not in proportion to the acceleration; in other words, the amount in each breath is less when the breathing is quicker, though the total quantity evolved in a given time is greater.

Air which has its carbonic acid gas increased by breathing is incomparably more injurious than air which has the same amount of pure CO_2 pumped into it artificially. If 1 per cent CO_2 has been added to the air from the breath of persons in a close room, the air is offensive to the sense of smell; but since CO_2 has no smell we infer that there must be other impurities. These are the organic matters which rapidly putrefy. If air which has been breathed be condensed in large quantities, the resulting moisture has a most offensive odour; and if injected into the veins of an animal, is found to be a malignant poison. Hence air which has once been breathed is unfit to be breathed again. Air containing 1 per cent of CO_2 is distinctly unwholesome, and causes headache and languor; while 3 to 4 per cent would be speedily fatal to human beings.

(*b*) *Suspended Impurities in the Air.*—The presence of dust in the air is a fact familiar to everyone, for who has not seen the thousands of dancing particles in the beam of sunshine as it enters a darkened room through the chinks of the shutters, not to mention the dust we experience on any windy day Even in air which appears to be absolutely free from such particles, their presence may be easily shown by first waving a piece of glass smeared with glycerine through the air for a time, and then examining it under the microscope. Scores of tiny particles will now be seen adhering to the glycerine, which were not there before.

This is the principle adopted in the construction of Dr. Cunningham's *aeroscope*, by means of which our knowledge of these foreign bodies has been greatly extended.

The suspended impurities are either *mineral* or *organic.* The mineral matters consist largely of coal-dust, rust, chalk, common salt, &c., and vary with the nature of the industries carried on in the locality, as well as the geology of the district.

Among the organic impurities small fragments of wood, wool, cotton, hairs, scales of skin, starch grains, &c., are very common. The pollen-grains of flowers, together with minute vegetable hairs and fibres, are also abundant; while the microscope has revealed the presence of some of the lowest forms of plant-life, such as *Bacillus*, *Spirillum*, *Bacterium*, &c. Some of the organisms which have been detected in the atmosphere are shown in Fig. 8.

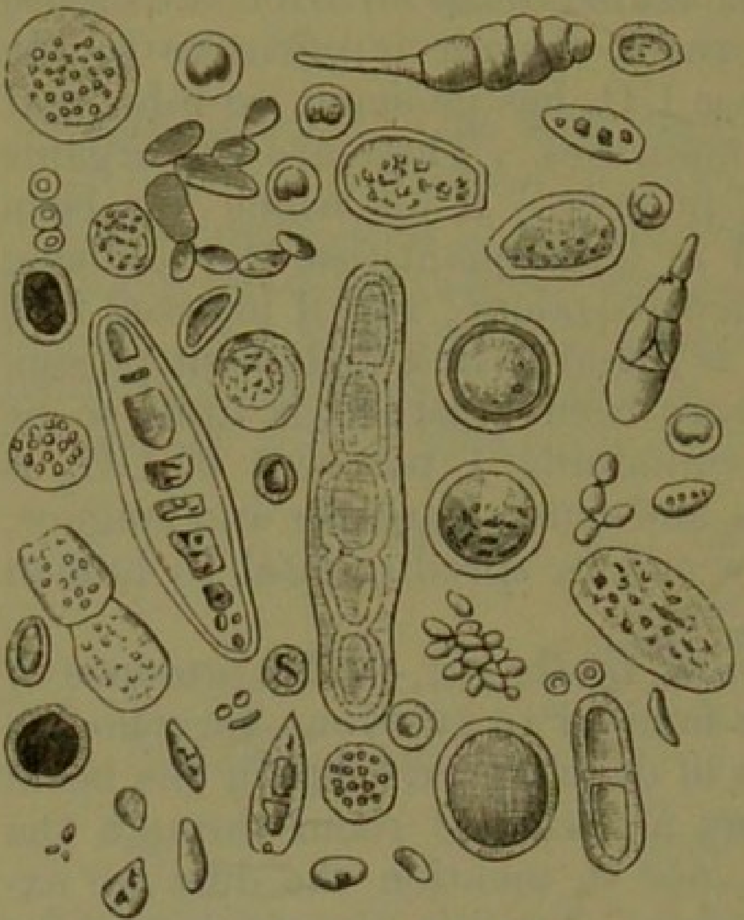

Fig. 8.—Atmospheric Organisms.

(*c*) *Gaseous Impurities in the Air.*—In addition to the carbonic acid gas of respiration, a great number of other gases pass into the atmosphere, either from natural causes, or from manufacturing processes.

The combustion of the materials we use for lighting purposes is the source of a number of hurtful products, prominent among which is carbonic acid. It has been calculated that an ordinary gas burner, consuming three feet of gas per hour, will add as much carbonic acid to the air as the breathing of three men. A duplex lamp, burning paraffin, gives off as much carbonic acid as six people; while a sperm candle will produce in one hour half the quantity of carbonic acid given out by a man in the same time. Moreover, impurified coal-gas is the source of certain sulphur compounds, such as sulphurous and sulphuric acid.

Sewer-gas is another source of contamination of the air. It is the result of the decomposition of sewage, and generally finds its way into the house from defective closets, soil-pipes, and traps. Another matter of no small importance is the air contained in the soil underneath a dwelling. Its amount varies considerably; but it is rich in carbonic acid, and probably contains organic substances derived from animal and vegetable substances. Whenever a house is artificially warmed, this ground air is aspirated into all the rooms, unless the floors have been made impervious to it. From "made-ground" such air is often very dangerous. Bacon, in his essay "Of Building," says, "He that builds a fair house upon an ill seat, committeth himself to prison;" the truth of which must be apparent to everyone.

Of the gases given off during manufacturing processes we may mention sulphuretted hydrogen, sulphurous acid gas, carbonic oxide, carbonic acid gas, &c., along with various acid fumes, all of which are deleterious to health.

The Dangers of breathing Impure Air:

(*a*) *Air Vitiated by Respiration.*—Of the dangers from breathing the air vitiated by respiration there are unfortunately too many records. The Black Hole of Calcutta is a striking example. On the night of June 20th, 1756, 146 English prisoners were shut up for about ten hours in a dungeon less than twenty feet square, and provided with but two small windows. When the door was opened in the morning, 123 were found to be dead, and the remaining "twenty-three ghastly figures, such as their own mothers would not have known, staggered one by one out of the charnel-house." Typhus fever, again, finds its home in overcrowded dwellings. When John Howard began his labours a century ago, the prisons of Europe were reeking with this disease; but now, owing to great sanitary reforms, the prisons are amongst the healthiest establishments in the country.

But what is of still greater importance is the fact that those who live in overcrowded, ill-ventilated places, suffer largely from consumption. Dr. Parkes cites a remarkable instance in support of this. There were two prisons in Vienna known as the Leopoldstadt and the House of

Correction, in which the diet and mode of living were practically the same; yet in the former, which was very badly ventilated, the death-rate from consumption alone was 51·4 per 1000; whereas in the latter, a well-ventilated building, only 7·9 per 1000 died from the same disease, the general death-rate being also equally low.

(*b*) *Suspended Impurities.*—Asthma, bronchitis, and consumption are caused by the inhalation of dust; proofs of this fact are to be found among colliers, millers, needle and knife grinders, stone-masons, &c. Most of the suspended organic impurities are comparatively harmless; but it is not so with all, for consumption, erysipelas, typhus fever, small-pox, and other epidemic diseases are undoubtedly propagated by "disease-germs," or *contagia*, through the medium of the air.

(*c*) *Gaseous Impurities.*—Vomiting, diarrhœa, and colic are the results of breathing sewer-gas. Diphtheria is frequently due to sewer emanations, while erysipelas and puerperal (childbirth) fever have often been traced to the pollution of air with sewer-gas. Carbonic oxide acts as a strong poison, producing death when inhaled even in very small quantities. Sulphuretted hydrogen gives rise occasionally to nausea and diarrhœa. Sulphurous acid gas is very irritating when breathed, and produces coughing and bronchitis.

* CHAPTER XIII.—VENTILATION.

The Air of Open Spaces.—In the previous chapter it was shown that human beings, and all animals that breathe air, as well as all fires and lights, are constantly robbing the atmosphere of its life-sustaining oxygen, and giving back in its stead carbonic acid gas and other matters. This process, it must be remembered, is incessant; and it would be only natural to conclude that the oxygen at our disposal is being reduced to such an extent, and the carbonic acid gas as surely increased, that in the course of time the atmosphere will be no longer capable of supporting life. Such a conclusion, however, would be altogether erroneous. The frequent chemical analyses of the air in open spaces show that the composition of the atmosphere is remarkably constant, and for reasons we now proceed to explain.

That the amount of carbonic acid gas in the air should be so stationary is not to be wondered at so much as in the case of the oxygen. Many causes may combine for the removal of any excess of the former gas, but with the latter there must be some means whereby its restitution is effected. How this is accomplished was first pointed out by Priestley, who showed that the plant-life on the earth's surface is responsible for this purification of the air. It is found that plants under the influence of sunlight have the power of absorbing carbonic acid gas from the air by the aid of their leaves and other green parts. When once absorbed, it is decomposed into carbon and oxygen by the combined action of the sunlight and the green colouring matter or *chlorophyll* of the plants. The carbon is retained to build up their various parts, and the oxygen, not being wanted, is returned to the air. Thus by the reciprocal action of plants and animals, a constant balance is maintained between the oxygen and the carbonic acid gas of the air. During the night a reverse action takes place; oxygen is then absorbed, and carbonic acid gas given off. For this reason many people object to plants in a bed-room; but the amount of CO_2 evolved by these is so trifling, that practically it has no effect upon the air of a room.

But the action of plants and animals thus given does not explain why the constituents of the air should be so intimately mixed. Considering that they are of different densities, why does not the heavy CO_2 collect in a layer at the earth's surface, with the oxygen next, then the nitrogen, and the ammonia over all? The explanation will be found in the action of the winds, and the diffusive power of gases.

When air is heated it expands; hence a given volume of air will not always have the same weight. A pint bottle of cold air weighs a little more than the same bottle full of warm air. So that if a column of cold air be side by side with a column of warm air, both will be acted upon by gravitation; but the cold air being denser will be drawn downwards with a greater force than the warm air, and will push under and displace the latter. This is exactly how winds are caused. The heating power of the sun's rays varies in different parts of the world. When any extent of land is heated, the heated surface communicates its temperature to the air in contact with it. The air then expands and at once rises to the higher parts of the atmosphere, while at the same time the colder surrounding air rushes in to take its place, and a wind is produced. A powerful circulation is thus established which thoroughly mixes the air, though it is not entirely to the action of the winds that such a result is due.

The last cause which operates in keeping the composition of the air uniform is that known as the *diffusive power of gases*, or simply *diffusion*. By this term is meant the property which gases of different densities have when they meet of becoming intimately mixed together. This may be shown in the following manner:—Invert a jar filled with atmospheric air over one containing only carbonic acid gas. After some time, remove the upper jar, pour into it a little lime-water, and shake it up. The formation of a white precipitate of carbonate of lime shows that some of the carbonic acid gas, though heavier than air, has ascended into the upper jar. Its place in the lower jar has been taken by the lighter air. Experiments upon this subject show that every gas diffuses with a velocity inversely proportional to the square root of its density; thus hydrogen gas will diffuse four times quicker than oxygen, the density of oxygen being sixteen times that of hydrogen.

Such, then, are the means whereby the constitution of the air is everywhere kept uniform; and it scarcely requires to be pointed out that they are at once important agents in ventilation.

Quantity of Air required.—From what has been said concerning the rapid vitiation of the air of confined spaces by respiration, and the consequences attending the breathing of such impure air, it is evident that if our health is not to suffer from such a cause, we must endeavour to get the air of dwellings and other rooms to resemble in point of purity that in the open as much as possible. The importance of this cannot be too strongly impressed upon all those in charge of large numbers gathered together in schools, workshops, &c.

Normally the external air contains 4 parts of carbonic acid gas in 10,000 parts; but since each individual on an average expires ·6 of a cubic foot of carbonic acid gas every hour, it is next to impossible to maintain such a high standard of purity as this in inhabited rooms. We must, therefore, fix upon some limit of permissible impurity.

Now the amount of carbonic acid added to the air of a room by respiration is too small to have much influence on health. It is the organic matter which accompanies it that is really dangerous; but as this cannot be easily measured, it is customary when investigating the wholesomeness of the air for breathing purposes to estimate the amount of carbonic acid present, since it has been shown that there is practically a constant ratio between the two.

From a large number of experiments conducted by Professor de Chaumont, we learn that a feeling of closeness or stuffiness is experienced whenever the carbonic acid in the air of inhabited rooms exceeds that in the outer air by 2 parts per 10,000 of air. We may therefore regard this amount as the limit of respiratory impurity which may be safely allowed. In other words, when the air becomes vitiated by breathing to 6 parts of CO_2 (*i.e.* 4 of initial + 2 of respiratory) per 10,000, the limit compatible with perfect health is reached. It must be remarked here that the change from bad to worse is not perceived by persons remaining in a room, for the system to some extent accommodates itself to bad air. It is only when we pass from the open air into a confined space that the character of the air which the inmates have been breathing is found out, for nothing is so soon dulled as the sense of smell.

Since an adult, on an average, expires ·6 of a cubic foot of carbonic acid per hour, and as it is undesirable to allow a greater excess of this gas in the air than 1 in 5000, it is clear that every person must be supplied with ·6 of 5000 or 3000 cubic feet of fresh air per hour to maintain this standard in any inhabited room. This amount,—3000 cubic feet per head per hour—should be regarded as the minimum to be supplied. Wherever large numbers are gathered together, especially when artificial illumination is employed, a greater supply should be provided. The volume of fresh air required to maintain the air of a room at the standard given may be calculated from the formula of Dr. de Chaumont:

$$d = \frac{e}{p},$$

where e = the quantity of CO_2 exhaled by an individual per hour, p = the amount of respiratory impurity permitted in a cubic foot of air, and d, the volume of fresh air required in cubic feet per hour. Assuming that e = ·6 of a cubic foot per hour, then

$$d = \frac{\cdot 6}{\cdot 0002} = 3000;$$

or, giving e a higher value, say ·7:

$$d = \frac{\cdot 7}{\cdot 0002} = 3500.$$

Test for the Purity of the Air.—A simple method of ascertaining the purity of an atmosphere is as follows:—Take a wide-mouthed stoppered bottle of 10½ fluid ounce capacity, and wipe it quite clean and dry. A large linen duster should be crammed into the bottle and then quickly withdrawn, in order to fill it with the air to be tested.

Now pour into it half an ounce of perfectly clear lime-water, and having replaced the stopper, shake vigorously for a few minutes. If the lime-water remain clear the air is in a sufficiently pure condition, but if it become milky, the air is too foul to breathe.

Temperature of Air required.—The temperature of the external air will vary with the season of the year, but that of occupied rooms should never be allowed to rise above 60° F., especially in winter-time. An exception to this rule may be made in the case of infant-schools, where a temperature of 65° is preferable, because very young children are more quickly chilled than adults. This will be understood when it is remembered that heat is largely lost from the surface of the skin, and that the external surface of children is greater than that of adults in proportion to their size. Hence they lose heat very rapidly, and cannot resist the depressing influence of cold so well as adults.

The temperature of inhabited rooms must be ascertained by a thermometer, and never judged by our own sensations. In schools a thermometer should be placed in a prominent position in every class-room, and each teacher should frequently consult the instrument in his room. Whenever the temperature of the air within exceeds that of the air without by 10°, a draught is produced. This will lead to the closing of first one, and then another of the windows, until the atmosphere at last becomes intolerable, a condition which unfortunately is not perceived by the occupants themselves. The effect of such an atmosphere upon children is most disastrous. It lowers their state of health, causes the mental powers to flag, and favours the spread of zymotic diseases among them.

Moisture of the Air.—A certain amount of watery vapour in the atmosphere is essential to health; and one of the principal objections to the use of stoves is that they render the air too dry. On the other hand an atmosphere which is too damp is equally objectionable; for the air, being already saturated with moisture, cannot absorb any more, and evaporation from the body is checked, producing great discomfort. Moreover, the air as it comes from the lungs is also laden with moisture; so that in a saturated atmosphere much of the moisture will be deposited upon the walls and furniture, making them feel damp and clammy, besides setting up that offensive odour so common in all badly-ventilated and overcrowded rooms. The prevention of such saturation can only be secured by having a plentiful supply of fresh air.

The degree of humidity which is most agreeable has been determined to be about 75 per cent. The actual quantity of moisture present varies with the temperature of the air; the higher the temperature, the more moisture it can hold, without reaching the saturation point.

Amount of Space necessary for each Person.—Allowing 3000 cubic feet of air per head per hour, an individual remaining in a room, say, for eight hours, would require 24,000 cubic feet. To have rooms sufficiently large to hold such an amount as this at one time is out of the question; in this case the room would have to be 40 feet × 30 feet × 20 feet at least. So that we must be content to live in smaller places, and to renew the air from time to time in order to obtain the required quantity. In fact the air of a small room with several people in it may be kept much purer than that of a large room with but few occupants, if the provisions for the renewal of air are superior.

In this country the change of air in a room cannot be endured more than three or four times in an hour, a more rapid current giving rise to draughts. Hence we conclude that a space of 1000 cubic feet should be allowed for each person in our dwelling-rooms, so that the necessary 3000 cubic feet of air can be supplied each hour without discomfort. Thus a room measuring 10 feet in every direction and void of furniture, would only afford sufficient air-space for one person. For two persons a room at least 16 feet long by 12 broad and 10 feet high would be required. These dimensions, however, are far greater than most people are able to have.

Relation of Cubic Space to Air-supply.—There is a very common belief that cubic space compensates for a deficiency of air-supply; or in other words, that a person living in a very large room does not require the same amount of fresh air per hour as a person occupying a much smaller one. This is quite an error; for it matters not how large an inclosed space may be, it can only supply sufficient air for a limited time, after which the same volume of fresh air must be supplied, be the space small or large. The principal advantage of large rooms over smaller ones, is that the fresh air can be introduced and distributed in them with less perceptible motion. It must not be thought that we are underrating the value of plenty of space. By all means secure as much as possible. What we wish to impress is the fact that *size* of room can never compensate for want of change of air, except for a very short time.

Another mistake which is frequently made is to suppose that the provision of sufficient cubic space is all that needs attention; no regard being had to the manner by which it is best obtained—that is, the shape of the room. Cubic space is of no value when it is principally obtained by means of lofty ceilings. A space inclosed by four high walls, without roof and inlets, would, when crowded, become speedily unwholesome, although the space above is illimitable; and people have been known to die of suffocation in a crowd in the open air. Essential as cubic space is, that of floor space is equally so, especially in the case of rooms occupied by a number of individuals at one time.

The height of the ceiling should not be less than 12 feet, whilst no great benefit is gained by exceeding 14 feet, though of course there is no objection to a greater height. Assuming 12 feet to be the limit, a room to hold 1000 cubic feet of air would have an area of about 84 square feet, or a floor space measuring 10½ feet long and 8 feet wide. Allowing only 500 cubic feet for each person, then the floor space should be 42 square feet, represented by a room 8 feet long and 5¼ feet wide. Soldiers in barracks are allowed 50 square feet, with 12 feet in height. In schools, the Privy Council allow 8 square feet for each child in average attendance, an amount altogether too small. From 12 to 15 square feet of floor-space would be more satisfactory.

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*CHAPTER XIV.—VENTILATION (*Continued*).

Methods of Ventilation.—As generally interpreted, ventilation is the removal, or the dilution of the impure air of dwellings by the entrance of pure air without the production of draughts. The methods by which this is accomplished are divided into *natural* and *artificial.* Natural ventilation includes any plan which does not involve the use of elaborate contrivances for the renewal of air; the natural forces which set air in motion being mainly depended upon. Artificial ventilation refers to the supply of air effected by the aid of machinery. The natural forces which are utilized for ventilating buildings are *diffusion*, *winds*, and the *difference in pressure of masses of air created by inequality of temperature.*

Natural Ventilation—

(*a*) *Diffusion.*—Reference has already been made to the interchange of the air of rooms and the outside atmosphere wherever communication is possible, such as chinks and key-holes of doors, crevices in the walls, &c.; but Pettenkofer has pointed out that a large and hitherto unsuspected interchange of air takes place even through walls. Thus in one of his rooms with brick walls, and a capacity of 2650 cubic feet, the whole air of the room was renewed once in an hour, when the difference of temperature between the inside and outside air was 34° F. (66° inside, 32° outside), the doors and windows being closed. With the same difference of temperature, but with a good fire in his stove, he found that the change of air rose to 3320 cubic feet per hour. Even when all the openings in the windows and doors were thoroughly pasted up, there was still a change of 1060 cubic feet per hour by diffusion through the walls. When the difference of temperature fell to only 7° F. (71° inside, 64° outside), the change of air was reduced to 780 cubic feet per hour, and with the same difference the change rose to only 1060 cubic feet on opening a window 8 feet square.

The amount of spontaneous ventilation through walls will of course be greatly influenced by the materials with which they are constructed. Thus Märker and Schultze found that the passage of air by this natural process through one square yard of wall, the difference of temperature being 4° F., amounted per hour with walls of sandstone to 4·7 cubic feet, of quarried limestone to 6·5, of brick to 7·9, of tufaceous limestone to 10·1, and of mud to 15·4 cubic feet. But the common practice of plastering and papering, or painting and varnishing walls reduces diffusion to a very insignificant amount. Hence in most dwelling-rooms the purification of the air by diffusion is quite insufficient, especially as it fails to remove the suspended matters in the air.

(*b*) *Action of Winds.*—Winds are exceedingly powerful means of ventilation, and the atmospheric contents of a room are very quickly changed when the doors and windows are thrown wide open. For bed-rooms this plan may be adopted during the daytime, but for other rooms which are more or less occupied during the day it is out of the question, except, perhaps, during the summer months.

As a ventilating agent the wind may be said to act in two ways—directly by perflation, displacing the air that is before it, and indirectly by aspiration. The direct action of the wind is utilized in the plan introduced by Mr. Sylvester some sixty years ago. A large cowl, which always faces the wind, is placed at a short distance from the building to be ventilated. The air is carried by a pipe down into the basement, where it is warmed by hot-water pipes, or any other suitable means; then it rises upwards through apertures into the rooms above. From these it is conducted to the outside by pipes in the roof, which are surmounted by other cowls turning from the wind. A similar method of ventilation is to be seen on ships.

An illustration of the aspirating power of the wind is seen in the draughts of chimneys. The wind in its travels causes a partial vacuum on either side of its path, towards which the surrounding air rushes in to restore equilibrium. Thus the wind by diminishing the pressure of the air in the chimney over which it blows, produces an up-draught in the chimney, and so the air of the room below is gradually withdrawn, the outside air taking its place.

(*c*) *Movements produced by Unequal Weights of Air.*—The most important agent in natural ventilation is the movements in the air produced by a difference in its weight due to differences in its temperature. The winds are caused in this manner as already pointed out; but in discussing ventilation questions the two are kept distinct. When any gas is heated, it endeavours to expand and ascend, and if there be any kind of outlet a portion will escape. In that event, the air outside, being colder and heavier, will force itself in through any opening there may be. A simple experiment will prove this. If when a fire is burning in a room, and the doors and windows are closed, we hold the flame of a candle in front of the key-hole, or any other opening we may discover, the air will be found rushing in, perhaps with sufficient force to extinguish the light. Everyone is familiar with the discomfort such currents give rise to.

Openings for Ventilation.—Remembering that the warm foul air of our rooms is light, and rises to the top of the room, and that the outside air which we wish to introduce is cold and heavy, it would be quite rational to have openings near the ceiling for the escape of foul air, and to admit the colder fresh air through openings in or near the floor. That the outlets for the foul air should be as near the roof as possible is perfectly correct; but to have the inlets for the cold air in or near the floor is a most unsuitable arrangement, as it tends to chill the feet, and it is hazardous to disregard the excellent maxim which enjoins us to keep the feet warm and the head cool. On the other hand, if they are placed too near the ceiling the incoming air sometimes does not properly distribute itself, but passes at once through the outlet on the other side of the room. Hence we are compelled to arrange our inlets at other heights from the floor.

The size of ventilating openings is regulated by the velocity or rate of speed at which the air is to move, and the quantity of fresh air to be supplied. We have already seen that the latter ought to amount to 3000 cubic feet per head per hour, an extra allowance being made for lights, &c. Now it is found practically that a current of air moving with a velocity of 5 feet per second at its point of entry, will secure a sufficient change in the air of a room without the production of draughts. Supposing, therefore, that only 3000 cubic feet are required, an opening measuring 24 square inches in area will pass such a quantity at the velocity named within the hour. It can be reasoned out in this way: Say the opening is 6 inches long and 4 wide; such an opening would have an area of 24 square inches, or the $\frac{1}{6}$ of a square foot. If the air travels through such an opening at a rate of 5 feet per second, it follows that $5 \times \frac{1}{6}$ or $\frac{5}{6}$ of a cubic foot of air passes through every second, and as there are 3600 seconds in an hour, then $3600 \times \frac{5}{6}$ or 3000 cubic feet will pass in the hour. But if 3000 cubic feet enter every hour there must be a provision to let the same amount pass out. Thus a total inlet and outlet area of 48 square inches must be provided for each inmate.

On account of the expansion of a gas by heat it has been maintained that the outlets should always be larger than the inlets. Practically there is no necessity to make a difference in their sizes, as a cubic foot of air only expands to 1·020361 cubic feet with an increase of 10° in temperature, and this is so slight that it may be neglected.

Inlets for Fresh Cold Air.—The inlets for the admission of fresh cold air may be grouped under three heads, viz.:

I. Openings at the windows.
II. Openings at the floor level fitted with vertical shafts.
III. Openings in the walls.

I. **Window-openings.**—All windows ought to be made to open, and attention should be paid to the sashes so as to keep them in proper working order. When the temperature of the external air is above 50° they may be thrown wide open, but in cold weather such a method would let in unbearable currents of cold air. In order, therefore, to utilize the windows in winter, some arrangement must be devised to prevent draught.

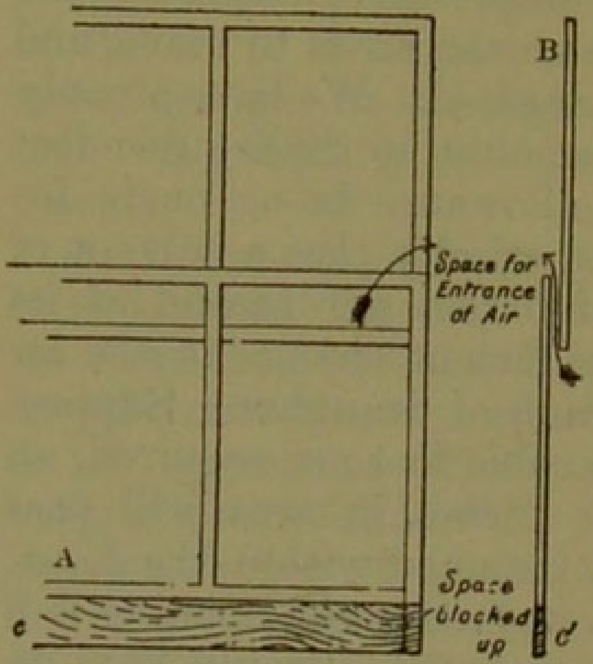

Fig. 9.—How to Ventilate a Room. A, Front view of window; B, Side view; c, c', Ventilating board.

(*a*) *Hinckes Bird's Method.*—One of the simplest ways of admitting air by the window is that recommended some years ago by Dr. Hinckes Bird. It consists in raising the lower sash about three inches, and then closing the opening thus made by a wooden board of the necessary length and breadth (fig. 9). The incoming air passes in an upward direction between the two sashes, and no draught is felt. The only disadvantage of this method is that in large towns "blacks" are carried in by the entering air.

(*b*) *Louvred Window-panes.*—These consist of parallel strips of glass fitted in a frame in such a manner that they can be easily opened or closed by pulling a cord. Windows provided with Venetian blinds may be converted into efficient inlets upon this plan. The upper sash is lowered, and the laths are made to slope upwards so as to give the incoming air an upward direction.

(*c*) *Cooper's Ventilator.*—Holes are cut in one or more of the upper panes of a window, and are opened or closed by a revolving disc of glass, on the hit-and-miss principle. It cannot be recommended.

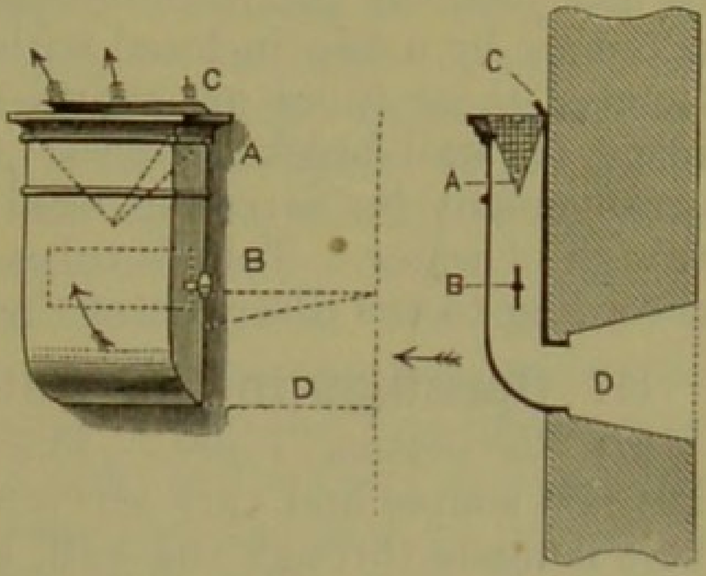

Fig. 10.—Wall Bracket Inlet on Tobin's System.

Section of Wall Bracket Inlet.

(*d*) *Double Windows.*—Buildings provided with double windows may be easily ventilated by raising the lower sash of the outer window, and lowering the upper sash of the inner window. The fresh air passes between the two windows, as in Hinckes Bird's method. Such double windows are not only valuable as ventilators but also as economizers of heat, the single windows causing a great loss of heat from a room.

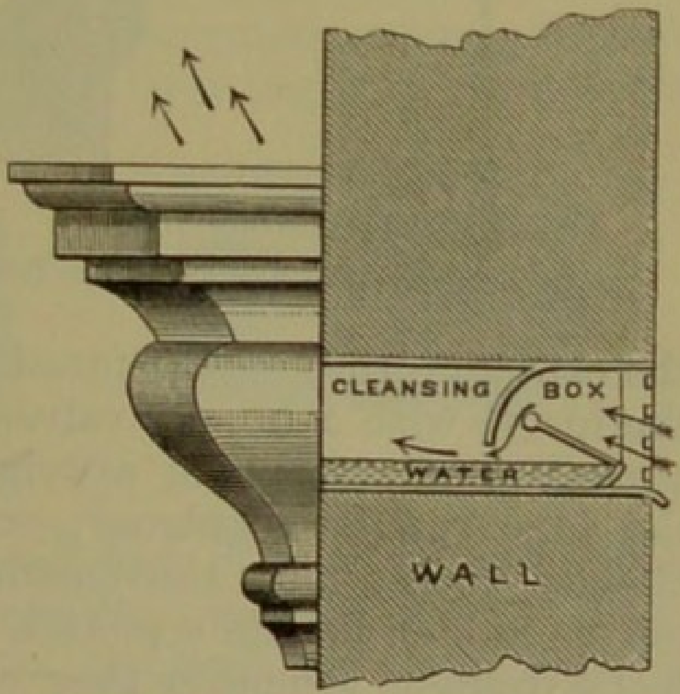

Fig. 11.—Ornamental Wall Bracket Inlet Ventilator, with Arrangement for Purifying the Entering Air.

II. Openings at the Floor-level Fitted with Vertical Shafts.

Tobin's Tubes.—A plan now much in vogue for the introduction of fresh air is that originally proposed by Mr. Tobin of Leeds, or some modification of it, and known as Tobin's tubes. These tubes are carried through the wall by a rounded L-shaped bend, opening outside against a grating or ventilating brick. Inside the room each pipe rises to a height of four or five feet, and is fitted at the top with a valve to control the amount of air coming in. No draught is occasioned by them, and by a simple arrangement the incoming air can be warmed by gas jets, the products of combustion escaping to the outer air by a flue inclosed within the tubes. Modifications of these tubes are shown in figs. 10 and 11 in the form of wall-bracket inlets; that in fig. 11 has an arrangement for arresting dust particles by means of a trough of water. Tobin's tubes sometimes act as outlets according to the direction of the wind.

III. **Openings in the Wall**:

(*a*) *Sheringham Valve.*—The Sheringham valve (fig. 12) is a simple and very serviceable inlet ventilator. A hole is made through the wall, high up, but not too near the ceiling. Into this is fitted an iron box provided on the inside with a hopper valve, and on the outside with a grating. By means of a weight and pulley the size of the inlet can be regulated; or if necessary, altogether closed. It is a most convenient form of ventilator, as it can be hidden behind a picture for those who fancy they feel a draught whenever they see a ventilator.

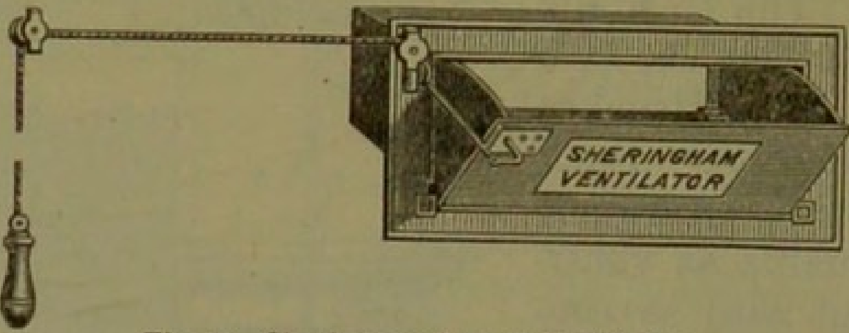

Fig. 12.—Sheringham Patent Ventilator.

(*b*) *Ellison's Inlet.*—This form of inlet consists of bricks pierced with conical holes. The holes are about $\frac{2}{10}$ of an inch in diameter on the outside, and $1\frac{1}{4}$ inch inside; by this arrangement the air is so distributed that there is no draught.

Outlet Ventilators:

(*a*) *The Chimney.*—In many houses the chimney is the only outlet provided, and this is frequently boarded up or closed with a bundle of old clothes when not in use. With an open fire the chimney affords a sufficient outlet for an ordinary room during the daytime, provided there are proper inlets. At night, when gas is being burnt, the chimney alone may not be sufficient. Impure air will then accumulate at the top of the room, as anyone will find out by standing on a step-ladder in the room during the evening. To remove this stratum of vitiated air some other form of outlet will be necessary.

(*b*) *Chimney-valve.*—Dr. Neil Arnott first devised a ventilator for this purpose. An opening was made into the chimney near the ceiling, and in this was inserted an iron box, provided with a light metal valve arranged to allow the air to escape into the flue and to prevent a reflux of smoke. However well made, such valves are apt to admit smuts, and the clicking noise they make in windy weather renders them very objectionable.

(*c*) *Boyle's Valve.*—An improvement upon Arnott's valve is Boyle's mica-flap ventilator (fig. 13). Instead of the metal valve several small flaps of mica are suspended from iron rods running across the iron framework. Being made of such light material, the flaps are easily made to open by an upward current of warm air, and to close whenever a down-draught takes place.

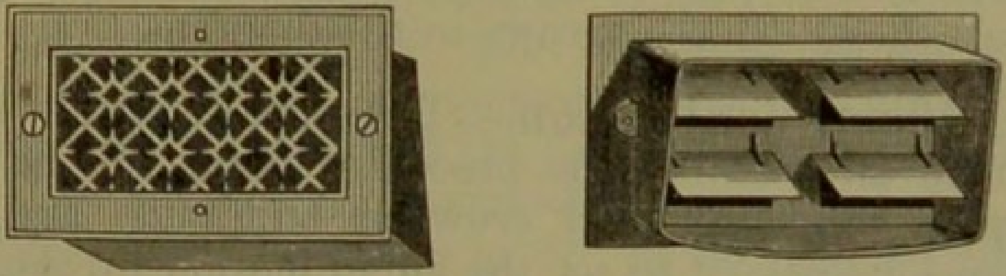

Fig. 13.—Mica-flap Outlet Ventilator (front view). Ventilator (back view)

(*d*) *Shaft Ventilators.*—A far better plan than either of those just mentioned is to have a separate air-shaft carried up in the same stack with the smoke flues, and provided with an opening in each room near the ceiling. The air in the shaft becomes heated and rises, and the foul air is consequently drawn from the top of the room

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(*e*) *M'Kinnell's Ventilator.* — This is a very suitable form of ventilator for small rooms, having no other rooms above them. It consists of two tubes, one inside the other (fig. 14), both opening at their lower ends in the ceiling of the room to be ventilated. The inner tube is carried higher into the air than the outer one, and forms the outlet shaft. Fresh air enters the annular space between the two tubes, and is first distributed along the ceiling by means of the flange on the inner or outlet tube. Rain is prevented from falling down the shafts by means of a hood placed a little above the tubes. The movements of the air are shown by the arrows in the diagram.

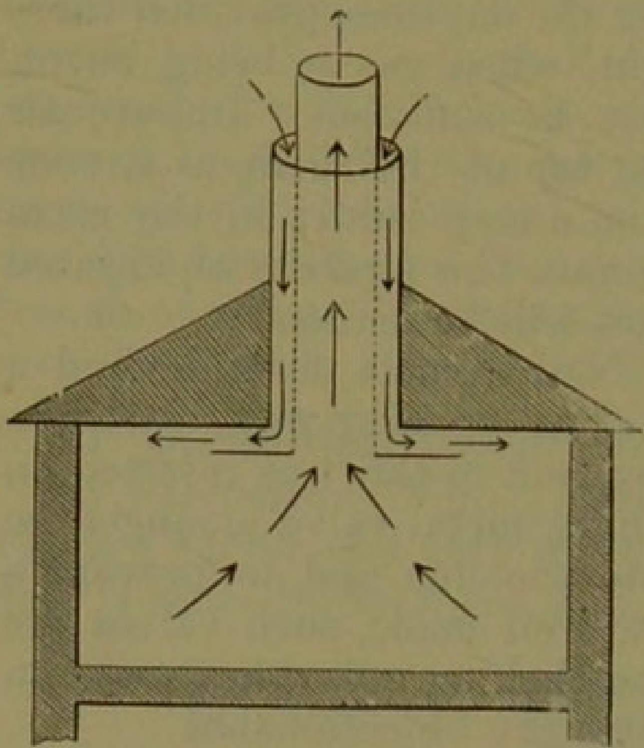

Fig. 14.—M'Kinnell's Ventilating Shaft.

Artificial Ventilation.—To ensure a constant supply of fresh air, none of the preceding plans will be found adequate for large and crowded buildings; and so it becomes necessary to set the air in motion by the aid of machinery. This may be done in one of two ways: (1) by *aspiration*, in which the foul air is drawn out of the building by machinery, fresh air being allowed to take its place, after being warmed if need be; (2) by *propulsion*, in which fresh air is driven along conduits into the building, the foul air escaping by shafts or flues. In both systems metal vanes, called *fans* or *screws*, driven by stationary engines, are employed to set up the necessary currents. Of the two methods that by aspiration is the cheaper, but the movements of the air are not under such control as in the plan of propulsion.

*CHAPTER XV.—WARMING AND LIGHTING.

General Remarks. — Intimately associated with ventilation is the subject of warming and lighting; but from the way most buildings are planned at the present day, one would conclude that they were in no way connected. This oversight, unfortunate as it is in ordinary dwelling-houses, is even more so in schools and other places where large numbers are gathered together for any length of time. To secure an abundant supply of fresh air is not all that is needed in a climate like ours, and provision should be made whereby the incoming air can be warmed, if need be, without robbing it of any of its vital properties. The question of expense of such a system, so frequently raised by self-styled economists, ought not to prevent its adoption when health is at stake; and we hope that the day is not far distant when the whole of our schools especially will be provided with an efficient system of warm-air ventilation.

The degree of temperature at which rooms should be kept will depend largely upon the purposes for which they are employed. A temperature of 60° to 63° for ordinary sitting-rooms and the like will be found comfortable. In workshops it should never exceed 60°, and school-rooms are best kept at 58° to 60°, except infant-schools, where it may be 65° with advantage. Bed-rooms are best kept cool, and should never exceed 60°.

Transmission of Heat.—By the transmission of heat is meant the various ways by which heat is communicated from one body to another. There are three ways in which heat passes, viz. by conduction, by convection, and by radiation.

1. *Conduction of Heat.*—Heat is said to be conducted when it passes from molecule to molecule of a body. It is in this way that the knob of a poker becomes heated when the other end is thrust in the fire. All bodies do not conduct alike, some being better than others. Metals,

as a rule, are good conductors; whilst such substances as glass, ivory, wood, wool, &c., are bad conductors.

2. *Convection of Heat.*—By the convection of heat is meant that process by which heat is distributed in the mass of a fluid body by a motion of its own particles. Public buildings are generally heated in this way by means of hot-water or hot-air pipes. The air in the room touching the pipes becomes heated, expands, and rises; while the cold air takes its place, to be heated and to rise in its turn.

3. *Radiation of Heat.*—When we stand in front of a fire or any other source of heat, we at once experience a sensation of warmth. Rays of heat diffuse themselves in all directions from the heating source. This passage of heat through intervening space is called radiation, and the heat thus passing is termed radiant heat. The sun warms the earth in this way. Radiation is not dependent upon the presence of the air. If a heated ball is placed in the receiver of an air-pump and the air then exhausted, the ball still continues to radiate its heat, as may be shown by a thermometer.

The radiant heat which falls upon a body is partly reflected and partly absorbed. By the absorption of heat is meant that property by which a body takes into its mass more or less of the heat which falls upon it. All bodies do not absorb heat to the same extent. The gases oxygen, nitrogen, and hydrogen absorb but very little; or, in other words, their *diathermancy* or power of transmitting rays of heat is nearly perfect. This explains why it becomes colder the higher we ascend above the sea-level. The atmosphere derives very little heat from the sun's rays as they pass through it to the earth, but is heated by contact with the warm earth. Thus the town of Quito, although situated upon the equator, enjoys a climate which has been described as a "perpetual spring," owing to its altitude. The decrease in temperature may be taken at 1° for every 300 feet of ascent.

Warming by Open Fires.—Having briefly explained the several modes by which heat is communicated from one body to another, we now proceed to discuss the various methods of warming our houses and other buildings. The radiant heat of the open fire is still preferred in this country to any other method of warming dwelling-rooms, notwithstanding the expense it entails. Much has been done, however, of late years to minimize the amount of heat lost by the chimney; but even now, in the majority of fire-grates, there is a wasteful consumption of fuel. Still the open fire lends a bright cheerful appearance to a room, and plays, as we have seen, an important part in ventilation, an ordinary fire extracting from 6000 to 20,000 cubic feet of air from a room per hour. Where open fires are employed, attention must be paid to the inlets for fresh air; otherwise cold currents of air will be drawn under the doors, and, travelling along the floor, may give the occupants cold feet.

For large rooms, open fires are very unsatisfactory on account of the unequal heating of different parts of the room. The other objections raised to the open fire are (1) the trouble of replenishing with fuel from time to time, and (2) the dust and smoke carried into the rooms by back-draughts, an occurrence which is principally due to the absence of inlets.

Since radiant heat is given off from a heated surface only, it is obvious that the amount of heat passing into a room will depend upon the extent of the red-hot fuel exposed to the room as well as the position and shape of the grate. Instead of having one red-hot mass presented to the eye, it too often happens that only the black surfaces of the unburnt coal can be seen. The remedy for this is the use of Teale's "Economizer," which is simply a sheet of iron having the same curvature as the front of the grate, and reaching from the hearth-stone to the bottom bar. The ash-pan is removed, and the space beneath the grate is then inclosed by the "Economizer." Cold air no longer enters from below, but is compelled to pass between the front bars. In this way a slower, but more complete combustion of the coal is secured. Some grates are built with a solid fire-brick bottom; but of the two plans, Mr. Teale's is the better, as it allows the ashes to fall under the grate.

The best position for a grate is in the centre of one of the inner walls. If built in an outer wall much of the heat would be conducted to the external atmosphere. The fireplace should be made to stand well forward into the room, and should be constructed of fire-brick as far as possible, as the metal work of which grates are generally made conducts away the heat to the surrounding walls. It should not be too deep from front to back, and the width of the back should be about one-third that of the front. It is a good plan to have the sides of the fireplace made of glazed tiles.

The Galton Grate.—The Galton grate, devised by Captain Galton, R.E., is an improved form of open grate by which the fresh air for ventilating purposes may be warmed before entering the room. The grate is so constructed that the flame, the heated products of combustion, and the smoke, are made to impinge upon a large heating surface, in order to utilize much of the heat which would otherwise escape by the chimney. Surrounding the flue is an air-chamber, which communicates on the one side with the external air, and opens on the other into a shaft which passes up alongside the chimney-stack and opens into the room above the fireplace by louvred openings. Fresh air enters this chamber, and after being warmed by contact with the heated sides of the flue passes up the air-shaft and issues into the room, where it becomes distributed by the already existing currents. The air-chamber and its shaft are completely shut off from the grate and chimney-stack, so that none of the products of combustion can possibly find their way into the room. The *Manchester school grate* is constructed upon the same principle.

Open Gas Fires.—Instead of burning coal or coke in the open grate, gas is sometimes used. The grate is filled with asbestos fire-balls, and these are made red-hot by means of several Bunsen burners placed under the grate. Such fires are very cleanly, and for this reason are frequently employed in a study or library. They are by no means economical, and unless ample provision is made for the escape of the products of combustion, the atmosphere is very soon rendered unwholesome.

Stoves.—Many places of public assembly are now warmed by close stoves, the heat being generated by the combustion of coal or coke. The fuel is introduced from time to time through a door placed near the top of the stove, and the air necessary for its combustion is admitted lower down by means of an aperture which can be opened or closed to any extent desired. So that when once the fire has been lighted, the burning may be made to proceed so slowly that a single charge of fuel will last the day. Thus a moderate warmth is secured with a small consumption of fuel.

Compared with open fires, stoves are more economical and cleanly, but are not so healthy. Receiving a limited supply of oxygen, carbonic oxide (CO) is largely generated in them, and this highly poisonous gas, with other products of combustion, may pass into the room through badly-made joints or accidental cracks, and even through the ironwork, especially if it be of cast-iron, as this metal is very pervious to gases. To minimize the latter danger wrought iron should be used, and the stoves well lined with fire-brick. Again: the small amount of air which stoves consume also means that they are of little value as ventilating agents. To meet this objection some of the stoves now in use have an air-chamber, where the fresh air, brought from the outside by means of a pipe, is first warmed before passing into the room.

Ordinary stoves warm the air itself through its coming into contact with the heated surface. This has the effect of making the air relatively very dry, occasioning thereby an unpleasant sensation in the skin and a disagreeable irritation in the throat and chest. This, however, may be prevented by placing a vessel of water upon or beneath the stove, when the evaporation of the water will keep the air sufficiently moist. Occasionally stoves create an unpleasant smell. This is when they become too hot and burn, as it is supposed, the organic particles floating in the air.

The advantages of the closed stoves are: (1) economy of fuel, (2) the length of time they continue burning without attention, (3) the control they are under with respect to the amount of heat they may be made to give off, and (4) cleanliness.

Gas Stoves.—As an illuminant, coal-gas has been familiar to all for a long time, but it is only within recent years that it has been employed for heating purposes as well. On the score of convenience, cleanliness, and the perfect control which it is under, coal-gas is far ahead of any other fuel; but in these days of dear gas its continual use for warming purposes is expensive. There is an endless variety of gas-stoves now upon the market, but only those known as *ventilating gas-stoves* should be employed. These, when well designed, are really an excellent means of warming large rooms. Within these stoves are a number of air-tubes, communicating below with the external air, and opening at the top of the stoves into the room. When the stoves are lighted the heat warms the air in the tubes and causes it to rise into the room. At the same time the colder outside air passes in to take its place, and so on. Thus a current of pure warm air is always entering the room when the gas is burning. The products of combustion are carried away by a flue.

Warming by Hot Water.—As a means of warming large buildings there is much to be said in favour of the hot-water apparatus, if properly constructed, although it is not without its disadvantages. Heating by hot water may be divided into two systems: one in which the temperature of the water is not raised above 200° F., and in which, therefore, there is no great pressure upon the pipes, and the other in which the water is heated to 300° or 350° F., so that the pipes are subjected to a great pressure.

In the former system a boiler is placed somewhere in the lowest part of the building. From the top of the boiler a pipe passes upwards to the rooms above, and after being carried around the rooms returns to the lower part of the boiler. The pipes and boiler are kept full of water. When a fire is lighted beneath the boiler, the hot water rises up the pipe leading from the top of the boiler and passes through all the rooms to the highest point to which it has been carried. By this time the water has parted with a considerable portion of its heat, and it now descends to the boiler again to be once more heated. Thus a continual circulation of warm water is kept up within the pipes as long as there is a fire in the furnace. In each room the pipe should be doubled upon itself several times in different parts of the room to secure a greater heating surface. The coils thus formed may be inclosed in ornamental gratings, and communications may be made with the outer air by means of air-bricks to admit fresh air. Care must be taken that the fresh air admitted remains long enough in contact with the hot pipes so that it may be properly warmed.

In the second system (Perkin's patent) the pipes are made much stronger than in the preceding method, and have an internal diameter of about ½ an inch. No boiler is employed, but instead a portion of the pipe passes through the fire.

The disadvantages of the hot water-apparatus are: (1) its costliness, (2) liability of getting out of order at a time when it is most required, and (3) the danger of the water freezing, and consequent bursting of the pipes during the winter vacations.

Warming by Steam-pipes.—Heating by steam is chiefly applicable in factories where there is a surplus supply of steam. It is more extensively used for warming buildings in the United States than it is in this country. In our Houses of Parliament the steam-pipes are in a chamber under the floor, and the fresh air is first made to pass over them before flowing into the house. The heating surface of the pipes is greatly increased by numerous vertical flanges attached to them. When the air in the house becomes too hot an attendant covers a greater or less surface of the pipes with woollen cloths.

Warming by Hot Air.—As a rule this system is only employed in large buildings, as in the Houses of Parliament for example, where the entering air is warmed in its passage by steam-pipes. In other cases the external air is made to pass over the heated flue of a furnace, and is then carried by shafts to the different rooms in the building, where it enters by means of gratings fixed in the floors. There are several objections to this system. In the first place the air supply is frequently drawn from the furnace-room, the air of which is far from pure, and especially when the room is underground. Moreover, the joints of the hot-air furnaces are apt to become loose, and then the carbonic oxide and sulphurous acid, two of the most dangerous products of combustion, may be carried into the buildings.

Lighting.—Intimately connected with the healthy arrangement and construction of houses is the question of light, and it is only within recent years that its importance as a sanitary agent has been recognized. Everyone is familiar with the depressing influences of a dull day, whilst the truth of the old saying that, "Where the sunshine never goes, the doctor does," is only too frequently proved in all our large towns.

The subject of lighting is usually considered under two heads, viz.: natural lighting and artificial lighting.

Natural Lighting:

1. *Area of Window-space.*—All rooms which are occupied during any part of the day should have large window lights. Well-lighted rooms are not only healthier than dark ones, but are more likely to be kept clean. For schools the area is variously stated as from one-fourth to one-tenth of the floor-space. Dr. Cohn proposes 30 square inches of glass at least for every square foot of floor-area. Upon one point all medical men are agreed, and that is, that there cannot be too much light in a school. Javal

says, "The school must be flooded with light, so that the darkest place in the class may have light enough on a dark day." Town schools require more window-space than those in the country, owing to the proximity of other buildings. For a similar reason class-rooms on the ground-floor require a greater window-area than those in a higher storey.

All windows should riseas near to the ceiling as possible since the best light is that which comes from the highest point. Windows that are too low down are of little use. A considerable portion of each window should be made to open for both ventilating and cleaning purposes.

2. *Position of the Windows.*—The best aspect for windows, according to most writers, is east or south, as these admit more light than any others during our school hours. In single-storied schools some light should be admitted from the roofs. From an oculist's point of view an ideal school-room would have a glass roof entirely.

The position of the windows with respect to the scholars is another matter of great importance. The best light for school-work is that which comes from the left, because the shadows of the hand, pen, or pencil do not fall upon the child's work when writing or drawing. The worst light is that coming from windows directly in front of the scholars. The teacher's face is thrown into a shade, and it is only with great difficulty that the children can see anything written upon the black-board. When the light comes entirely from behind a scholar, he generally twists his body round, so that his shadow shall not fall upon his books. When there is plenty of light coming from the left, windows at the back of the scholars are not so objectionable as in front.

3. *Excess of Light.*—Although we cannot have too much diffused light in school-rooms, still provision must be made to protect the children from direct bright sunshine. All the windows facing the south at least should be fitted with blinds, which must be kept in proper working order. They should be of the simplest construction, and either of a light gray or buff colour.

4. *Colour of School Walls.*—To increase the general cheerfulness of school-rooms, light, but not dazzling colours should be used for the walls and furniture. The best colour for walls is either cream or light gray. All internal wood-work is best sized and varnished only.

Artificial Lighting.—Artificial lighting is chiefly required for those classes which are held in the evening; but there are times in the year when it is also needed during ordinary school hours. Coal-gas and mineral oils are the commonest illuminating materials employed. Electric lighting is at present too expensive for school purposes; but there is no doubt that it will ultimately supersede all other methods of artificial lighting on account of its great sanitary advantages.

In all cases where gas or oil-lamps are employed, means for the escape of the products of combustion should be provided immediately over the burners; otherwise the atmosphere of the room is quickly loaded with noxious gases. One of the best constructed lamps for this purpose is that known as Wenham's gas-burner.

CHAPTER XVI.—EYES AND EYESIGHT.

Physiology of the Eye.—The eyes are two globular bodies situated in bony cavities, called orbits, and are about one inch in diameter. At the back of each orbit is an opening for the *optic* and other nerves, as well as for blood-vessels. The outermost layer of the eye is the *sclerotic* (H, fig. 15), and is the part commonly called the "white of the eye." In the very front it bulges out and becomes transparent, so that light can pass through, and receives the name of the *cornea* (A).

Immediately under the sclerotic is the *choroid coat* (I). Viewed from without, the choroid shows an intricate network of blood-vessels; from within it is seen to have a smooth black surface, except where it approaches the iris.

Here it is gathered up into folds called the *ciliary processes*, the roots of which are connected with a ring of muscular fibres which fasten the iris to the sclerotic, called the *ciliary muscle* (F G).

The *iris* (D), so called because it gives the colour to the eye, is a circular curtain with a hole in the centre called the *pupil* (C). It hangs in front of the crystalline lens, and controls the size of the pupil in order to limit the number of rays entering the lens. For near vision or for a bright light, the pupil is small; for distant vision, or for a dim light, it is large. Between the iris and cornea is a space called the *anterior chamber* (B), filled with a clear colourless liquid, the *aqueous humour*. Immediately behind the iris is the *crystalline lens* (E), which is perfectly transparent and doubly convex. It is held in its place by the suspensory ligament which passes back all round from the lens, and grows to the inside of the ciliary processes. Around the edge of the lens, and within its covering, is a

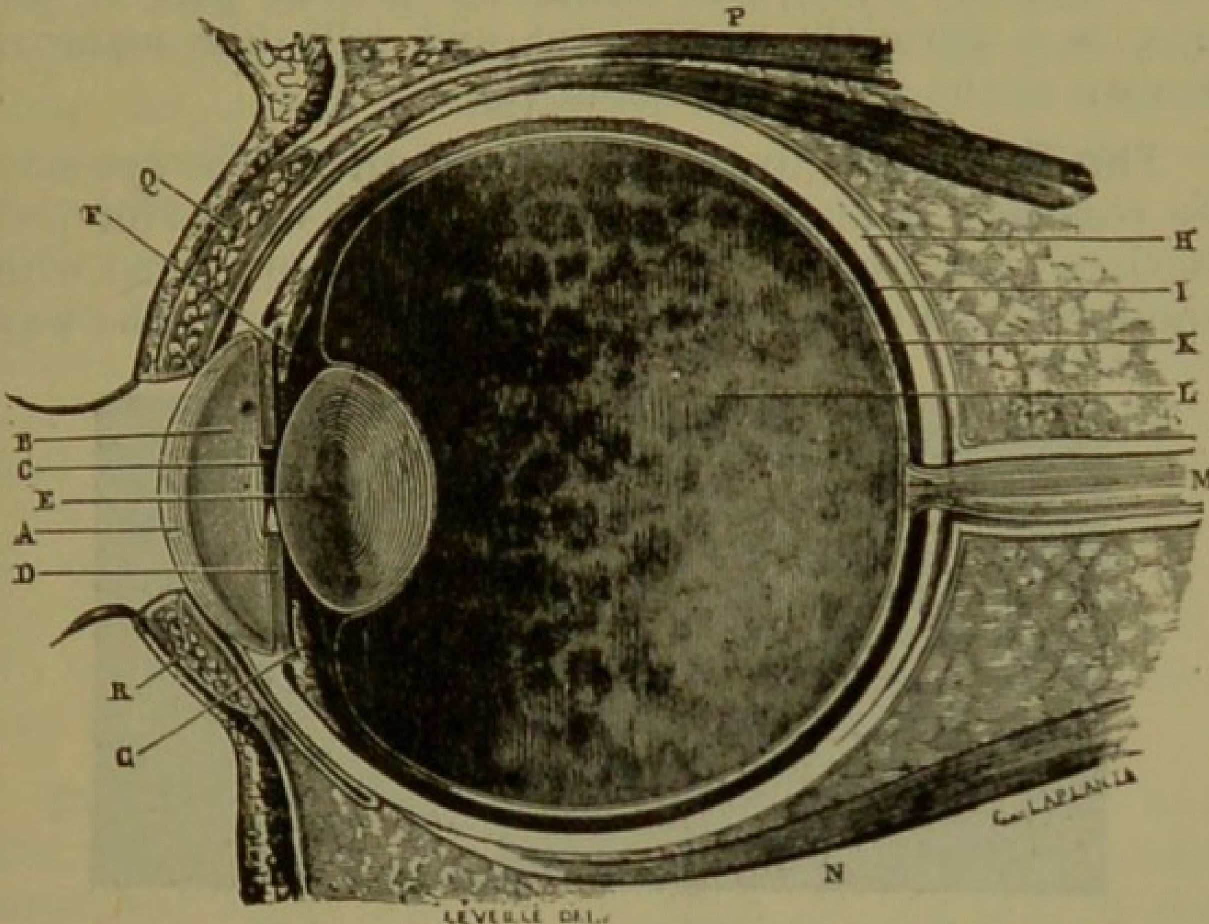

Fig. 15.—Representation of a vertical cut through the Eyeball in its Socket.
For description see text.

small triangular space called *Petit's canal*, which affords sufficient room for alterations in the shape of the lens.

The innermost lining of the eye is the *retina* (K), and is the most important structure of all. It lines nearly the whole of the choroid coat, and consists largely of nerve fibres derived from the optic nerve (M). In contact with the retina, and filling the greater part of the eye, is a perfectly transparent and jelly-like material known as the vitreous humour (L).

The Eye as an Optical Instrument.—The eye may be regarded as an optical instrument of wonderful perfection, by means of which we are made acquainted with the forms and colour of the objects around us. The way in which this is accomplished may be exemplified by the photographer's camera, which is nothing more than a clever but clumsy model of the eye. In front of the camera is a double-convex lens, and at the back a sheet of ground glass. Rays of light proceeding from an object *a b* (fig. 16) in front of the camera are refracted in such a manner by the lens O as to form a real but inverted image of *a b* upon the ground glass at A B. It is in exactly the same manner that the rays of light entering the eye are refracted by the crystalline lens to form images of the objects looked at upon the retina. The great difference between the two is—the eye *sees*, and the camera does not. The impressions received by the retina are

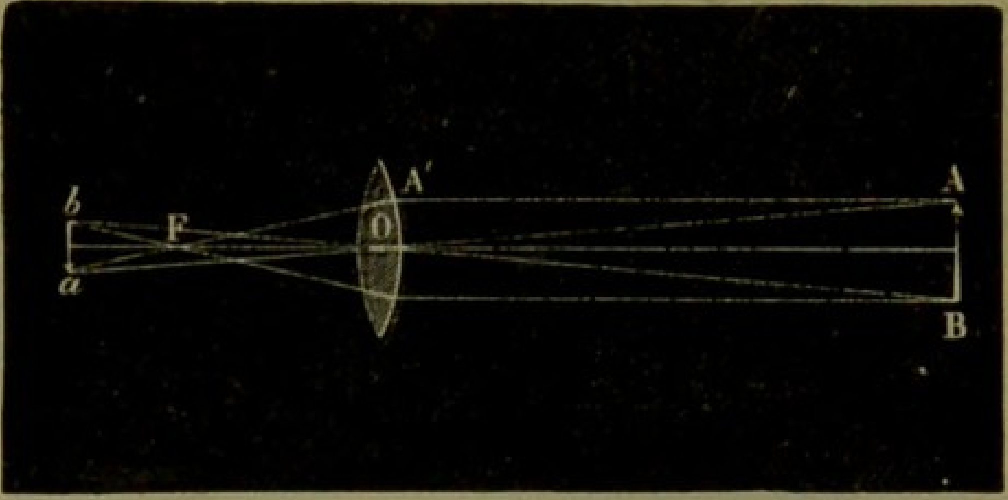

Fig. 16.—Formation of an Image by a Convex Lens.

conveyed by the optic nerve to the brain, where they produce the sensation of sight.

Accommodation of the Eye.—In the pursuit of his calling, the photographer finds that in photographing objects at different distances he has to keep altering the position of the ground-glass screen of his camera in order to obtain what he terms a "sharp," *i.e.* distinct, picture of the objects before him. So, too, has the eye to accommodate itself for objects at the different distances; but this is accomplished, not by moving the retina backwards or forwards, for the eye has no power to do this, but by altering the shape of the crystalline lens. It becomes more convex in near vision, and less convex in distant vision; the movements being effected by the action of the ciliary muscle. This muscle contracts in near vision, and pulls forward the ciliary processes. These pull forward the suspensory ligament and thus slacken it, thereby taking off pressure from the front of the lens, which, by the elasticity of its own substance, bulges forward. In long vision the ciliary muscle relaxes, and this enables the lens to flatten, so as to refract less strongly.

Defective Vision.—In the healthy or *emmetropic* eye the rays of light coming from a distance are focussed upon the retina without any effort on the part of the eye whilst at rest. But since the rays proceeding from near objects are more divergent, it follows that they must be focussed behind the retina, unless the eye can accommodate itself so as to bring them to a focus sooner. Now some eyes are not capable of doing this, owing to some defect in their construction; some are too short from front to back, others are too long. The result is, that instead of always having sharp and clear pictures of objects at any distance, some are occasionally blurred and indistinct; in other words, there is defective vision. The ordinary forms of defective vision are *Hypermetropia*, *Myopia*, and *Astigmatism*.

Hypermetropia or *Long-sight* is the defect in which the lens is too flat, making it of long focus, and the eyeball short from front to back, so that the focus lies behind the retina (fig. 17, C). A newspaper placed at a moderate distance from the eye appears indistinct, and in order that the printed matter may be read, it is necessary to remove the paper to a greater distance. Even then, in bad cases, it requires a strong muscular effort to bring the rays to a focus on the retina, and if this is long continued it leads to trouble of three kinds—pain and fatigue after reading or writing a short time, headache, and sometimes squint. Long-sight is not caused by an improper use of the eyes, but is often hereditary. It is remedied by means of double-convex spectacles. *Myopia* or *Short-sight* is the exact opposite of the former condition. The lens is more curved than usual, giving it a shorter focus, whilst the eyeball is longer than usual from front to back (fig. 17, B). Thus the rays from distant objects are brought to a focus in front of the retina, and therefore only indistinct images are seen. On the other hand, near objects are seen clearly. Like hypermetropia the tendency to short-sightedness is hereditary, but there is no doubt at all that much of the myopia prevailing in this and other countries is due to the manner in which children are allowed to work in school, and hence can be, and ought to be, prevented.

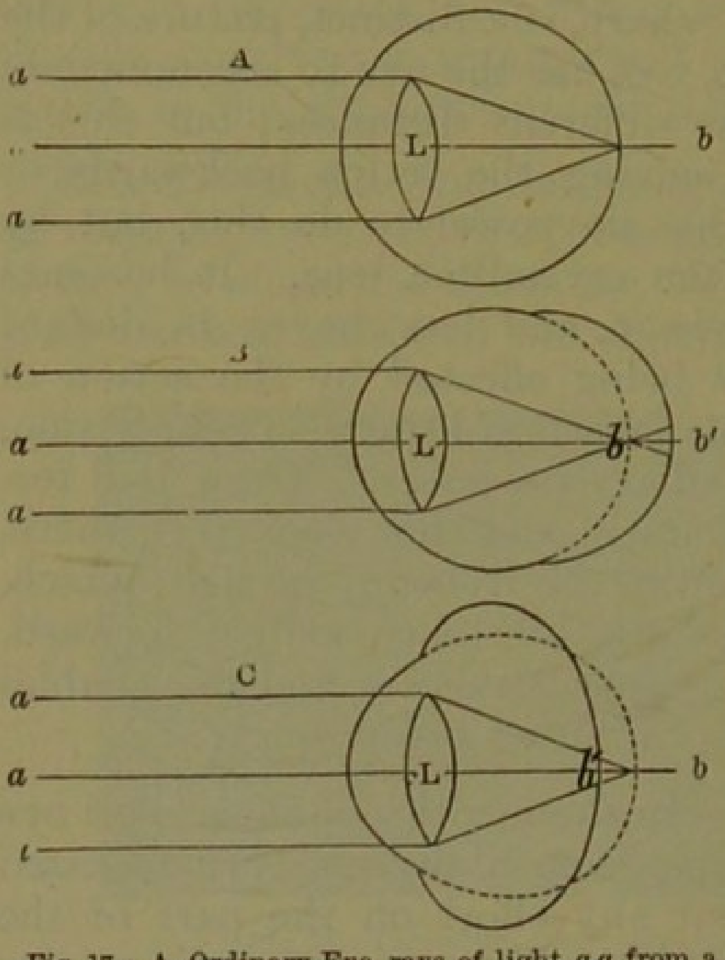

Fig. 17.—A, Ordinary Eye, rays of light *a a* from a distance coming through the lens L to a point *b* on the retina. B, Short-sighted Eye, rays from a distance coming to a point *b* *in front* of the retina *b′*. C, Long-sighted Eye, rays from a distance coming to a point *b* *behind* the retina *b′*. L is the lens in each case.

That myopia is developed during school-life was first pointed out by Jäger in 1861, who found in one of the schools he examined 80 per cent of the children thus afflicted. In 1865, Dr. Cohn, of Breslau, made an examination of 10,060 school children, and found that 1004 (9·9%) were myopic, 239 (2·3%) hypermetropic, 23 astigmatic, and 396 (4%) suffering from some other eye-diseases. The labours of other investigators in other towns show the same deplorable state of affairs, and at the time the statistics were taken Heidelberg had 61 per cent of its school children short-sighted, Hamburg 45, Dresden 71, Darmstadt 56, and Coburg 80.

Fortunately short-sightedness is not so prevalent as this amongst the children of our own country. In 1880, Mr. Priestley Smith, ophthalmic surgeon to the Queen's Hospital, Birmingham, examined the eyes of the children in four of the Birmingham board schools; of the 2158 examined, 99, or about 4½ per cent, were short-sighted. About the same time he examined the students in four of the training colleges, and found that of the 357 students, 72, or about 20 per cent, were myopic; a result which agrees with the observations of other medical men, namely, that the number of short-sighted scholars is greater in advanced than in elementary schools. Persons suffering from myopia should use concave spectacles.

Astigmatism arises from a difference in the degree of the curvature either of the cornea, or of the lens, from top to bottom, and from left to right. Hence vertical and horizontal lines are not seen with equal clearness at the same distance.

The Prevention of Short-Sight.—The causes operating in schools whereby short-sight is induced are several, of which the chief are:—(1) Badly constructed desks, (2) insufficient lighting, (3) bad print and smallness of type in reading books, &c., (4) prolonged exertion of the eyes, and (5) needlework. The subject of lighting has already been discussed, and the consideration of school desks will be dealt with in the next chapter.

(*a*) *Type.*—Of the remaining points, bad print and small type are very prejudicial. A boy's book should be held at least twelve inches from his eyes, and to enable him to read easily at this distance, his books should be clearly printed with a good and reasonably large type.

The following are specimens of the medium sizes of types employed for books:—

ENGLISH.

Our Father, which art in heaven.

PICA.

Our Father, which art in heaven.

SMALL PICA.

Our Father, which art in heaven.

LONG PRIMER.

Our Father, which art in heaven.

BOURGEOIS.

Our Father, which art in heaven.

Size of type is of course a main factor in producing distinctness in the printed page; but what is just as important is the quality of the printing. A *smallish type well printed* is clearer than a much *larger type badly printed.* Thus well-printed *Bourgeois* is better than badly-printed *Small Pica.* Proper spacing of the words and of the lines is also important. A large type with words and lines much squeezed together may be very indistinct.

As to the paper employed, it should be of a uniform thickness and unglazed, or but slightly glazed. A highly finished surface brings out "cuts" well, but is apt to fatigue the sight with the glossiness. Dr. Cohn prefers a pure white paper; but Javal, fearing that the contrast between the black and white is too great, advises yellow, and the Hygienic Congress at Turin in 1880 adopted his views. Another authority, Weber, prefers a pale gray colour.

(*b*) *Overworking the Eyes.*—Of late years there has been a considerable outcry about "over-pressure" in schools, and not without good reason; for it may be safely asserted that the amount of work the scholars in many schools, especially middle-class schools, have to do, inflicts too great a strain upon their eyes. And to make matters worse, an amount of home work is given out before dismissal that will keep them employed for several hours in the evening besides. Such a system as this cannot be too strongly deprecated. It is impossible to fix the number of hours that a scholar of any given age should devote to study, as much depends upon his own peculiarities, as well as the conditions under which he is compelled to work. But the three-hours' school in the morning, and two-hours' school in the afternoon, with an interval in the morning, say, from 10 to 15 minutes for recreation, is infinitely better than "morning schools" only, where the lessons frequently go on for five consecutive hours. Each lesson, again, should not be too long. For children under seven years of age a single lesson should not exceed a quarter of an hour. From seven to ten years the lessons should be of half an hour's duration, and from 45 to 50 minutes for the elder scholars.

(*c*) *Needlework.*—Sewing is exceedingly trying to the eyes if very fine work is insisted on. Back-stitching on fine linen, such as is used for shirt fittings, is especially so; and now that sewing-machines are so generally used, not one in a hundred would practise such work after leaving school, as it can be done equally well and infinitely quicker by machine, without the trouble of "counting threads." Needlework, writing, and drawing lessons should be conducted during the brightest hours of the day.

Annual Examination of the Eyes.—Besides paying attention to the points already given, teachers are earnestly recommended to make an annual examination of the eyes of the children committed to their charge, in order to diminish the number of cases of myopia, &c., as much as possible. The examination is very simple, and need not occupy more than half a minute per child. A test sheet* is placed in a well-lighted part of the room,

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* The Midland Educational Company (Birmingham) have printed a sheet, with full instructions, for this purpose.

and the children are made to toe a line drawn at a certain distance from the chart. Any difficulty in recognizing the printed characters at once indicates defective eyesight, and the parents should be immediately acquainted with the fact, so that they may take the necessary steps to prevent any further mischief.

CHAPTER XVII.—SCHOOL FURNITURE.

School Desks and Seats.—The only articles of school furniture which call for special attention are the desks and seats, black-boards and easels. Of these the desks and seats are by far the most important from a hygienic point of view; and it is a matter for regret that the majority of school-managers are not more fully alive to the dangerous effects which ill-constructed desks have upon the easily yielding frames of childhood.

It may be safely affirmed that nearly the whole of the children admitted to the lower classes of our schools possess sound eyesight, and yet as we pass to the upper standards we find the number of cases of short-sightedness gradually increase; a result undoubtedly due to working under existing school conditions. This has been abundantly proved in the German schools, especially by the investigation of Cohn, Weber, and others. Moreover, instances are not wanting where badly-constructed desks have led to curvature of the spine (fig. 18) and other malformations. Even with the best of hygienic school-desks, a long continuance in any one position is the cause of considerable mischief; and teachers will do well if they devote a few moments to arm exercises at intervals during the writing-lessons. For similar reasons the children should be encouraged to use the left hand, and not depend so much upon the right, as they do at present.

The first grand mistake in connection with school-desks is made in having them of only one size throughout the school; ignoring altogether the fact that children are of different statures. Consequently for some of the scholars the desks are too high, and this compels them to unduly raise the one shoulder (fig. 18) in order to place their arms upon the desks for writing purposes. On the other hand the elder scholars find the desks too low, and so their heads fall more and more forward until their eyes are too near their work, the very thing which causes and increases short-sight, besides making them "round-backed." Flat desks are also bad, and tend to the same result. There should be at least three sizes of desks in every school-room, and for exceptional cases of dwarfed stature, foot-boards should be provided.

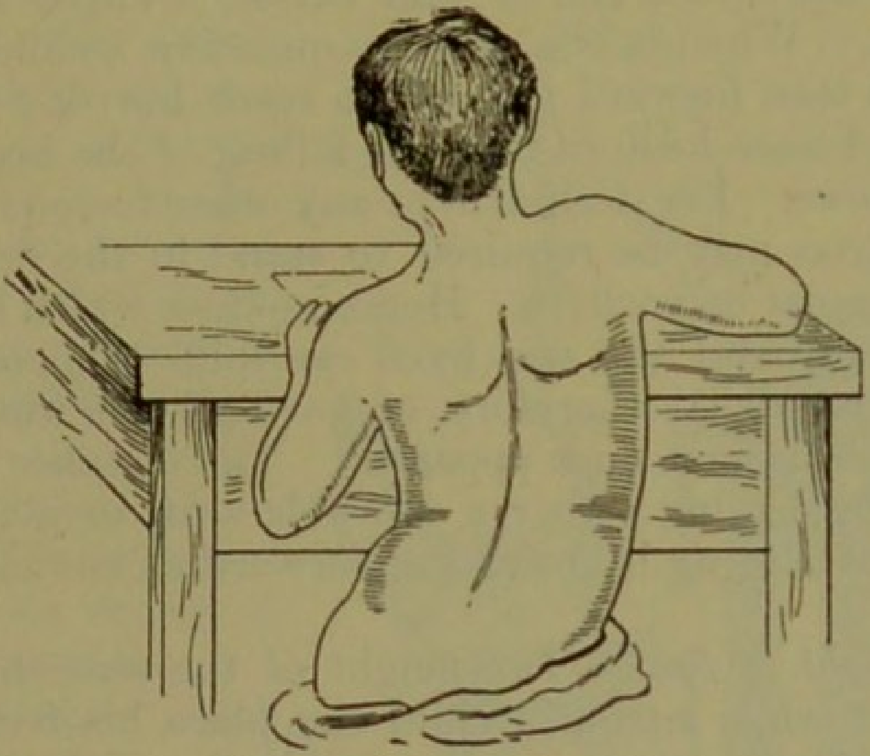

Fig. 18.—Curvature of the Spine.

The points to be attended to in school-desks are: (1) the difference; (2) the distance; (3) height of seat; and (4) slope of desk.

1. *Difference.*—By the *difference* is meant the vertical distance between the desk and seat. The higher the desk, or in other words the greater the difference, the nearer is the child's work to his eye. The accommodation of the eye is thus unduly taxed, and a tendency to short-sight is induced. The height of the desk above the seat

should be such that a child when sitting down can place his forearms comfortably upon the desk, without having to raise or depress the shoulders. The difference may be taken at about one-sixth of the height of the whole body.

2. *Distance.*—This refers to the horizontal distance between the inner edge of the seat and a vertical line let fall from the edge of the desk. For writing purposes the distance should be nil, or still better, a slight negative quantity. When it is a positive quantity, a child is compelled to lean forward in order to reach his copy or other book, and once he does this, the falling of the head naturally follows. For desk-drill or any other lesson in which the children may be required to stand in the desks, the distance must be positive. Hence no desk which has both the desk-top and the seat fixed can fulfil this condition; and the necessity, therefore, of having some kind of adjustable desk is at once apparent. The distance may be altered by having either a movable seat, or a desk-top capable of sliding backward or forward as circumstances require.

3. *Height of Seat.*—The height of the seat should be such that when sitting a child can place his feet firmly upon the floor; otherwise they will be dangling in the air. The height should equal the length of the scholar's leg from the sole of the foot to the hough, or back part of the knee-joint. The width of the seat must be at least ten inches, or better still, twelve, so that ample support may be given to the legs. All seats ought to be provided with a *back-rest*, for no one can sit upright for any length of time without some support being given to the back. It need only consist of a piece of wood about three inches broad, and slightly hollowed out to fit the shape of the back. Its height above the seat will vary with the size of the child.

4. *Slope of Desk.*—Desks should not be flat, but when used for writing should slope 15° towards the child. A portion of a desk should be capable of being raised to 45° to form a book-rest during reading-lessons.

A Model Hygienic Desk.—Since attention has been called to the evils arising from ill-constructed desks, several educational companies have endeavoured to meet the requirements of both teachers and medical men. At the request of the Midland Educational Company, Mr. Priestley Smith has designed a hygienic desk embodying the principles laid down by Dr. Cohn, and other authorities on school hygiene. Referring to this desk in an article in the *Ophthalmic Review* for June, 1886, Mr. Smith says: "I have lately designed a school-desk which embodies the recognized essentials in as simple and inexpensive a manner as seems to me to be possible. . . .

"Adopting, with little alteration, the proportions given by Professor Snellen for the various parts of his desk, I have, for the sake of convenience and economy, slightly altered the progression, and reduced the number of sizes to four. I divide the scholars according to their heights into four classes, advancing in each case by six inches, thus: 3 feet 6 inches to 4 feet, 4 feet to 4 feet 6 inches, 4 feet 6 inches to 5 feet, and 5 feet to 5 feet 6 inches."

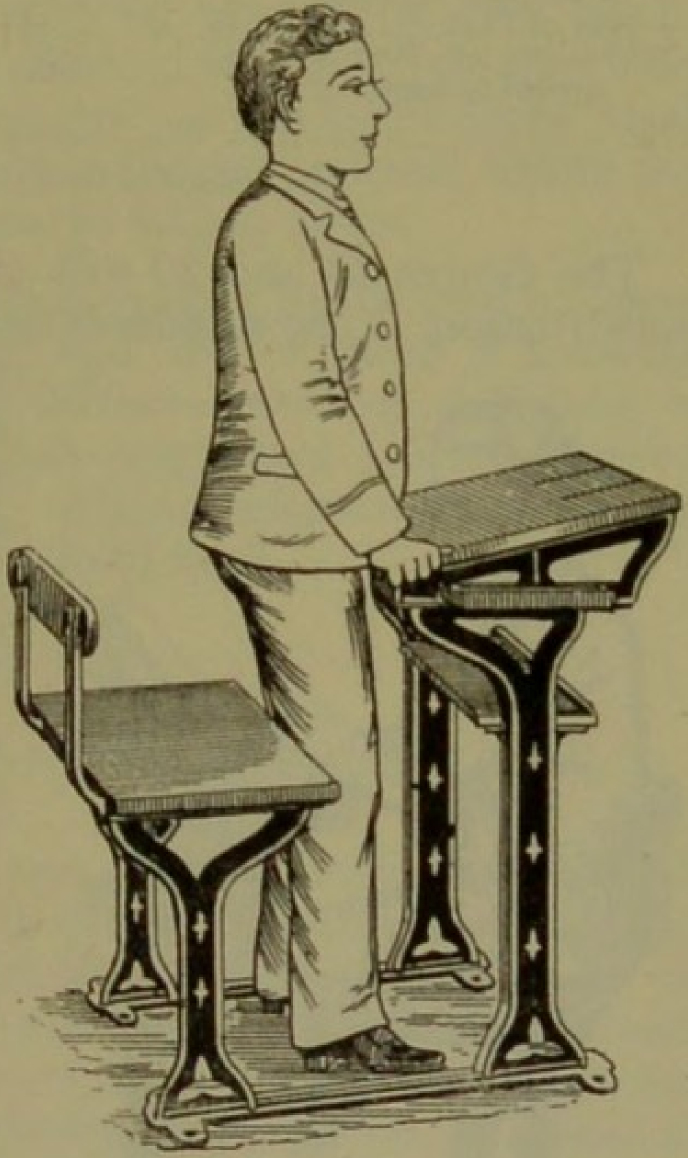
Fig. 19.—Model Hygienic Desk.

The dimensions of the four sizes of these desks will be seen in the following table:—

	No. 1.	No. 2.	No. 3.	No. 4.
Height of Scholars, ..	3ft.6in.–4ft.	4ft.–4ft.6in.	4ft.6in.–5ft.	5ft.–5ft.6in.
a Height of Seat from Floor, ...	13 inches.	14½ inches.	16 inches.	18 inches.
b Breadth of Seat, ...	10 ,,	11 ,,	12 ,,	13 ,,
c Height from Seat to Edge of Desk,	8 ,,	8¾ ,,	9½ ,,	10½ ,,
d "Overhang" of Desk,	1 ,,	1 ,,	1½ ,,	1½ ,,
e Play of Desk, ...	4½ ,,	4½ ,,	6 ,,	6 ,,
f Breadth of Desk (front to back), .	15 ,,	15 ,,	17 ,,	17 ,

Slope of Desk, 1 in 5.

The figures 19 and 20 will give a general idea of its construction. The standards and cross pieces are of cast-iron. The back, seat, top, and book-shelf are of wood; and either single or dual desks may be had.

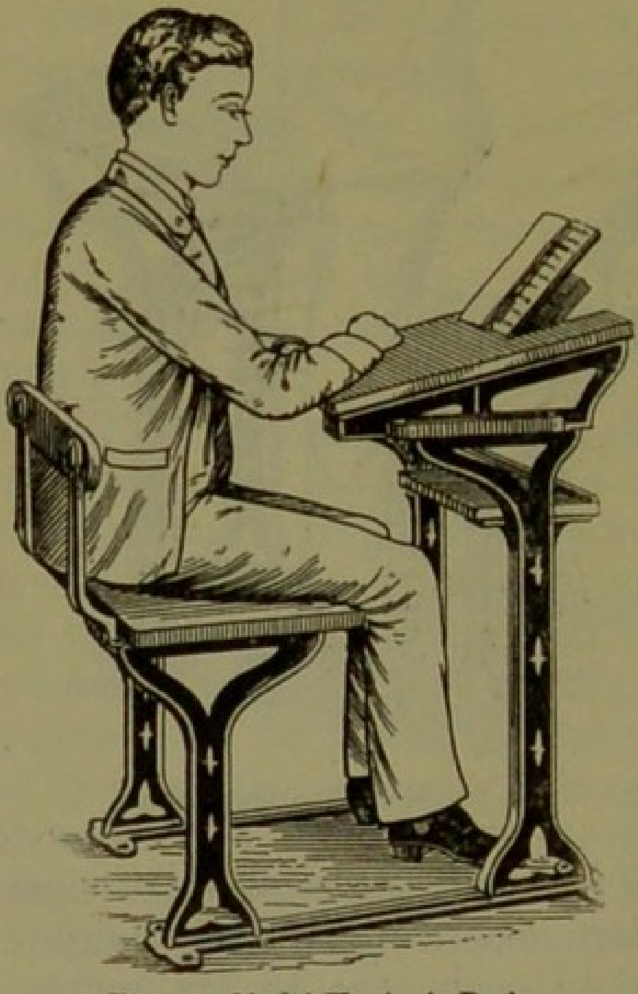
Fig 20.—Model Hygienic Desk.

The "Patent Adjustable Modern Desk" of the North of England School Furnishing Company can also be recommended as fulfilling every hygienic requirement.

Black-boards.—The black-boards should be of a good size, and made of well-seasoned wood. Their surfaces should be kept dull, so that the children shall not have any difficulty with the reflection of light. Black-boards upon easels, or those which slide up and down in wooden frames after the fashion of window-sashes, are preferable to the boards which swing upon pivots. With the latter kind the teacher has to assume ungraceful attitudes when working upon the lower part of the board, whilst the children are compelled to keep rising from their seats to see what has been written there. In addition to blackboards, it is a good plan to have slate slabs let into the walls in front of the class. They will be found extremely useful for many purposes.

Easels.—Easels should be made firm and strong. The flimsy three-legged easels should be avoided. They do not afford sufficient support to the larger-sized blackboards, and serious accidents have happened before now in consequence of the boards falling down.

Pictures.—Pictures add greatly to the general cheerfulness of school-rooms, and are of great educational value. Many excellent pictures are now published by many firms, and we need only warn teachers against choosing them too small. All *charts* for teaching purposes should be printed in very bold type.

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*Chapter XVIII.—LOCAL CONDITIONS.

Soils.—From a hygienic point of view the term soil includes all that "portion of the crust of the earth which by any property or condition can affect health." If we examine the surface of any country we find it covered by a soft layer, usually not more than two or three feet in thickness, known as *surface soil* or *mould*. Under this is a somewhat harder layer, the *subsoil*, which may be many feet thick; whilst beneath this again are the rocks from which the soils above are mostly derived. Hence the nature of the soil will largely depend upon the character of the rocks beneath. But in addition to the mineral matter which forms the greater bulk of soils, there is invariably present a varying proportion of animal and vegetable materials. This is especially the case with what are known as "made soils," which abound in many town and suburban localities. These "made soils" are composed of all kinds of rubbish—offal, road-sweepings, the contents of dust-bins, and such like—which have been tipped into hollows or on low-lying ground for levelling purposes. From such accumulations as these, offensive gases arise from the decay of the organic matters contained therein, and there can be little doubt that such emanations must be highly prejudicial to health.

The Air in the Soil.—All soils contain a certain amount of air, the hardest rocks only being free from it. Its amount varies with the character of the soil and with the level of the ground-water, much of the air being driven out as the ground-water rises. It is extremely rich in carbonic acid, often containing 4 per cent, and even 6 or 8 per cent of that gas. Occasionally it contains carburetted hydrogen, and sometimes sulphuretted hydrogen. Buildings which are artificially warmed are continually aspirating this air from the soil, unless the floors have been made impervious; and the air from cesspools, defective drains, &c., finds its way into houses in a similar manner.

The Water in the Soil.—Soils are sometimes spoken of as pervious or impervious, according as they allow water to pass through them or not. Rocks like sandstone, chalk, gravel, &c., allow the water to pass freely through them; whilst those of a clayey nature retain it. Hence all those rocks which are more or less impervious will contain a large quantity of water, and to this water the term ground or subsoil water has been given. This subterranean sheet of water is met with at various depths according to the nature of the rock of the district; sometimes it is only 2 or 3 feet from the surface, in others it may be as many hundreds. Even in the same locality the level of the water changes from time to time, now higher and now lower. These variations in its level are due to several causes, such as rainfall, overflowing of rivers, tides, &c. The nearer to the surface the subsoil rises, the damper and more unhealthy becomes the soil. If possible it should never be allowed to come nearer the surface than 6 feet; and no site can be considered as satisfactory if the level of its ground-water is subject to frequent changes. The best soil so far as its general freedom from dampness is concerned, is a gravelly one, provided, of course, that the site is not below the level of the surrounding country. Peaty soils, and the alluvial soils formed by the mud brought down by rivers, are usually very damp, besides containing considerable organic matter.

Subsoil Drainage.—It is only within the last few years that the health of a district has been proved to be greatly influenced by the nature of the soil and its drainage. Formerly ague was very common in this country, but the thorough drainage of all our old fen and marshy districts has now practically banished it from our shores. Abundant statistical proof has also been given by Dr. Buchanan in his reports (1866–67) that consumption is closely connected with damp soils. For instance, the number of deaths from consumption in Kent, Surrey, and Sussex was found to be lowest on the Thanet and other sands, and highest on the clays; whilst the death-rate from the same disease was reduced about 50 per cent in Salisbury, Ely, Macclesfield, and other towns by a thorough system of subsoil drainage. Outbreaks of malarious diseases, typhoid fever, cholera, dysentery, and yellow fever have also been attributed to the soil on which the houses were built. Among the lesser ills, either promoted or entirely produced by damp soils, rheumatism, neuralgia, colds, and toothache are the commonest.

The importance, therefore, of obtaining a dry soil is at once apparent. To attain this desired end two methods are commonly resorted to, viz. deep drainage and opening the outflow. In deep-soil drainage, artificial channels are laid from 8 to 12 feet deep, and from 10 to 20 feet apart, and made to slope towards some proper outlet. In the second measure the clearing of water-courses, removal of obstructions, and formation of new channels are the chief points to be carried out. The provision of sufficient *surface-drains* to carry off storm-water, &c., much of which would otherwise soak into the ground, is also to be recommended. The ordinary sewers are generally depended upon to do this, but it is a better plan to have separate drains for the purpose.

Building Sites.—By the term *building sites* we mean the plots of ground on which houses, &c., are built. In large towns, unfortunately, Hobson's choice—"this or none," is about the only one most people have. When, however, a choice does exist, the following points should be borne in mind in selecting a site:—

(1) *The site should be dry.*—Therefore avoid all low-lying ground; it is not only damp and cold, but receives the drainage of the parts around. Promoters of school-buildings especially ought to be most careful in deciding upon a site, and no buildings should be erected upon it until they have satisfied themselves as to the nature of its soil. Trial holes may be dug until the subsoil-water is reached, so that the extent of the alterations in its level can be determined. The character of the subsoil will also be seen from such trial holes.

In those districts which partake of the nature of plains, advantage should be taken of any elevated portion. On the other hand, in hilly districts the summit of a hill is likely to be very cold and bleak. The best situation is the slope of the hill, as it is easily drained, and not subject to the extremes of temperature of the base and summit. Care, however, must be taken to keep all buildings erected clear of the ground at a higher level. This can be done by raising the site, and making the surface slope downwards from the house to the rising ground.

(2) *The site should admit of proper drainage.*—No difficulty in this respect will be experienced where the ground slopes away from the house in every direction. Level or low-lying ground is not easily drained, and it should be a *sine qua non* that no site should be selected which does not admit of a proper drainage.

(3) *The site should be airy.*—The site should be freely exposed to the air on all sides, and not surrounded by hills, trees, or high buildings, so that a free circulation

of the air is impossible. For a similar reason, the houses in towns should never be built "back to back," but always in wide streets, with plenty of space between the two rows. Unless there is a free circulation of air about our houses, we can never expect them to be dry; wet clothes are never shut in a box to dry.

(4) *The site should not be on the banks of a river.*—The immediate neighbourhood of rivers, and especially sewage rivers, is to be avoided; it is almost certain to be damp. The same danger is to be feared from the proximity of large sheets of water, for which some sites are particularly chosen, prettiness of landscape being considered before healthiness.

(5) *Aspect.*—The position of the site in reference to the points of the compass is also important. It should be such that the house can receive plenty of sunlight, and not be open to prevalent cold winds. "A northerly aspect is always bleak and cold, and almost always damp. An easterly aspect is cold, especially in the spring; but it is fairly dry, though a good deal of rainy weather comes at times from the south-east. A southerly aspect combines as much warmth, dryness, and sunshine as the peculiarities of the climate will in any way allow. A westerly aspect is warm, but inclining to damp, and exposed to the moist and rainy gales which, especially on the channel coast, come almost always from the south-west" (Turner). It is better for the house not to face any one of the cardinal points of the compass, but diagonally to these. On the whole the best aspect which can be given to a house is the south-east, and the rooms occupied most during the day should be also on that side. For a steady, diffused light, such as is best for a library or study, a northerly aspect should be selected.

(6) *The site should not be near offensive works.*—The smell arising from many processes, such as bone-boiling, soap-making, &c., is very objectionable, if not actually injurious. The neighbourhood of cesspools, middens, manure-heaps, &c., is to be specially avoided.

(7) *Trees should not be too near.*—The presence of trees is undoubtedly beneficial, but they must not be too close

to the house. They serve to ward off the cold winds, and assist in drying the soil. The *blue gum-tree* of Australia, and our common sunflower, are especially noted for the latter property.

(8) *"Made-soils" must be avoided.*—If possible "made-ground" should never be selected; but where there is no other alternative, then the superadded earth should be dug out until the virgin soil is reached. By virgin soil we mean that which has not been disturbed in historical times. On no account should the excavation made be used for underground dwellings, or playgrounds in the case of schools, unless proper means are adopted for the removal of the pernicious ground-air.

Climate.—By the climate of any particular place we mean the prevailing or average character of its weather. It is the combined effect of the various atmospheric phenomena, and includes therefore the temperature of the air at different times and seasons, direction and force of the prevailing winds, humidity of the atmosphere, rain-fall, &c. Hence the climate of a country will have an important bearing upon the health of its inhabitants.

Causes which Modify Climate:

(1) *Distance from the Equator.*—This is one of the most important factors in the determination of the temperature of a place, for upon it depends the amount of direct solar heat which the place enjoys. The amount of solar heat which any given place receives is in proportion to the time of exposure to the sun's rays, and the angle at which they strike its surface. In the tropics they descend vertically at noon, and so produce their maximum effect; but as we recede from the equator the rays fall more and more obliquely, and are not so hot, partly because they are distributed over a greater area, and partly because of the absorption of some of the heat in its passage through the thicker layer of atmosphere. The mean yearly temperature at the equator is about 82° F.; for this country it is about 50° F.

(2) *Proximity to the Sea.*—Land is heated more rapidly

than water, but being a good radiator of heat, cools more quickly. Consequently the temperature over the ocean is more equable than that over the land. Hence places situated upon the sea-board do not experience such extremes of temperature as places further inland, and this has led to the division of climate into *insular* and *continental.* A marked feature of sea-side places, especially those on tropical islands, is what are known as *land* and *sea breezes.* When the earth's surface is heated by the solar rays, it communicates its heat to the atmosphere resting upon it; and since land is heated more rapidly than water, it follows that the air over the land will be hotter than that over the sea. The warmer air of the land being light, rises, and the cooler heavier air from the sea flows in to take its place, thus giving rise to a sea-breeze. At night the land radiates its heat more rapidly than the sea; the atmosphere over the land, therefore, becomes colder and denser than that over the sea, and a gentle breeze sets from the land to the sea, and continues until sunrise. This is the land-breeze.

(3) *Altitude above Sea-level.*—Since the atmosphere receives the greater part of its heat by conduction from the earth, the air as a general rule will be colder as we ascend from the surface. We say as a general rule, because there are exceptions to it, as proved by Mr. Glaisher in his balloon ascents. The air of higher regions is also purer, being richer in ozone and freer from dust than that of the lower regions. In India, sanitaria are established at considerable altitudes in the Himalayas and Neilgherries; and Europeans generally move to the hills in order to recruit their health, when it has broken down through the excessive heat of the plains below.

(4) *The Prevailing Winds.*—Winds partake of the temperature of those countries over which they have travelled. The east winds, so prevalent in England, come from Siberia and Northern Russia, and are therefore cold and dry. On the other hand, our south-west winds are moist and warm; consequently our western coasts have a greater rainfall and milder climate than the eastern coasts.

(5) *Presence or Absence of Vegetation.*—The rainfall of a district is greatly influenced by the presence or absence of vegetation. Where no vegetation exists, as in the sandy plains of Sahara, the land becomes intensely heated, and the air partaking of its temperature would be able to hold more and more moisture, so that the fall of rain is next to impossible. Land covered with an abundant vegetation has its soil kept cool, and thus greatly assists condensation.

(6) The other factors which influence climate are: the presence of *ocean currents; direction of neighbouring mountain chains; nature of the soil*, and its *degree of cultivation*, &c.

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*CHAPTER XIX.—CONSTRUCTION OF BUILDINGS.

Healthy Houses.—Good food, fresh air, pure water, and healthy houses are among the chief essentials for the maintenance of health. The first three requisites have already been studied, and we now proceed to discuss the principal points to be borne in mind in the healthy construction of buildings intended to be occupied by man. For this purpose we shall divide the subject into two parts, dealing first with the materials employed, and then the manner in which they are built.

Building Materials.—The materials employed in the construction of houses will depend largely upon local circumstances. In those parts where *stone* is abundant the greater number of houses will be constructed of it, as in the West of England and Wales; but where a proper building-stone is wanting, the houses will be mostly built of *brick*. A combination of *wood* and brick, known as half timber-work, is also used in country-places. *Concrete*—a mixture of cement and broken stone, &c.—has been requisitioned of late years, and for temporary schools and churches *corrugated iron* is chiefly employed. The latter, however, has the disadvantage of being very cold in winter and hot in summer when used alone. The better plan is to have a lining of match-boards, and the space between the two filled with saw-dust; the extremes are in this way avoided. Occasionally *mud* is resorted to, but such a material is highly objectionable, on account of the organic matter which it invariably contains.

Whatever materials are employed, the importance of having them new cannot be overrated. Defective and unsound drain- or soil-pipes, cisterns, and second-hand materials of any kind should on no account be used. Frequently the improvement schemes of large towns necessitate the pulling down of many old houses. This gives the "jerry" builder an opportunity of speculating, and he never fails to take advantage of it. His purchases are then used for the erection of "new" houses, their true character being hidden by a coat of plaster or paint. We have even seen the foul saturated bricks of old sewers used before now for inner walls of houses, a practice which no words of ours are strong enough to condemn.

Construction of the House:

(1) *Preparation of the Foundation.*—The stability of a building depends upon its foundation, and the thickness of its walls in proportion to their length and height. Unless the walls are erected upon a firm foundation, sinking or settling must inevitably follow, and this leads to cracks in the walls, and the jamming of the door and window frames. To obtain a substantial foundation the ground should be excavated to such a depth as will secure a solid bed of earth or rock. A bed of concrete should then be laid so as to extend completely under the house, and at least six inches beyond on all sides. It should not be less than eighteen inches thick, and is best made of Portland cement and crushed brick or small gravel. Where the expense of concrete is objected to, a layer of well-kneaded (puddled) clay is a good substitute.

In commencing the foundation walls, "footings" (fig. 21) are usually constructed first. These are for the purpose of affording a proper bearing surface for the superincumbent walls to rest upon. In height they should be equal to two-thirds of the thickness of the wall resting upon them, and should project on each side of it at least one-half of the thickness of the wall. Thus in the case of an eighteen-inch wall, the height of the footings would be twelve inches, and the width at the base about three feet.

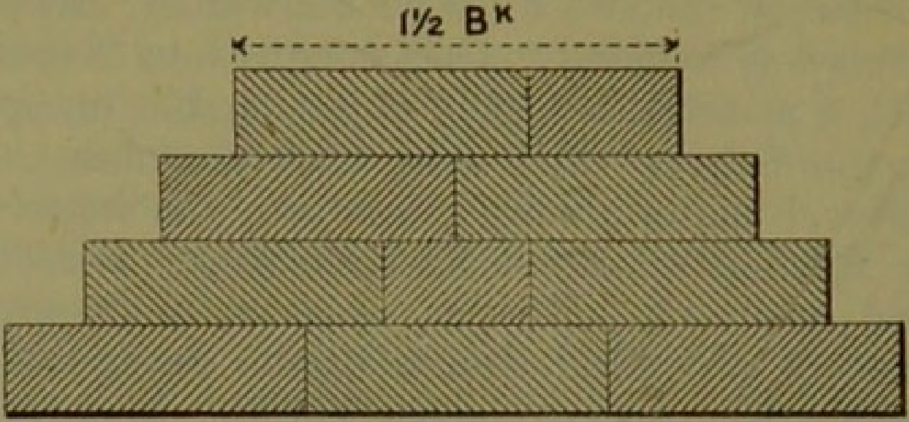


Fig. 21.—Footing for Foundation Wall.

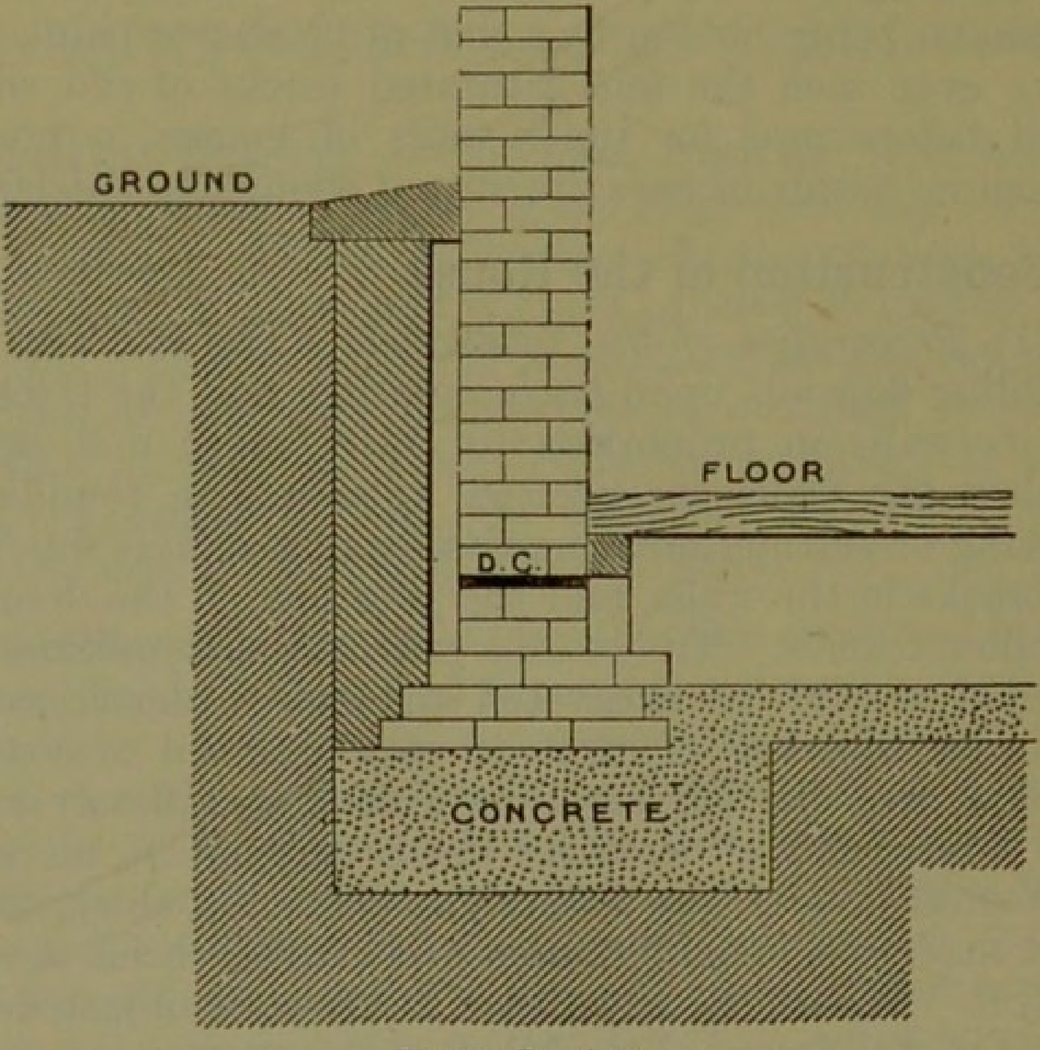


Fig. 22.—Dry Area.

In order to keep the whole of the foundation brickwork as dry as possible, a free circulation of air should be allowed around the basement. One of the best ways of securing this is to excavate an "open area" round the house, or where this is impracticable, what is called a "dry area" (fig. 22) may be constructed. The latter is simply a space of sufficient width to keep the damp soil from contact with the walls, and covered at the top, except at a few points where openings are left for the thorough ventilation of the area. In both open and dry areas it is necessary to arrange for their proper drainage. Underground cellars, when properly constructed and thoroughly ventilated, also assist greatly in keeping the house dry.

(2) *The Walls.*—Efforts must not only be made to try and keep the foundation-walls dry, but in case they should in any way become damp, means must be taken to keep the moisture from rising into the walls above the ground-level; for it is to be remembered that water spreads through brickwork like ink through blotting-paper.

The plan most generally adopted for this purpose is to insert a layer of some impervious material, called the *damp-proof course*, in the wall a little above the level of the ground. This course is made of various materials, such as sheet-lead, two or three layers of slates bedded in cement, a layer of asphalte about $\frac{3}{4}$-inch thick, or perforated glazed tiles made specially for the purpose. Sheet-lead forms an excellent material for damp courses; it is easily laid, and in case any settling occurs in the house it readily "gives," as it is technically termed, and yet does not break, although twisted and bent out of its original position. The perforated stoneware tiles (fig. 23) are equally good, and are preferred by many because the holes which run through them act as ventilators for the space below the floors. In the case of those houses which have a basement storey, or a half-sunk basement storey, the damp-proof course must be placed below the ground-level.

The outer walls of buildings are also liable to become very damp by the rain beating against them during continued wet weather; and to prevent it from passing to the inner walls other precautionary measures must be adopted. Ordinary bricks are 9 inches long, $4\frac{1}{2}$ inches broad, and $2\frac{1}{2}$ inches deep; and since each brick is capable of holding about a pint of water, it is evident, when the number of bricks in the outer walls is taken into consideration, that the danger of dampness from this cause is considerable.

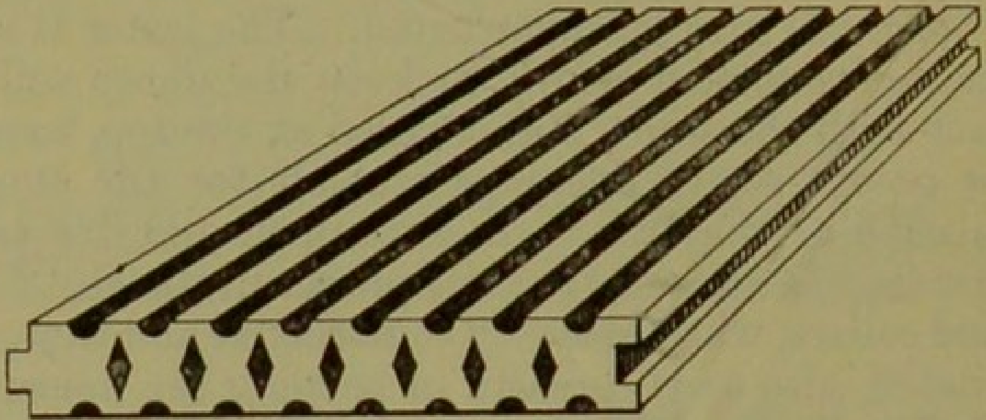


Fig. 23.—Perforated Stoneware Tiles.

Various methods have been resorted to for the purpose of keeping the inner walls dry, such as making the outer walls double, leaving a space of two or three inches between the two, and tying them together by a sufficient number of "bonding-ties" of iron or glazed stoneware (fig. 24). Walls which are in very exposed situations should be covered with a layer of good cement, or with overlapping slates or tiles.

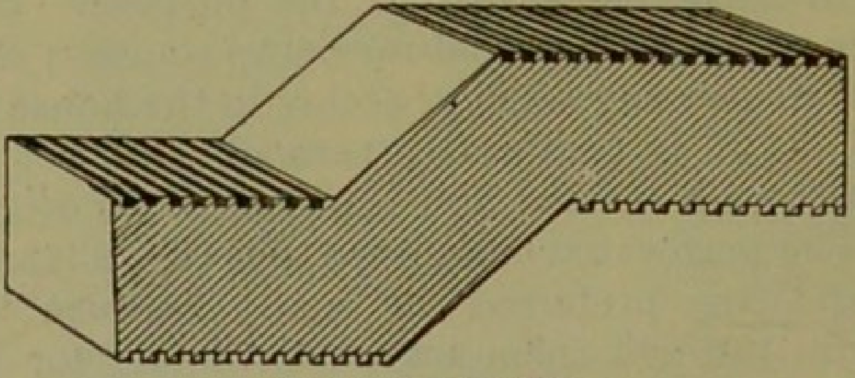


Fig. 24.—Bonding Ties.

(3) *The Roof.*—Badly-constructed roofs are a common source of dampness. They are made of either tiles or slates, the latter being more generally preferred. *Thatch* is used

in rural districts, and makes a most comfortable roof; but it is so liable to injury by birds and mice, as well as from fire in dry weather, that it is being rapidly replaced by other materials. The slope of the roof should extend some distance beyond the walls, and be provided with a good gutter. Down spouts should stand clear of the walls, so that in case of an overflow the water will not run down them.

(4) *Floors.*—Wood, stone, or tiles are the materials commonly employed for floors. Of these wood is certainly the best for living rooms; stone and tile are too cold, and are better for kitchens, sculleries, lobbies, &c. The wood should be hard and well seasoned. When the floors are made with ill-seasoned wood, the boards gradually shrink, until at last there are considerable spaces between them, through which the ground air and other foul gases may pass from the soil into the rooms above. Or dust and other matters may fall through and collect between the floor and the ceiling of the room below. Such accumulations are almost certain to decompose and so vitiate the atmosphere.

The ground-floors of all buildings should be raised some distance above the soil, and on no account must the joists of a wooden floor rest upon the ground. The best of timber is liable to rot from several causes, but rotting can be greatly prevented by having a free circulation of air beneath the boarding. The ends of the joists should also be surrounded by an air-space which communicates with the external air.

For schools, an excellent floor can be made by paving the rooms with blocks of wood set in asphalte. The blocks are about two inches square and nine or ten inches long, and are laid herring-bone fashion. Such floors are more expensive than the ordinary ones, and are not so easily cleaned, but they are much warmer, less noisy, and more durable.

To prevent the sound from one room being audible in another immediately below, a layer of rough boards should be placed on fillets nailed to the joists, and the space thus formed between the two boardings filled with saw-dust, or better still a layer of lime-and-hair mortar. Slag-felt is also said to have a remarkable power of deadening sound.

(5) *Inside Walls.*—The inside walls should be made perfectly impervious, so that respiratory and other impurities cannot soak into them. For this purpose there is nothing better than glazed bricks or tiles. They form a perfectly smooth surface, and are easily and thoroughly cleaned. If the expense of such a method be objected to, then let there be a dado only of glazed tiles, say four or five feet high, and the space above covered with hard cement, which may be afterwards painted and varnished.

Wall-papers are very objectionable, being the most absorbent of all coverings. Varnishing improves them, as it does not enable the dirt to stick so easily, and makes them more impervious. School walls must never be papered. If glazed bricks or tiles are too expensive, they are better plastered and coloured. Ceilings are also to be treated in the same manner.

Ledges and other projections which can harbour dust should be abolished as far as possible. Cornices and the like should never be permitted, and the tops of doors and windows should be levelled off.

(6) *Staircases.*—Staircases should be constructed of fire-proof material. They should be broken by short landings at every 12 or 15 steps, to diminish the seriousness of a fall. For this reason spiral stairs without landings should never be permitted where children are concerned.

(7) *Cloak-rooms.*—All schools ought to have ample cloak-room accommodation. A separate peg should be allowed each child to hang his outdoor garments upon, and properly drained umbrella-stands should also be provided. In some cloak-rooms the garments are inclosed in cupboards which are kept locked during school hours. This is a very objectionable method. The clothes should be freely exposed to the air, to enable them, if wet, to dry by the time school is dismissed. In fact, cloak-rooms

should be constructed with the view of drying the clothes, if need be. They should be heated by a system of hot-water or hot-air pipes, and properly ventilated to remove the vapour arising from damp clothes.

In large schools it is better for the sake of discipline to have several smaller cloak-rooms, rather than one large one; but on no account ought they to be used for class-rooms.

(8) *Playgrounds.*—Playgrounds should be added to every school, and as large as circumstances will allow. They should be thoroughly drained, and provided with sufficient protection from cold winds and wet weather, especially in the case of infant schools.

*CHAPTER XX.—REMOVAL OF REFUSE MATTERS.

Necessity of Removing Refuse.—Every day, in every house, a certain amount of waste matter is produced. Among such waste matters are the solid and liquid excreta of human beings; house slops, including the water used in cooking and washing; organic refuse of animal or vegetable origin; ashes, dust, &c. If these were allowed to accumulate about our dwellings, they would not only become an eyesore, but a positive source of ill-health. However perfectly our houses may be constructed, lighted, heated, and ventilated, unless there is a sound system for the removal of such refuse there will always be a danger of the outbreak of those diseases that are known to be associated with bad conservancy. These diseases include typhoid fever, diarrhœa, diphtheria, cholera, ophthalmia, and many others. So that as far as the health of the community is concerned, the speedy removal of all waste matters is of prime importance.

In the primitive condition, and in sparsely populated districts, no great difficulty is experienced in this direction As a rule they are returned at once to that great deodorizer—the soil. But when a great number of people are gathered together, as in towns, such a method is obviously out of the question, and therefore other means have to be adopted.

Conservancy Systems.—The systems employed for the removal and disposal of refuse may be arranged under two heads:—

1. The dry system, by which most of the refuse is carted away, and
2. The water-carriage system, by which most of the refuse is carried away by water.

In most towns to-day the water-carriage system is principally employed; but in those places far removed from the sea or any water-course, dry systems are still largely used, and in many instances with considerable success.

Dry Systems.—The various dry systems which have been, or are still employed, include the *midden* and *cesspool systems*, the *pan* or *pail system*, and the *dry-earth system.*

(1) *Middens and Cesspools.*—The sanitary arrangements in many parts of this country a few years ago were of the vilest description. Closets, such as we have now, were unknown among the poorer classes, and everything in the shape of sewage, garbage, &c., was thrown into the streets, ditches, and fields, or whatever came handiest. The first step towards remedying this shocking state of affairs was the setting aside of a special plot of ground for the reception of the refuse of one or more houses, forming what is known as a "midden heap." No out-houses were erected, and if any convenience existed at all, it simply consisted of a cross-bar or plank for a seat. The refuse was allowed to accumulate for an unlimited time, or until it was required for manuring purposes.

Very frequently separate receptacles were made for the human excreta, ashes and the like being thrown into a heap only. At first these "cesspools," as they are termed, were merely excavations in the ground, through which the excretal matters percolated into the surrounding wells. In fact, in very porous soils this natural drainage would be practically sufficient to keep them empty; and numerous instances are on record of cesspools being permanently covered in on this account. The generality of cesspools, however, required emptying from time to time, much to the discomfort of the neighbourhood around. Very frequently instead of emptying them they were simply covered in, and new ones dug; and the late Mr. Eassie says that many of these cesspools are to be found in the older houses of London.

This cesspool system is still very common in country places, but under no circumstances should it be permitted in towns, or where a large number of houses are in close proximity to one another. Where cesspools are unavoidable they must at all times be made perfectly water-tight. This is best done by making them of brick set in cement, lining the inside with the best hard cement, and surrounding them with puddled clay. They should always be situated at a considerable distance from the house, and frequently emptied.

(2) *Pail System.*—The pail system is a great improvement upon the previous one, inasmuch as the excreta are removed at more frequent intervals from our dwellings. In one form of the system a galvanized iron vessel is placed under the seat in every closet for the reception of human excreta only. These pans are removed every week, during the night, and clean ones left in their places, by men employed for the purpose. House drains are provided for the removal of the house-slops, &c. A large wooden tub, with iron handles at the side, is also provided for the ashes, broken crockery, and other dry refuse. It is generally placed at the back of the closet, and is sheltered from the rain by an extension of the closet roof. It is sometimes emptied at the same time that the pails are changed, but quite as frequently in the daytime.

A still better plan is that known as the "Manchester Pail System." Fæces alone decompose but slowly, and urine will remain unchanged for several days, but when the two are mixed decomposition rapidly ensues. In order, therefore, to retard this decomposition, various methods have been tried to keep the excreta as dry as possible, and the "Manchester Pail System" is one of them. A movable pail is placed beneath the seat as above; but in the closet wall are several openings, through one of which ashes may be thrown. These are received upon a sieve, by which they are separated into fine ashes, which fall into the pail under the seat, and larger cinders, which fall into another pail, from which they can be removed through a second opening, and used again as fuel. The other kinds of refuse are received into a tub as before. On the other side of the closet wall are openings for the scavengers to change the pail and ash-tub.

In the Goux system the pail is lined with some kind of absorbent material, which is pressed into shape by means of a cylindrical mould. The excreta are received into the cavity thus formed, and the fluid portions are more or less completely taken up by the absorbent lining according to the length of time the pail has been in use. A few days, however, are sufficient to saturate the lining, so that the pails must be removed once a week at least.

(3) *Dry-earth Closets.*—The dry-earth system is without doubt the best of the many dry methods yet proposed. Its application in large towns, however, is very limited on account of the enormous quantity of earth that would be required for its proper working; but in country places, where earth is more easily obtained and stored, it may be made a decided success. The powerful deodorizing properties of dried earth were first pointed out by the Rev. H. Moule, and since then many different forms of dry-earth closets have been invented.

In the majority of them the dried earth is placed in a box or "hopper," which is provided with a mechanical arrangement, so that each time the closet is used about 1½ lbs. of the earth fall upon the dejections. In others the dried earth is simply scattered over the excreta by a scoop in the hand of the user. According to Dr. Buchanan, dry clay and loamy surface-earth, but especially the brick-earth of the drift formation, are the best kinds of earth for the purpose. Charcoal, saw-dust, and a mixture of peat and earth or ashes, have also been successfully employed. Sand, gravel, and chalk are of little use. But whatever kind of earth be selected, it must be thoroughly dried and finely sifted before being put into the hopper. As soon as the closet pail is full its contents may be either spread over the land for manure, or stored in a heap under a shed until the earth has completely disintegrated the fæcal matters, when it may be used over again.

The Water-carriage System.—When the offensive nature of sewage, to say nothing of its possibly infected character, is considered, our first care should be to remove it at once from about our dwellings; and any system which does not enable us to do so is fraught with considerable danger to health; the superiority, therefore, of the water-carriage system, by which the most dangerous portion of the refuse is immediately washed away, is at once apparent. Instead of the filthy middens and cesspools—the emptying of which was always a terrible nuisance to the neighbourhood—each house is connected by impervious drains to the sewers, which ultimately pour the whole sewage of the town into rivers, the sea, or carry it to a sewage-farm. The objections which have been raised against the water-carriage system are in almost every case the result of defective sanitary appliançes or else bad workmanship. If there is a constant smell of ammonia about the house, it is a sure sign that there is something wrong with the drains, and no time should be lost in remedying the defects.

Drains.—The house-drain is the pipe which conveys the waste water, &c., to a cesspool or sewer. A sewer is a drain which receives the contents of the drains of a number of houses. Outside the house the drains may be constructed of glazed stoneware pipes with cemented joints, or with Stanford's patent joints. Inside the house and in made ground, quicksand, or in the neighbourhood of trees iron pipes are preferable. They should be coated inside and out with Dr. Angus Smith's solution, or treated by the Barff process, and should have their junctions well caulked and leaded. Brick channels, unglazed pipes, and wooden conduits should never be used for house-drains. Select only those drain-pipes which are well glazed, perfectly smooth inside, true in section, and of uniform thickness.

The diameter of the drain will depend to some extent upon its fall, the amount of water used per head per day, and the amount of rainfall, unless the rain-water be collected and stored in cisterns. For small houses 4 or 5 inch pipes, and for larger ones, 6-inch pipes will generally be found sufficient.

In laying drains great care should be taken that the pipes rest upon a firm foundation, and that they have a proper fall. For pipes of 4 or 6 inches diameter a fall of from 1 in 40 to 1 in 60 is desirable. When the fall is very slight, some form of flushing apparatus, such as Field's flush-tank, should be used. The joints between the pipes must be made perfectly water-tight to prevent the sewage soaking into the ground. They are best made with good cement; but it is important to see that they are carefully wiped inside the pipes, otherwise pieces of the cement may project into the drain against which the solid matters will lodge, and thus obstruct the onward flow of the sewage.

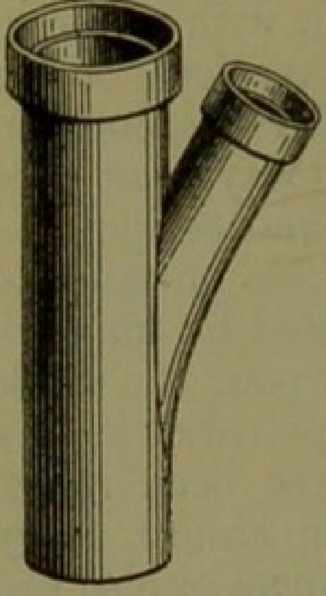


Fig. 25.—Junction of Drain-pipes.

All junctions with the main drain should be made by means of specially constructed lengths (fig. 25). They should never be effected at right angles, but slanting in the direction of the stream of sewage. They are frequently made by cutting a hole in the main pipe, into which the branch pipe is inserted, and the junction completed with bits of slate, &c., and cement. Such a primitive method as this should not be tolerated for a moment.

Drains should never be placed underneath a house, but should pass external to it; but if perforce they must go under the house from front to back, the wisest plan is to let them run along one of the foundation walls in the cellar, so that they may be easily inspected from time to time, and any leakage discovered.

Traps.—At the point where a drain leaves the house a complete break should be made with that part connected with the sewer, by means of some form of ventilating trap. Such a trap is shown in fig. 26, where A is the inlet pipe from the house, and B the outlet to the sewer, the connection between the two being broken by the trapping-water in the syphon. The air-chamber or inlet for fresh air is at C, and is fitted with a movable grating. The opening at D is for inspection purposes, and for the removal of any dirt which may have lodged in the trap. In many forms of traps there is another opening provided for a small ventilating shaft between the trapping-water of the syphon and the outlet to the sewer. Potts' Edinburgh trap is of this description. Hellyer's drain interceptor, and Doulton's traps are other forms that can be safely recommended.

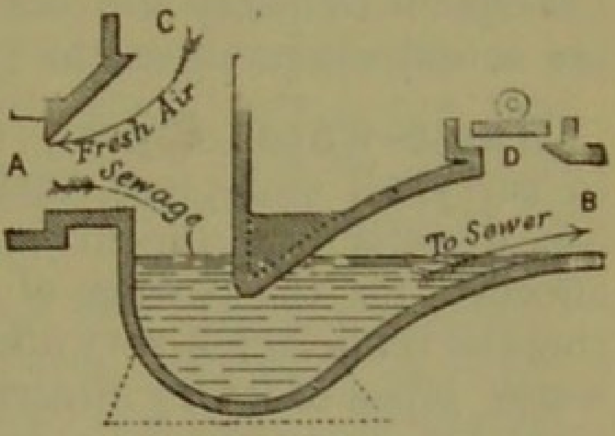


Fig. 26.—Buchan's Ventilating Trap, with Access Pipe.

Among the bad forms of traps there are two still much in use. The first is called the D-trap, from its resemblance to the shape of the letter D. It is a most insanitary appliance; for instead of being self-cleansing, it acts as a receptacle for the filth which should pass through it. The second kind of trap is still more objectionable. It is employed for trapping sink-pipes, yard-drains, and the like, and is a most reprehensible form. It is known as the Bell-trap (fig. 27), on account of the bell-shaped piece of iron fastened to the under side of the grating. The bell frequently gets broken, or is left off altogether by careless or thoughtless people; filth collects at the bottom of the box, and the water intended to act as a trap either evaporates or becomes displaced by dirt. A worse form of trap could not possibly be devised, for there is no safeguard whatever against the foul sewer gases passing into the atmosphere. The Dipstone-trap, Lip-trap, and Liverpool Bell-trap are other forms of yard-traps, and are as objectionable as the two preceding ones.

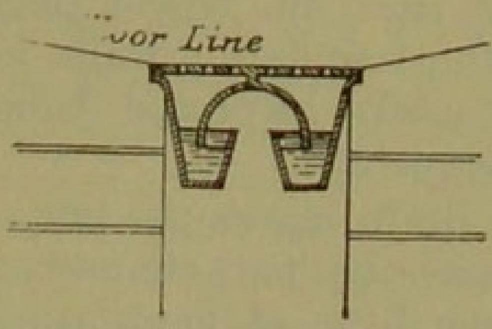


Fig. 27.—Bell-trap.

Waste-water Pipes.—Formerly it was the practice to carry all sink-pipes, bath-room pipes, lavatory-pipes, &c., directly into the drains. A ready means was thus afforded for the passage of sewer air into the dwelling, thereby rendering it very offensive and unhealthy. Waste-water pipes of every description should deliver always into the open air, over a trapped gully, or a disconnecting trap. Even then there is a danger of cold air, and possibly bad smells, being drawn through them into the warm rooms. Hence it is advisable to place syphon traps under the sinks, lavatory basins, &c., care being taken to have them properly ventilated.

Soil-pipes.—The soil-pipes into which the closets discharge should be invariably outside the house, and should be ventilated by a pipe of equal diameter, carried to a height above the roof, and clear of all windows and chimneys; the top of the pipe may be left wide open or protected by a suitable cone. Unless this be done there is a great danger of the water discharged from one closet drawing off the water from the trap of another, and so opening up a way for the entrance of sewer air into the house. The dangers from a soil-pipe inside the house, or built into the wall, are numerous. Ignorance of its position has often led to its being pierced by nails; while the temptation to "scamp" the work, knowing that it will be out of sight, is productive of many leaky joints. Frequently it is riddled with holes which have been caused by the corroding action of sewer gas on the leaden wall, and occasionally a hole is made by the gnawing of rats. In all these cases sewer air must inevitably find its way into the house.

Soil-pipes are usually made of lead or iron, each of which has its own advocates. When lead is used it should be drawn-lead without any longitudinal seam. Pipes made of sheet-lead with soldered vertical joints very rapidly corrode on account of the soft nature of the solder. With iron pipes there is a greater difficulty in making sound joints between the lengths than there is with lead pipes, but on the other hand there is not that danger of their being pierced by nails or eaten through by rats. Iron pipes must be prevented from rusting by treating them with Angus Smith's solution. Soil-pipes are often made too large; from 3 to 4 inches in diameter will be found ample for most places, even when there are three or four closets connected to one pipe. To protect soil-pipes from frost, they may be covered with some non-conducting material, such as Smith's patent felt.

Water-closets.—In the greater number of instances the places set apart for closets are far too small, and more often than not are both badly lighted and ventilated. Now unless the closets are to become an intolerable nuisance and a source of ill-health, attention must be paid to their construction and situation. It is no uncommon thing to find them under staircases, and in dressing-rooms connected with bed-rooms, and cases are not wanting in which they have been fixed in cupboards in bed-rooms without any pretence of ventilation. Closets as far as possible should be out of doors; but where this cannot be carried out and they must be indoors, they should be separated from the rest of the house by ventilated lobbies.

Of the many forms of water-closet in use, the pan closet (fig. 28) is about the worst ever invented. In this closet, the receptacle or basin is closed below by a hinged pan, which holds a certain quantity of water, and into which the lower edge of the basin dips. In order to allow of the movement of this pan there is a large box, generally made of iron, below it, called the "container," a most appropriate term, for besides an accumulation of filth, foul gases also collect in it, which escape into the room every time we raise the handle. From the bottom of the container passes a 3-inch pipe to a D-trap, which in turn is connected by a leaden pipe with the soil-pipe.

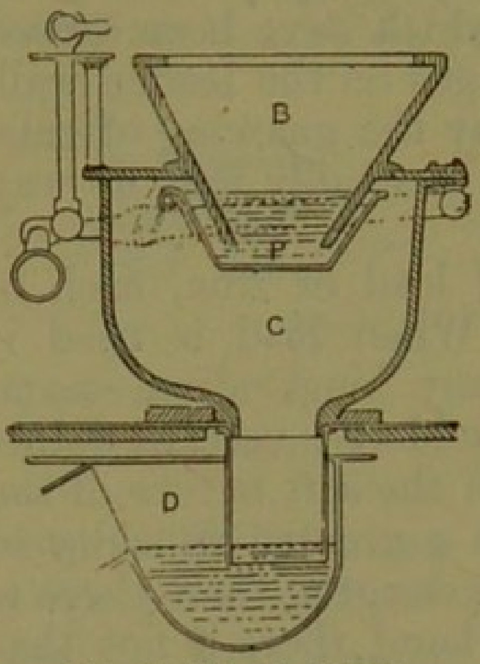


Fig. 28.—The Pan Closet.

Another bad form of closet frequently met with in servants' offices and in the humbler class of houses is the "long hopper" (fig. 29), so called from the length of its basin or hopper. Owing to the conical shape of the basin, the sides are always fouled by the excreta, and the flushing water very rarely, if ever, washes out the syphon. In the improved form of this closet, the cone is shorter, and the back of the basin nearly vertical.

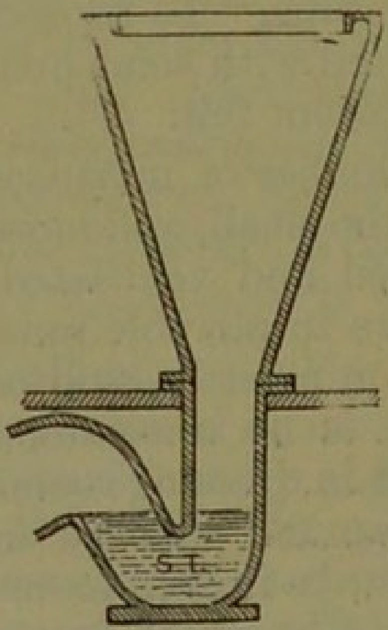


Fig. 29.—The Hopper Closet.

The valve-closet (fig. 30) is a great improvement upon the preceding ones. In this there is no container, and the bottom of the basin is closed by a water-tight flap-valve, which is kept in its place by a counterweight on the lever to which the "pull-up" is attached. On raising the handle this valve is swung back in the valve-box, and the contents of the basin are at once discharged into the syphon trap (T), and thence into the soil-pipe. Since the valve is water-tight, it is necessary to provide an overflow pipe, which should be trapped at the point where it joins the valve-box.

But of all the closets the most satisfactory are those known as wash-out closets, which are really highly improved short hoppers. They are made in one piece, and have no mechanism likely to get out of order as in the valve-closets. The bowl of this type of closet is so shaped that a small quantity of water is retained to receive the excreta; and by means of a good flush of water, directed through a proper flushing-rim, the contents of the basin are driven into the trap T, and so into the soil-pipe S. Fig. 31 is an illustration of one of these "wash-outs."

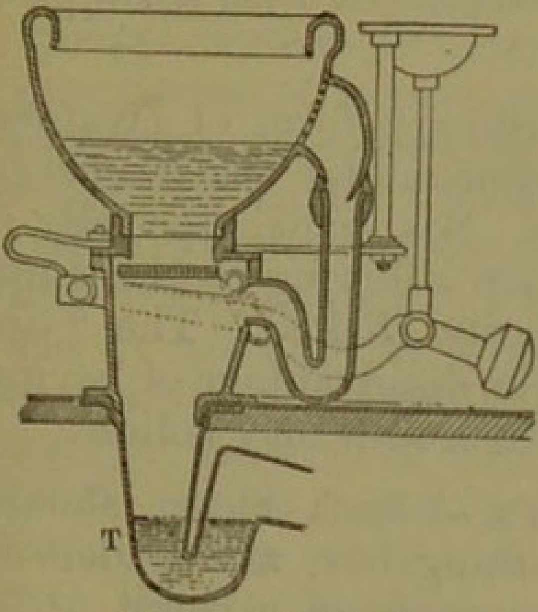


Fig. 30.—Valve Closet.

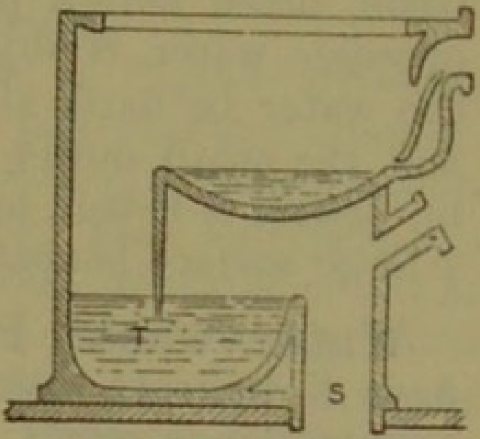


Fig 31.—Wash-out Closet.

Latrines.—For large institutions, such as factories and schools, the more complicated forms of water-closet are entirely out of place. By far the better plan is to have the seats fixed over a water-tight trough connected at one end by a syphon trap with the common drain, and at the other with a Field's automatic flushing-tank. The latter is fed with water from a tap, and can therefore be so regulated that the flushings may occur at longer or shorter intervals as desired. After each flush, a sufficient quantity of water is left in the trough to cover the next dejections.

Urinals.—Unless kept very clean, urinals quickly become foul-smelling from the decomposition of the urine. Hence they should be supplied with a liberal amount of flushing water, which may be allowed to run in a continuous stream, or discharged from an automatic flush-tank every few hours. They should be constructed of slabs of smooth slate, or better still, of glazed stoneware pans. The floor should be paved with tiles set in cement, and sloping towards a gutter connected with a trapped gully.

Lavatory Basins.—The ordinary form of lavatory basin, fitted with a plug arrangement for the discharge of waste water, is objectionable. Soap-suds, especially if the water be hard, always remain adhering to the sides, and the small outlet pipe is easily choked. The "tip-up" basin is better, but it has the disadvantage of having a large surface beneath it on which filth may collect.

Water-waste Preventers.—Each closet should have a separate cistern or flushing-box, and under no circumstances ought the water-supply of a closet to be obtained from the same cistern which supplies the drinking-water. To prevent a waste of water, the closet cistern should be furnished with a water-waste preventer, by which a certain quantity of water, and no more, is discharged into the basin when the handle or chain is pulled. To secure a proper flush the cistern should be placed not less than four feet above the seat, and the flushing-pipe should be from 1¼ to 1½ inches in diameter.

* CHAPTER XXI.—PERSONAL HYGIENE.

Habits.—Sanitary science and sanitary legislation may do much to give us healthy homes to live in and pure water to drink; but unless attention be paid to our individual habits, all the science and legislation of the world will not diminish that ill-health which, though not ending fatally perhaps, is the cause of much personal discomfort. There can be no doubt that we habitually eat more food than is actually required for the wants of the system; and every superfluous particle is not only useless, but injurious. The intervals, again, between the meals, partly on account of our being to a great extent the creatures of circumstances, are frequently very erratic. Sometimes we allow ourselves too little time at a meal, and in consequence have to eat our food hurriedly, a practice inevitably ending in indigestion. Hence the importance of proper mastication; and yet how many mothers give food which requires chewing to their infants when they have no teeth to chew with.

The evils of intemperate habits as regards drinking have been detailed at some length in a previous chapter; and we need say no more than that extreme temperance in the use of alcoholic drinks is the best, and perhaps, for the majority of individuals, total abstinence is the safest. With regard to the use of tobacco among adults there is some conflict of opinion; but one and all agree that its use among boys is most detrimental to their health. "Boys who smoke much are less disposed to bodily exertion. Smoking interferes with appetite, impairs bodily activity, and in some way must damage the circulation or the composition of the blood. Add to this that a young man without the least good to himself is forming a habit which may become very burdensome to him, and that if he is a poor man he is spending money for which there are fifty better and more pressing applications" (Dr. Parkes).

Keeping late hours, apart from the tendencies it has to encourage alcoholic indulgence, undermines the strongest constitution in the long run. Sufficient periods of repose are absolutely necessary for the proper repair of disintegration and the recruiting of strength.

Attention to the Action of the Bowels. — The regular action of the bowels is most essential to health. Neglect in this important particular leads to constipation, indigestion, hæmorrhoids (piles), and even inflammation of the bowels. A free evacuation once every day at least should be secured, and this is best promoted by visiting the water-closet at a certain hour every day, after breakfast being the best time. If, in spite of this habit, costiveness still prevails, a variation of diet may bring about the desired result. Aperients should be avoided as much as possible, the bowels being kept regular by exercise in the open air, daily ablution of the whole body, the use of oatmeal, brown bread, fresh vegetables, and fruit both cooked and raw—if it be ripe.

Care of the Teeth.—Without good teeth the thorough mastication of food is impossible, and this, as we have seen, is a fruitful source of indigestion. Many people injure their teeth by attempting to masticate hardened substances, or by using them as nut-crackers. Bits of food, again, often remain between the teeth after a meal, and unless removed will decompose and injure them. The mouth, therefore, should be rinsed with water after every meal; but in addition to this the teeth ought to be brushed over every morning with water, in which a little salt has been dissolved. If soap be used for this purpose it ought to be Castile soap. When the teeth show any signs of decay they should be immediately *stopped* to prevent the decay from going further.

Cleanliness.—The skin which forms the natural covering of the human body consists of a superficial layer called the epidermis or scarf-skin, and a deeper layer known as the dermis or true skin. Opening at the surface of the skin are a great number of very small tubes known as sweat-glands. Each of these glands—of which there are between two and three millions in the body—consists of a tube, usually about $\frac{1}{300}$ of an inch in diameter and a quarter of an inch long, the secreting portion of which is coiled up into a little ball in the lower part of the dermis. The function of these sweat-glands is to separate from the blood the perspiration or sweat, which, if it were to remain in the body, would be very injurious. Now unless the skin be kept thoroughly clean, the dirt which lodges upon it forms with the perspiration a kind of crust which chokes up the pores and prevents the glands from doing their work properly, so that other organs, principally the lungs and kidneys, are compelled to do extra work in order to get rid of the waste matter. This, however, they cannot do for long; and sooner or later they get out of order, and illness follows.

To keep the body perfectly sweet and clean, we must have frequent if not daily ablutions; it is not enough to wash the hands and face only. In houses with proper bath-room accommodation, no difficulty will be experienced in having a daily bath; but in small houses, where it is not so easily managed, the usual plan is to leave it until the week-end, when the "Saturday tub" is indulged in. In any case, as much of the body as possible should be washed well with soap and water every day, the arm-pits and groins receiving particular attention. This is best done before retiring for the night, or before dressing in the morning.

If it can be had, a *cold bath* every morning, well followed up by rubbing with a rough towel, is a most invigorating as well as a delightful process. It is not necessary to soap the body; simply plunge into the bath and out again, and dry the body as quickly as possible. Such a practice as this greatly diminishes the tendency to "catch cold," and has a most beneficial effect upon the nervous system. Immediately upon coming out of the bath a pleasant sensation of warmth ought to be experienced from the return of the blood to the skin, a reaction which is greatly aided by the friction of a rough towel. If a feeling of chilliness remains for some time after taking a cold bath it should be discontinued, and a bath at a temperature but little below that of the body taken instead, followed by a rapid sponging with colder water. The best temperature for a cold bath is about 60° F., and the use of water considerably below this point is a great mistake.

Cold water, however, does not remove the dirt so efficiently as warm water; so that to ensure a thorough cleansing of the skin it is advisable to have a warm bath, with a free use of soap, once a week. This should be done the last thing at night, because it renders the skin very susceptible to changes of temperature, and there is thus a great risk of taking a chill from a subsequent exposure to cold. This danger can be lessened by a rapid cold sponging of the body upon leaving the bath, and then drying quickly with a rough towel. For some persons there is no more perfect and delightful mode of cleansing the skin than regularly taking a Turkish bath. Those suffering from heart or lung diseases should not take them without first consulting their medical adviser.

In the case of children the cold-water bath in the morning must not be insisted upon at first. The chill should be taken off, especially in winter-time, to begin with, and the temperature then gradually reduced until quite cold water only is employed. In fact this is the plan that should be followed in all cases.

Soap.—The ordinary yellow soap in daily use is known to the chemist as the *stearate of soda*, and, in fact, is what he would call a "salt". Common table salt is an article familiar to everybody; but to describe soap as a salt must appear somewhat strange to those uninitiated in the mysteries of chemistry. The difficulty, however, will soon disappear if at the outset we examine the nature of a chemical salt. Such a substance is formed by the chemical union of two bodies, having opposite properties, which are more or less neutralized by their combination; and the salt thus produced has entirely different properties to those of its constituents.

The two classes of bodies referred to in the formation of salts are known as *acids* and *bases* respectively. The acids, as a rule, possess a sour taste, and have the property of reddening many vegetable substances, such as litmus. A base may be defined as a compound which is converted into a salt by the action of an acid. The bases are almost always *metallic oxides*, such as *sodic oxide* (Na_2O), calcic oxide (CaO), and ferric oxide (Fe_2O_3), or *metallic hydrates*, such as sodic hydrate ($NaOH$) and potassic hydrate (KOH); and when soluble in water they have usually an alkaline reaction—that is, they turn red litmus blue.

To illustrate the formation of a salt, the following experiment may be performed. Take some sulphuric acid, and cautiously add to it a solution of caustic soda, testing the mixture frequently with a strip of blue and red test-paper. A point will be reached when the colour of these two papers will no longer be changed; the mixture is now said to be neutral. Evaporate the neutral solution thus obtained until it becomes concentrated, and put it on one side to cool slowly. Beautiful crystals of a salt called sodium sulphate will be obtained. The exchange which occurs in this experiment will be seen from the following equation:—

$$\underset{\substack{\text{Acid}\\(\textit{Sulphuric Acid})}}{H_2SO_4} + \underset{\substack{\text{Base}\\(\textit{Caustic Soda})}}{2\,NaOH} = \underset{\substack{\text{Salt}\\(\textit{Sulphate of Sodium}).}}{Na_2SO_4} + \underset{\text{Water.}}{2\,H_2O.}$$

We are now prepared to investigate the bearing which this introduction has upon the manufacture of soap. In the first place, we must consider of what common washing soap is made. It is obtained by boiling together a mixture of some kind of fat and caustic soda. Fat is chemically a salt, for it consists of an acid and a base. In a hard fat, such as mutton suet, the acid is called *stearic acid*, and the base is called *glycerile*, the two together forming what is known as *stearine* or the *stearate of glycerile.* If this be acted upon by caustic soda, the stronger base, soda, displaces the weaker base glycerile, and, combining with the stearic acid, forms *stearate of soda*, which is really soap—soda soap. The manufacture of soap on a small scale may be illustrated in the following manner. Bring a weak solution or "lye" of caustic soda to the boiling point, and add to it some tallow or chopped-up suet. Let this mixture continue boiling gently for half an hour, when a strong solution of caustic soda is to be added gradually. As the boiling proceeds, it will be found that the fat and the lye gradually unite to form a mass of a gluey consistency. After adding some common salt and boiling for some minutes, the mixture is allowed to cool. There will now be found a cake of soap and a watery liquid, in which the common salt, together with some free soda and glycerine, remain dissolved. The following equation will represent the double decomposition which takes place in the formation of soap:—

$$\begin{array}{c}\text{Stearate of Glycerile}\\ \text{(Stearine)}\end{array} + \begin{array}{c}\text{Caustic}\\ \text{Soda}\end{array} = \begin{array}{c}\text{Stearate of Soda}\\ \text{(Soap)}\end{array} + \text{Glycerine.}$$

At the soap-works, the fat and soda are boiled together in large soap-pans made of iron. Some of these are as much as fourteen or fifteen feet in diameter, and of the same depth. In some boilers the heat is obtained from a coil of pipe through which steam is continually passing; and if the steam be injected, it acts like a stirrer, and keeps the contents of the boiler in motion.

The object of adding common salt can be readily demonstrated by trying to dissolve a hard soap in salt water; no solution takes place, not even on boiling, for soap is insoluble in salt water. Hence the addition of salt to soap-pans precipitates or separates the soap from its solution in the watery portion of the mixture.

There are several kinds of soap. The one commonly employed for household purposes is soluble in water; but there are some soaps, such as lime-soap and magnesia-soap, which are insoluble in water, and therefore of no value for washing and laundry work. All hard soaps are made from fats by soda. Soft soap, on the other hand, is generally made from oil, such as rape oil and fish oil, and *caustic potash*. What is known as "marine soap", is made from cocoa-nut oil. It will form a lather with sea-water, and is therefore very useful on board ships when the supply of fresh water is running short.

Everyone has experienced the unpleasantness of washing in hard water: the soap clings to the hands and to the sides of the basin like a kind of curd. The explanation of this is because there is lime, or magnesia, or both, in solution in the water, and these substances decompose the soap. An insoluble lime or magnesia soap, as the case may be, is produced, and it is not until the whole of the mineral matter has been precipitated in this way that a lather is possible.

Action of Soap.—The cleansing or detergent properties of soaps depend upon their power of dissolving fatty matters. Water alone will not effect the removal of grease from the fabrics to be cleansed. It is necessary to employ soap. The alkali of the soap combines with the oily matters, forming an emulsion which is readily soluble in water. The waste of soap which follows the employment of hard water has been pointed out, and, apart from this fact, soft water has a great advantage over hard water for cleansing purposes. Linen has invariably a yellowish tinge after being washed in hard water.

Swimming.—Swimming is a most valuable accomplishment, combining as it does both bathing and exercise. Every boy and girl should be taught early to swim, and it is to be hoped that the time is not far distant when it will be considered a necessary part of every child's education. There is scarcely another exercise which is so valuable as swimming. It develops the muscles, expands the chest, braces up the whole body, adds to a child's courage, energy, and self-reliance, not to mention its value as a means of saving human life. Every large school should have its swimming-bath; but where this is impossible, arrangements ought to be made by the school managers for the use of the public baths, where these exist, on certain days of the week. A responsible person, who, it is needless to say, should be a capable swimmer, must be present during the bathing operations to see that all goes well.

Hints for Bathers.—The following rules for bathers are issued by the Royal Humane Society:—

"Avoid bathing within two hours after a meal.

"Avoid bathing when exhausted by fatigue, or from any cause.

'Avoid bathing when the body is cooling after perspiration.

"Avoid bathing altogether in the open air, if after having been a short time in the water there is a sense of chilliness with numbness of the hands and feet; but bathe when the body is warm, provided no time is lost.

"Avoid chilling the body by sitting or standing undressed on the banks or in boats after having been in the water.

"The vigorous and strong may bathe early in the morning on an empty stomach.

"Avoid remaining too long in the water; leave the water immediately there is the slightest feeling of chilliness.

"The young, and those who are weak, had better bathe two or three hours after a meal—the best time for such is two to three hours after breakfast.

"Those who are subject to attacks of giddiness or faintness, and those who suffer from palpitation and other sense of discomfort at the heart, should not bathe without first consulting their medical adviser."

Sea-bathing.—Sea-bathing is far superior to fresh-water bathing for those who are healthy; the salt-water is more refreshing and invigorating. Immediately upon entering the water, the whole of the body should be wetted at one dip, so that all parts may be equally cooled, and those who cannot swim should not remain in the water for longer than five minutes.

Exercise.—In the widest sense of the term, exercise means the use to which all the organs of the body are put; but as now employed it refers chiefly to the action of the voluntary muscles.

A certain amount of exercise is necessary at all periods of life, but never more so than during childhood. A child contains within himself all the organs of the perfect adult in miniature, but their development, assuming they are free from disease in the first instance, depends solely upon the manner in which they are exercised. There can be no doubt that nowadays too much school work is expected of young children, and in consequence but little time is devoted to recreation. It is true that a few minutes for play are given in most schools in the morning; but this is not all that is wanted. Those children who are delicately constituted, or are suffering from short-sight, will hie away to the more secluded parts of the playground, preferring their books rather than entering into the games of their more robust school-fellows, and so matters go from bad to worse. Physical exercises must therefore form a part of the school curriculum, and no school can be considered efficient from which they are entirely banished. Whatever system is adopted, it must be such as will bring all the muscles of the body into play in turn.

With regard to adults, the kind of exercise will depend upon the nature of the work engaged in during the day; when this is physical, the exercise may be purely mental, and *vice versa*.

Exercise, to do good, must be regular, and as varied as possible; care being taken that it is not carried to over-fatigue. When the muscles are not used they become feeble, and gradually waste away by a process of degeneration. This is clearly shown in the case of a broken limb, or in one paralysed by disease. When a limb is broken it has to be kept motionless for weeks in splints, and when these are removed the effect of deficient exercise is at once perceived; the limb is considerably thinner, and has lost nearly all power of motion.

By gradually and steadily increasing the work done by a set of muscles, they increase in size and strength to meet the demand put upon them. Hence it would appear that we cannot have too much exercise. This, however, is a mistake; for if it be carried to excess, without proper periods of rest, the muscles instead of growing will commence to waste, this being especially noticeable with small groups of muscles. Thus clerks suffer from what is known as *scriveners' palsy*, the muscles of the hand being seized with spasm each time that writing is attempted. A similar condition is met with among type-setters, violinists, telegraphists, tailors, and others.

No excessive muscular exercise should be undertaken without a proper preparation or training by those who follow sedentary occupations the greater part of the year. In the eagerness "to make the most of their time" during a holiday, it not infrequently happens that the sudden and severe exertion which the body is called upon to perform has a most disastrous ending.

Besides aiding muscular development, regular and systematic exercise benefits the system generally—first, by promoting the action of all the excretory organs, especially of the lungs; secondly, by increasing the force of the heart's beat, and also its frequency, thereby quickening the circulation; thirdly, by aiding digestion, except when the exercise is taken immediately after meals; and lastly, by improving the nervous system. The good effects of exercise are much more marked when it is taken in the open air.

Rest.—Now this exercise of the body cannot be continued without proper intervals of rest, and the time for the cessation of vigorous activity is usually indicated by a sense of fatigue. This fatigue may be general, or it may be localized in some particular part. In the latter case the necessary rest can be obtained by a change of occupation. For example: the student who has been exercising his brain all day will give that organ rest by taking a walk, or by indulging in gymnastic exercises. On the other hand, the man who has been engaged in manual labour throughout the day will rest his muscles by sitting down to read or study.

It is, however, impossible not to make some demand upon the brain during the waking hours, and as this implies a disintegration of brain-substance, it is evident that the opportunity for renewal can only occur during sleep. It is impossible to lay down a general rule as to the amount of sleep necessary, as this depends on so many conditions, especially age, sex, temperament, and occupation; but, generally speaking, a healthy adult, doing a fair day's work, requires at least seven hours' sound sleep. Children need more, and should not have less than eight or nine hours' rest in this way.

Clothing.—The chief use of clothing is to assist in keeping the body at a uniform temperature. Thus in cold climates, when the temperature of the surrounding air is below that of the body, clothing prevents heat being lost by radiation. On the other hand, in hot climates, clothing is made to act as a shield, protecting the body from the burning rays of the sun. It is obvious, therefore, that if clothing is to fulfil this double duty, it must be made of some material which will not allow the passage of heat either way, or in other words, it must be a bad conductor and radiator of heat. At the same time the clothing must not interfere with the evaporation of the perspiration, otherwise the body will become enveloped by a film of moisture, which is apt to cause dangerous chills.

Now the material which fulfils these requirements the best is wool, and in such a changeable climate as ours it should always be worn next the skin, both summer and winter. With good woollen underclothing there is little need for those heavy cumbrous ulsters and overcoats we so often meet with. Children, and all those liable to lung affections or rheumatism, should also wear woollen night-garments; but for those who enjoy robust health cotton or linen ones are preferable.

Silk is another valuable material for clothing, but its use is greatly limited on account of its costliness. It is a bad conductor of heat, and for equal thicknesses more so than wool. For those persons who find wool too irritating for the skin, a thin silk vest is an excellent substitute. Cotton and linen are good conductors of heat, the latter being the better of the two. They are non-absorbents of moisture, and on this account should not be worn next the skin. They are, however, very durable, and easily washed, and as an intermediate clothing may be worn at all seasons except winter.

In this country leather is chiefly used for boots, shoes, and leggings; but in some countries it is employed for other articles of dress. It forms an extremely warm clothing, being quite impervious to the wind, and therefore well adapted for cold and windy climates. Waterproof clothing is also useful as a protection against wet;

but it should not be worn longer than necessary, as it is an exceedingly hot dress, and prevents the escape of the perspiration.

As regards the colour of clothing, this is a matter of little importance unless we are exposed directly to the sun; and then the best reflectors, such as whites and light grays, are the coolest, while dark-coloured materials, by absorbing so much heat, become insufferably hot. There is a common notion that clothing possesses a natural warmth of its own. That this is not so may be easily proved by wrapping a cold stone in a piece of flannel or fur, and leaving it for several hours; the stone will be found no warmer than when it was first wrapped up. Clothes do not give us warmth; they simply serve to keep in the heat of the body.

The texture of clothing is another point which demands consideration. The quicker our clothing conducts the heat of the body to the outside air the colder the dress feels. Now garments which are made of smooth materials envelope the body more closely than rougher made goods do. Consequently, they are more likely to abstract the heat of the body, and conduct it away more rapidly. On the other hand, clothing which is made to resemble wool does not come into such close contact with the body, and there thus exists a film or layer of air between the two. But, since the air is a bad conductor of heat, it is obvious that loosely woven materials will be warmer than those more compact. Besides, a material of loose texture will hold a considerable quantity of air in its meshes, and this explains the great feeling of warmth which is experienced from the employment of furs, flannels, and, in the bedroom, of eider-down quilts.

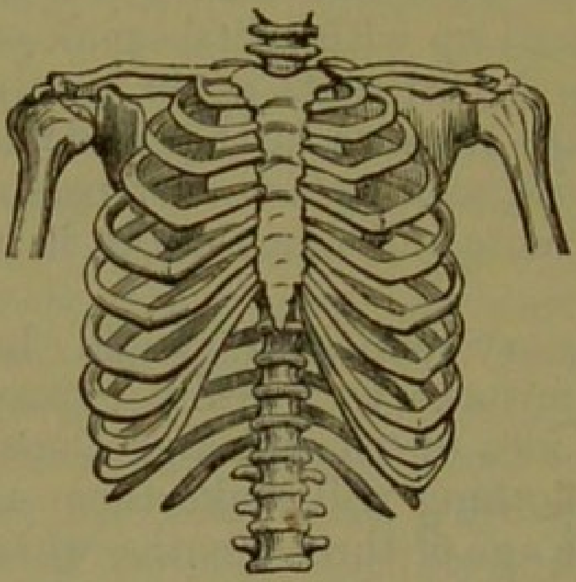
Clothing of Children.—Children are more susceptible to cold than adults. This is because they have a much larger surface in comparison to their bulk than what grown-up people have, and therefore a larger surface from which heat can escape. To illustrate this fact let us take the case of two cubes. A cube of 1-inch sides has 6 square inches of surface to 1 cubic inch of bulk;

while a cube of 10 inches each side has an area of 600 square inches to a bulk of 1000 cubic inches, or as 6 is to 10. Hence it follows that children require to be more warmly clad than adults. But what are really the facts? Daily we meet with children dressed in the most absurd fashion, girls especially being the chief victims of the caprices of their fond but foolish parents. How many little girls, upon the suggestion of taking them for a walk, really shrink from the ordeal, and begin to cry at the thoughts of their previous experiences, instead of hailing with joy the idea of going out into the open air. In the first place, their dresses are made with short sleeves, and just as if these were not already short enough, they must needs be tied up with a little pink or blue ribbon. Their skirts and petticoats again barely reach to the knees, and to make them as further nude as possible, they are provided with socks which only pass a few inches up the legs. A more ridiculous outfit it is impossible to conceive.

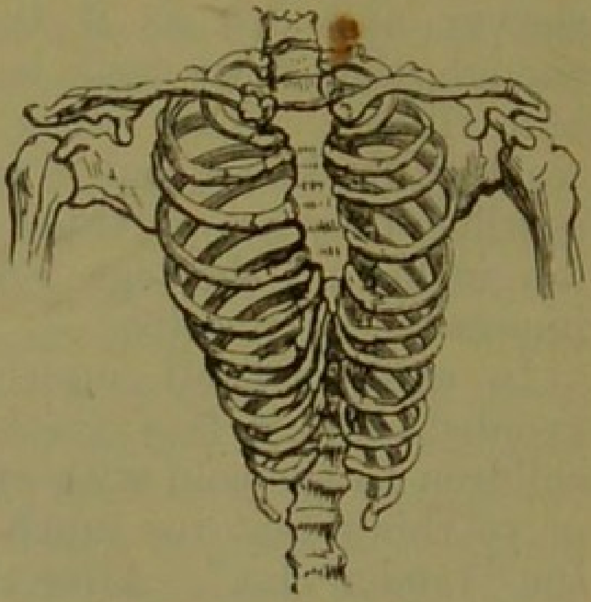
In childhood all unnecessary exposure should be avoided, and it is a great mistake to wilfully expose children to the cold with an idea of "hardening" them, or to think that too much clothing will make them as the "tender vine". After the age of three months, when the long clothes are exchanged for short ones, a child should be dressed as rationally as an adult. The dress should be provided with long sleeves, and should fit well up in to the neck; while the petticoats should be of a suitable length, and the legs incased in good stockings.

Errors of Dress.—With respect to the errors of dress, it is in the clothing of women that the greatest mistakes are usually made, although that of the sterner sex is not entirely faultless. So much has been said and written about the evils of unhealthy clothing that to write more is like flogging the proverbial dead horse; but it is only by persistently calling attention, in season and out of season, to the dangers of modern fashions that teachers of hygiene can hope to bring about a more rational style of dress. In following the dictates of fashion there is often a perfect disregard of health. In the first place, the clothing of females is unevenly distributed over the body. Frequently the high-necked dress is the only covering over the upper part of the chest; whilst the waist and hips are enveloped in a wealth of clothing out of all proportion to the warmth which it affords to the lower extremities.

In the second place, the clothing is often so tight that free and easy movements are well-nigh impossible. This is to be seen in the case of sleeves and gloves. But perhaps the most serious error in dress is that commonly designated "tight-lacing", a practice which causes grave injury to the very mainsprings of life.



Natural Waist.



Unnatural Waist.

The ribs play a most important part in breathing, and free and easy breathing is absolutely essential to health. Nothing, therefore, should be worn about the chest and waist that will interfere in the least with the full expansion of the chest during the act of breathing. The pressure of tight-fitting stays upon the soft ribs of growing girls results in a deformity which they will at last permanently keep. At the same time, all the abdominal organs are compressed and displaced, the action of the heart is impeded, and the respiratory movements are quite altered. The upper part of the chest is compelled to do more work, and the lower part less. Consequently the lower portions of the lungs expand but little, and this makes them very susceptible to disease. The accompanying figures will illustrate the effect of tight-lacing upon the ribs.

The feet, too, are deformed by wearing ill-fitting and tight boots or shoes. The human foot is in the form of an arch; and as long as the natural arch is preserved, the tread will always be light and springy. High-heeled boots, however, quickly break down the arch of the foot, and the gracefulness of walking is at once destroyed. Add to this the effect of tight boots, which make the toes overlap each other, and we have the kind of foot which is unfortunately only too prevalent at the present day.

Garters, again, by impeding the circulation, may lead to varicose veins, and varicose veins predispose to and are the common cause of ulcerated legs. It is the wiser plan to support the stockings by suspenders from the waist.

CHAPTER XXII.—PARASITES.

Parasites.—Parasites (Gr. *para*, beside; *siteo*, I feed) are the low forms of animal or vegetable life which live in or upon other animals or plants, from which they obtain their nourishment. It is now generally believed that epidemic diseases are produced by similar organisms, but in this chapter we shall only deal with those low forms of life that are commonly spoken of as parasites.

Animal Parasites.—The parasitic animals met with in the human subject are divided into two classes—1st, internal parasites, often spoken of collectively as *Entozoa* (Gr. *entos*, within; *zoön*, an animal); and 2nd, external parasites. The Entozoa include the several varieties of intestinal worms and the rarer forms of animal parasites found occasionally in the muscles, liver, kidneys, and the eye. The external parasites are the several species of louse and itch.

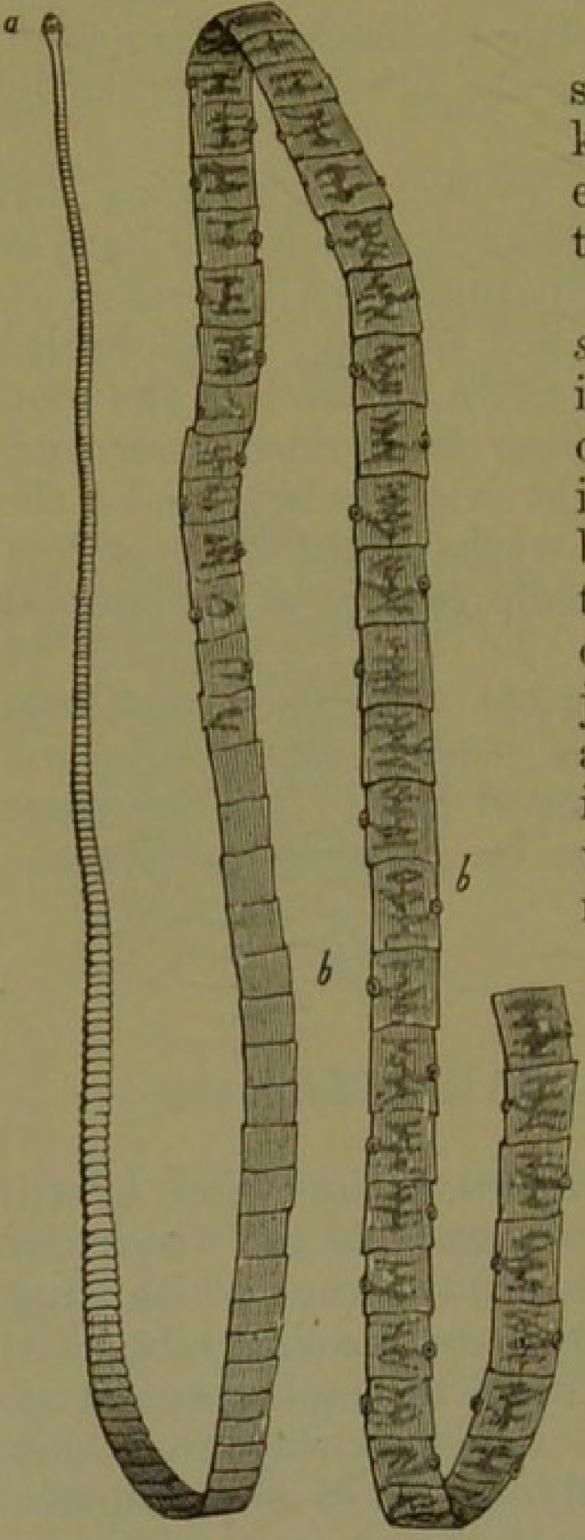


Fig. 32.—Tænia solium (Pork Tape-worm).

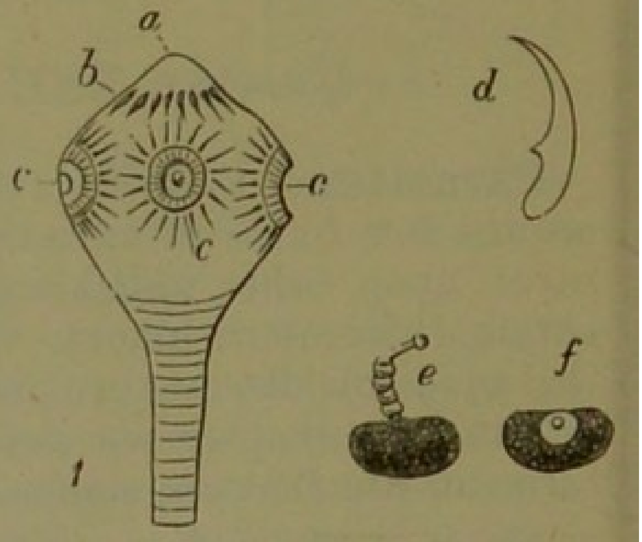


Fig. 33.—Parts of the Pork Tape-worm.

Tape-worms. — Several species of tape-worm are known, of which the commonest are the *Tænia solium* and the *T. medio-canellata.*

1. *Tænia solium.*—The *Tænia solium*, or Pork Tape-worm, inhabits the alimentary canal of man. In its mature state it has a flattened tape-like body (fig. 32, *bb*) from four to ten feet in length, consisting of a number of segments or joints loosely united to one another, and gradually tapering towards one extremity, where it ends in a minute rounded "head" *a*. The "head" is from $\frac{1}{45}$th to $\frac{1}{35}$th of an inch in diameter, and is provided with four suckers (*c*, fig. 33) and a double row of hooklets (*b*), by which it firmly attaches itself to the mucous lining of the alimentary canal. What nervous organs

exist are found in the head, which is truly the animal, the rest of the body being produced by a process of budding. The head, however, possesses no reproductive organs, and the eggs are produced solely in each fully-developed joint. Hence we must not regard the tape-worm as one individual, but rather as a colony of animals. Each ripe joint is termed a *proglottis*, and the whole colony of proglottides which form the tape-worm is known as a *strobilus*.

A remarkable feature in the life history of a tape-worm is the fact that its eggs cannot be developed in the body of the man infested with the parasite, but only in that of some other warm-blooded animal, usually the pig. As soon, therefore, as the ova are matured, the segments break off and are expelled from the body. The joints decay, and the liberated eggs are scattered abroad, some of which may find their way into the stomach of the pig. Here they are hatched, and the embryo, called a *scolex*, armed with six boring-hooks, makes its way into the muscles or other structure suited to it. It then develops from its hinder end a small cyst or bladder filled with fluid, and constitutes what is called a *cysticercus cellulosæ*, or immature tape-worm. Having reached this stage it remains quiescent, and no further development occurs until someone devours the pork. When a large number of these cysticerci are present in pork, it has a white speckled appearance, and is then said to be "measly."

We will now suppose that someone eats a piece of this "measly" pork. As soon as the meat reaches the stomach the embryo is liberated from its cyst by the action of the gastric juice, and at once attaches itself to the mucous lining of the intestine. It then commences to throw off buds from immediately behind the head, till ultimately we have a similar animal to the one we started with. Thus the animal has two different hosts or bearers, one of which maintains it in its cysticercus stage, and the other when it is fully developed and capable of reproducing its species.

2. *Tænia medio-canellata.*—The Beef Tape-worm, *Tænia medio-canellata*, is very similar to *T. solium*, and with the naked eye the two are not easily distinguished. The difference between them lies principally in the structure of the head. The former kind of worm has neither proboscis nor hooklets; but only four suckers (fig. 34), by which it adheres to the walls of the intestines. Hence we are more likely to succeed in detaching it and bringing it away than we are with *T. solium*. Its life history is similar to that of the pork tape-worm, save that its cystic stage is passed in the muscles of the ox, instead of the pig. Beef infested with immature tape-worms is spoken of as "measly," and when such meat is eaten the embryos are liberated, and, settling in the bowel, develop into mature worms often 30 feet in length.

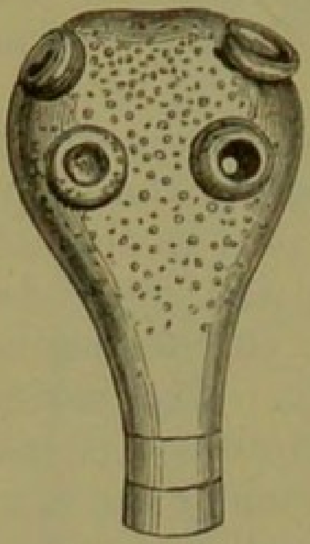


Fig. 34.—Head of Beef Tape-worm (highly magnified).

3. *Bothriocephalus latus.*—The Broad Tape-worm (*B. latus*, fig. 35) is rarely met with in this country, being a native of Russia, Poland, and Switzerland. It sometimes attains the length of 25 feet, and may possess as many as 4000 joints. It is believed to pass its cystic stage in the pike and other fresh-water fish.

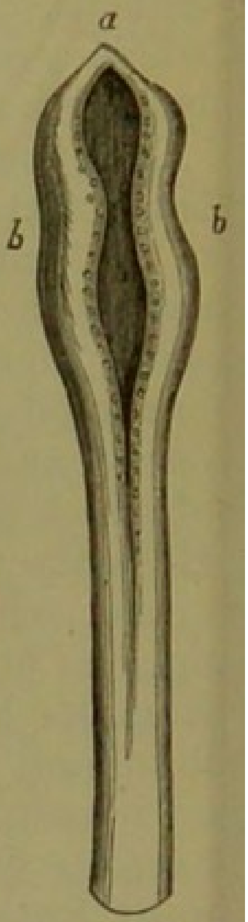


Fig. 35.—Head of the Broad Tape-worm.

4. *Tænia echinococcus.*—The life history of *Tænia echinococcus* is somewhat different from that of the tæniæ we have described. Its adult condition is found in the dog and wolf, but its cystic or larval stage is occasionally passed in man. It is a very small worm, measuring only ¼th of an inch in length, and has but four segments, one of which forms its head. This latter organ is provided with a double row of hooklets and four suckers. The last segment, which contains the eggs, is equal in length to the other three together.

From the digestive canal of a dog infested with this parasite large numbers of eggs are passed, and should any of them find their way into the stomach of man, they are at once developed, and the embryos set free.

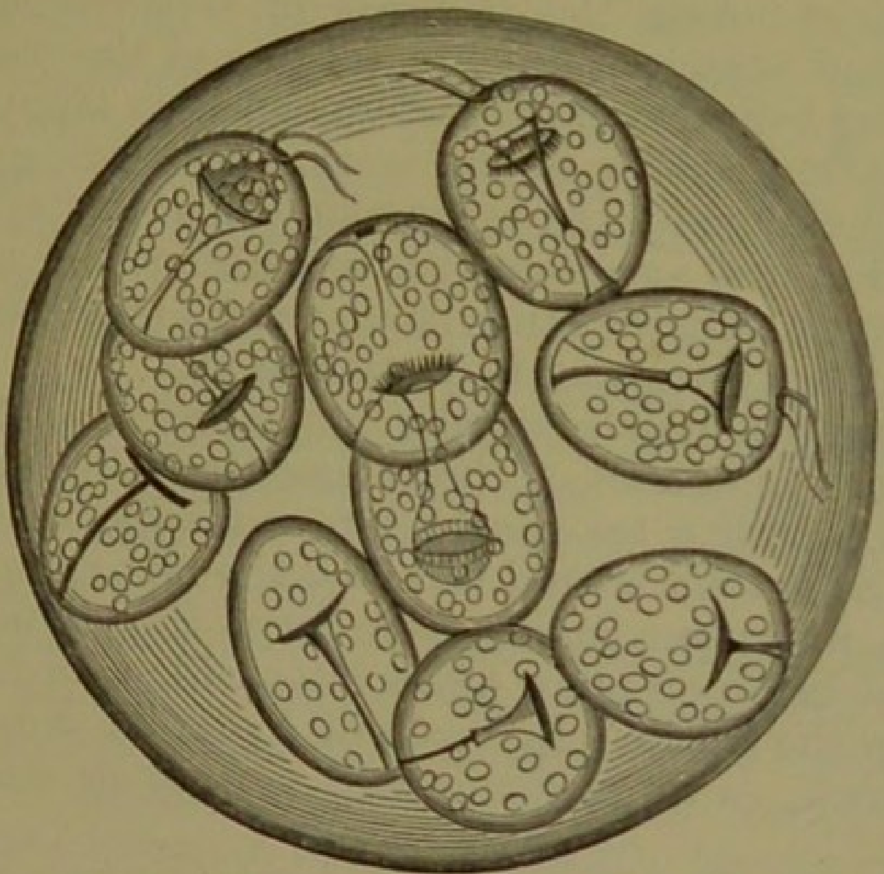


Fig. 36.—Hydatid Cyst.

These, by the aid of six boring hooks with which they are armed, work their way into the blood-vessels, and finally ensconce themselves in the liver, and occasionally in the lungs, brain, and other organs. Here the embryo becomes changed into a hydatid cyst, usually small at first, but sometimes growing to a large size. The cyst is a sac or bag filled with both fluid and granular materials. Within the cyst a number of "brood capsules" (fig. 36) are developed, the contents of each of which become an echinococcus head.

Echinococcus disease is only occasionally met with in this country, but in Iceland, where large numbers of dogs are kept, it is very prevalent, and at one time it was estimated that 10,000 people were suffering from the disease. The eggs may be introduced into the stomach in the drinking-water, or by imperfectly washed vegetables, to which they adhere, such as celery, water-cress, &c.

Symptoms and Treatment of Tape-worm.—The symptoms denoting the presence of tape-worms are a variable and voracious appetite, picking of the nose, heat and itching sensation of the rectum and anus, slimy stools, fetid breath, grinding of the teeth, and starting during sleep. Occasionally the sympathetic nervous system is disturbed to such an extent that convulsions and epilepsy are produced. On the other hand, worms may be present without there being any indication at all.

The remedy now generally employed is either the powder or the extract of the common male-fern (*Lastrea filix-mas*). Half a tea-spoonful to a tea-spoonful and a half of the extract should be taken the first thing in the morning, no supper having been taken the night before. A dose of castor-oil a few hours later will assist in bringing away the worm. In a case of hydatids surgical aid is necessary, as no medicine will destroy or stop their growth.

Bearing in mind, however, that "prevention is better than cure," it behoves us to have our meat thoroughly cooked, and to exercise the greatest care in washing and examining all salads and vegetables. It has been proved that the cysticerci cannot withstand a temperature of 140° F. for five minutes, so that by having meat properly cooked throughout, the danger of tape-worm will be minimized if not altogether removed.

Round-worms.—The round-worms (*Nematoda*) differ from the tape-worms in several respects. In the first place, as their name implies, there is a difference in shape; but the great distinction between them lies in the fact that the round-worms are not hermaphrodite like the tape-worms, but have the sexes separate. The round-worms are provided with an alimentary canal, having a mouth at one end and an anus near the other; tape-worms, on the other hand, obtain their nourishment by simply imbibing the nutritive fluids of their host through their delicate integument.

1. *The Common Round-worm* (*Ascaris lumbricoides*) measures from six inches to upwards of fifteen inches in length when full grown, and resembles the earth-worm in appearance. Its home is the small intestines, and here the female discharges on an average 160,000 eggs daily, each egg being about the $\frac{1}{340}$ to $\frac{1}{440}$ inch in diameter. From 1 to 3 grains of santonin for a child, and twice the quantity for an adult, will effect their removal.

2. *The Common Thread-worm* (*Oxymuris vermicularis*) is the pest of children. It is a small white worm inhabiting the large intestine, especially the rectum, where large numbers of the species may often be found. For their removal, repeated injections of salt and water into the bowel generally suffice.

3. *Trichina spiralis.*—People who are in the habit of eating imperfectly cooked pork and sausages expose themselves to the attack of the much-dreaded parasite, the *Trichina spiralis.* It is a very small worm, only the twenty-fifth part of an inch in length, but provided with powerful boring instruments which enable it to penetrate the firmest muscle. In the human muscle the trichinæ are found inclosed in little cysts, which are about the $\frac{1}{75}$ of an inch in length, and about the $\frac{1}{300}$ of an inch in breadth. To the naked eye these cysts appear like white specks. They have a rough exterior, and are filled with a granular secretion in which the little worm lies coiled up (fig. 37).

Man becomes infected with them by eating trichiniferous pork. The worm, dormant whilst in the muscle of the pig, is now freed from its capsule by the action of the gastric juice. It develops rapidly, and begins to breed in enormous numbers. The young worms, working their way into the blood-vessels, are carried by the blood to the capillaries, from which they migrate into the substance of the muscle. Having arrived at their destination they become encysted and undergo no further change.


Fig. 37.—Trichina spiralis.

The disease due to Trichina is called trichinosis, and is marked by sickness, fever, emaciation, diarrhœa, and rheumatic-like pains in the muscles, accompanied by swelling. About the seventh or eighth day of the disease dropsical swellings appear on the face and soon become general. The fever increases, and the patient at length dies from exhaustion. If the attack be mild, the patient may survive, in which case the parasites, after remaining encysted for a few months, degenerate and become of a calcareous nature.

The disease is almost unknown in this country, and is chiefly confined to those countries where raw or underdone smoked pork is eaten. The protection therefore against trichinosis is the thorough cooking of all forms of pork.

* **External Animal Parasites.**—The external animal parasites are the several kinds of lice and the itch. Of lice there are three varieties—*Pediculus capitis*, or Head-louse; *Pediculus corporis*, or Body-louse; and *Pediculus pubis*, or Crab-louse. The first variety infests the head, especially of children, running amongst the hairs and multiplying with wonderful rapidity by means of eggs, called *nits.* The irritation which lice produce causes the person to scratch the parts, and this may lead to an inflammation of the skin, or "*Impetigo.*" The animals themselves are readily destroyed by saturating the hair with "white precipitate" ointment. This treatment, however, will not destroy the vitality of the nits, which

adhere very firmly to the hairs. For their removal the head should be bathed with vinegar and water, and the hair thoroughly combed through with a very fine tooth-comb.

The *Body-lice* abide in the folds of the underclothing, only visiting the skin when in want of food. Ironing the clothes with very hot irons will kill them and their eggs.

The *Scabies* or *Itch* is a disease caused by a minute animal parasite known as the *Acarus scabiei* (fig. 38), which, when viewed under a microscope, looks very much like the cheese-mite. The disease usually appears between the fingers, or in front of the wrists and in the bending of the joints, and is attended with intense itching, which becomes intolerable as the person affected gets warmer. The itch is very contagious, the shaking of hands being sufficient to cause infection.

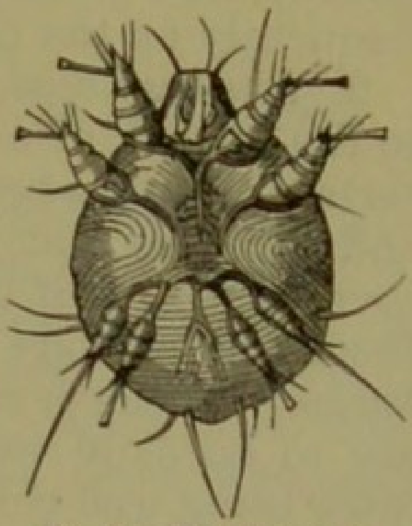


Fig. 38.—The Male Itch Insect (magnified).

The male itch-acarus is just visible to the naked eye. It has eight legs, and two of the hind ones are provided with suckers. The female is slightly larger than the male, and is the one which burrows in the epidermis and there lays its eggs. These are hatched in about fourteen days, and the females, having become impregnated, commence burrowing operations on their own account, and so the disease spreads.

Fortunately these parasites are easily destroyed, the contact with sulphur being sufficient to kill them. The affected person should take a hot bath, using plenty of soft soap, and at the same time scrubbing the skin well. Sulphur ointment is to be then rubbed over the whole body, especially where there are any signs of an eruption. If this treatment be followed for a few days, the cure of the disorder is certain. The patient's clothing and the bed clothes should be steeped in boiling water, otherwise the disease is liable to recur.

* Vegetable Parasites:

1. *Thrush.*—Thrush is a common disease in early infancy, and is occasionally met with in after-life. It appears as a number of small white patches on the inside of the mouth and especially on the tongue, and is due to the growth of a microscopic plant, *Oidium albicans*, brought about by improper feeding, or by dirty feeding-bottles. Arising, therefore, as it does from gastric disturbances, the first treatment consists in giving very mild aperients, such as magnesia, and then applying a local remedy, like glycerine of borax, which is to be smeared frequently on the parts affected by aid of the fingers.

2. *Pityriasis versicolor.*—This is a disease of the skin due to the growth of a vegetable parasite called *Microsporon furfur*. It forms brownish-coloured patches which extend and unite, so that the whole of the trunk may become covered with it if it be not checked in time. It attacks those who perspire freely, and who do not take frequent baths. It seldom occurs in children. The affected parts are to be daily washed with soft-soap and water, and after being well rubbed with a rough towel, treated with a weak carbolic lotion.

3. *Ringworm.*—Ringworm is an extremely contagious disease, being readily communicated by means of hats, gloves, towels, brushes, &c. It is caused by the growth of a fungus to which the name *trichophyton* has been given, and may attack the scalp, beard, or any other part of the body. When it occurs amongst the hairs, it is much more difficult to eradicate, as the spores extend to their roots. It commences in small red patches, and occasions considerable itching. The fungus grows at the margins, and as it spreads the central portions heal, a mode of growth which gives the disease its ring-like appearance. In ringworm in the head, the hairs become very brittle, splitting and breaking off near the skin, and leaving only their discoloured stumps.

As soon as the disease shows itself it should be painted with the tincture of iodine, or bathed with a lotion of bi-chloride of mercury (two grains to the ounce of water).

If it be in the hairy parts, it will be necessary to cut the hair away for a little distance around, so as to get at the seat of the disease better. All diseased hairs should be pulled out by the aid of pincers.

4. *Favus.*—Favus is the worst form of ringworm. It is due to the growth of a minute fungus called *Achorion Schonleinii.* It attacks the scalp, where it forms a number of yellow cupped discs, some of which are half an inch in diameter. It is very infectious and difficult to cure, and hence the disease may last for years.

* CHAPTER XXIII.—SCHOOL EPIDEMICS.

Infectious Diseases.—The epidemics which are liable to break out among school children include not only the skin diseases described in the previous chapter, but also those to which the name of *infectious* and *catching* diseases has been given. They are measles, scarlet fever, diphtheria, small-pox, typhus and typhoid fever, whooping-cough, mumps, and chicken-pox.

It is believed that they all originate in, and are propagated by means of, organized bodies of an excessively minute size, called disease-germs, and that each form of fever has its own specific fever-germ. The danger, therefore, of permitting to attend schools, children who are sickening for, or are still suffering from an infectious disease, or who come from homes in which an infectious disease is present, must be apparent to all; and to guard against any such contingency teachers should make themselves thoroughly acquainted with the symptoms indicating the onset and the duration of infection of all the ordinary infectious diseases.

Measles.—Measles commences with the symptoms of a common cold. At first the patient feels chilly, and then hot and feverish; the eyes water and become red, and are very sensitive to light; the nose runs, and there is a peculiar ringing cough, together with sneezing. These symptoms increase up to the fourth day, when a rash appears about the face and neck, and thence spreads gradually over the whole body. The rash at first appears in small dots, not unlike flea-bites; but these soon increase in size, and form patches of a crescentic shape which are raised above the skin. After remaining out about four days the eruption begins to disappear, and by the seventh is generally entirely gone. On the disappearance of the rash very fine scales separate from the skin.

Scarlet Fever or Scarlatina.—Scarlet fever begins with chilliness and shiverings, languor, headache and sickness, and sore throat. On the second day a scarlet efflorescence of the skin and mucous membrane of the mouth and throat makes its appearance. The rash usually declines on the fifth day, and disappears entirely by the seventh; after which the skin begins to peel and dust off in a remarkable manner. Each scale is loaded with the fever-poison, and hence the disease is infectious until after every scale has completely peeled off the body, which occurs as a rule by the sixth week from the commencement of the disease.

Diphtheria.—The commencement of diphtheria is marked by shivering fits, loss of appetite, heaviness, and paleness of the skin. The patient complains of a slight headache, especially over the eyes, and next day experiences a difficulty in swallowing. If the throat be examined, small white patches will be noticed on the tonsils and neighbouring parts of the throat, which spread and join together, ultimately forming a leathery-looking membrane all over the back of the throat, tonsils, and uvula in very severe cases. Pieces of this membrane are constantly separating from the affected parts, and are either spat out or else in young children swallowed, the membrane forming again as quickly as before.

Small-pox.—The symptoms of small-pox are very strongly marked, and once seen, are not likely to be mistaken for those of any other disease. The onset of small-pox is indicated by feverishness, which is often severe, sickness, and great pain in the small of the back. The eruption appears on the third day of the fever, first on the face and neck, and afterwards on the trunk and limbs. At first it is in the form of minute pimples slightly raised above the skin; but these gradually grow larger, and on the fifth day a very small vesicle, containing a milk-like fluid, may be detected in the middle of each pimple. By the eighth day the contents of the vesicles become yellowish, and the eruption now assumes the form of pustules or small abscesses, surrounded by inflamed margins. These continue to enlarge for the next two or three days, but on the eleventh day the inflammation and swelling begin to abate, and the pustules gradually become scabbed over by the drying up of their contents.

Typhus Fever.—The symptoms of typhus fever are very varied in their character, and the attack may be very sudden and severe, or so gradual as to escape observation until the disease is well advanced. In the former case the first symptoms are shivering fits, headache, sleeplessness, and incapacity for any exertion. About the fifth or seventh day a rash, consisting of dusky red spots, appears first on the sides of the chest and belly, and then spreads all over the body within a couple of days. After remaining fully out for two or three days it begins to fade, and generally disappears about the fourteenth day.

Typhoid or Enteric Fever.—The diseases we have just considered may be spread by means of the atmosphere, or by contact with infected persons; typhoid fever, on the other hand, is rarely propagated in such a manner, being nearly always due to drinking water contaminated by enteric excreta. Typhoid fever may occur at any age, but especially with the young. Its onset is very slow, and the disease lasts several weeks, being characterized by great disorder of the stomach and intestines. Diarrhœa is frequent, but does not occur in all cases.

Whooping-cough. — Whooping-cough generally begins with all the symptoms of a common cold and cough, lasting from ten days to a fortnight. At the end of this time the well-known "whoop" is heard during fits of coughing. A child who is labouring under this complaint coughs so long and so violently that he gets quite out of breath; then follows a deep inspiration which gives rise to the peculiar "whoop," and another long cough. This generally continues until the child is sick, which at once relieves him until the next attack.

Mumps.—Mumps is an inflammation of the parotid gland, occurring epidemically and being very infectious. In Scotland it is called *branks.* The disease commences with a slight feverish attack; and after a short time a hard and painful swelling will be noticed before and under the ear. This continues for four or five days, after which it begins to subside; and by the end of three or more days has entirely disappeared.

Chicken-pox.—Chicken-pox is not at all a dangerous disease. It is ushered in by the symptoms of a mild fever which lasts for twenty-four hours, when rosy-red pimples appear on the head, neck, back, chest, and shoulders, but rarely the face. On the second day the pimples fill with water, and are fully matured on the third day, after which they quickly burst and form a thin scab. A little difficulty may be experienced in distinguishing chicken-pox from modified small-pox; but in the former the vesicles are rarely on the face, whereas in small-pox this is the principal part affected.

Onset of Infectious Diseases.—The premonitory symptoms of the above diseases do not show themselves immediately upon the entrance of the disease-germ or poison into the body. There is a longer or shorter interval between the time of taking the disease and the time at which it shows itself, called the *period of incubation* or hatching. It is maintained by some medical authorities that these diseases are not infectious during incubation; but the wiser plan for teachers to adopt is to assume they are in all cases.

As soon as a teacher notices that a child is suffering with any of the early symptoms which have now been given, he should at once send the patient home and inform the parents of his opinion, so that they may seek medical advice immediately; and in case of an infectious disease a child should not be allowed under any circumstances to return to school without a medical certificate.

TABLE OF INFECTIOUS DISEASES.

Name of Disease.	Duration of Infection.	Quarantine (the time after which a child who has been exposed to disease is safe).
Measles, ...	From 2 to 4 weeks.	16 days.
Scarlet fever, ...	From 5 to 8 weeks (when all peeling of skin has ceased).	14 ,,
Diphtheria, ...	From 14 to 21 days.	12 ,,
Small-pox, ...	,, 4 to 5 weeks.	18 ,,
Typhus and typhoid fever,	,, 4 to 5 ,,	28 ,,
Whooping-cough, ...	When cough has quite ceased.	21 ,,
Mumps, ...	From 14 to 21 days.	24 ,,
Chicken-pox, ...	,, 4 to 5 weeks.	18 ,,

Disinfectants.—Disinfectants are substances capable of destroying the poison of infectious diseases. Many of the so-called disinfectants are little more than *deodorants*, that is, they merely mask bad smells, and are quite useless in preventing the spread of disease. Those that are of the greatest value are carbolic acid; chloride of zinc; sulphurous acid, produced by burning sulphur or carbon bisulphide; and chlorine, obtained by pouring any dilute acid upon chloride of lime, or by warming a mixture of hydrochloric acid and the black oxide of manganese.

As soon as an infectious disease is known to be prevalent in a school district, the strictest attention must be paid to the ventilation and other sanitary arrangements of the school premises, together with the free use of the two first-named disinfectants. It may happen that the Local Sanitary Authority will recommend the closing of the school for a time. In such an event, the premises should be thoroughly disinfected before the reassembling of the children. To do this, all the cupboards, drawers, and the like, should be thrown wide open, the fireplaces closed, and all cracks and openings pasted up with strips of paper. Sufficient sulphur, broken into small pieces, is then placed in an iron dish (an old sauce-pan lid answers the purpose), supported over a bucket of water. As soon as the sulphur has been ignited by means of a few live coals, the doors are closed, the crevices sealed as before, and the rooms left for twenty-four hours. After this a thorough cleaning will render the premises wholesome. It is usual to allow 1 lb. of sulphur for every 1000 cubic feet of space.

*CHAPTER XXIV.—ACCIDENTS AND INJURIES.

Wounds and Bleeding.—In attempting to arrest the hæmorrhage or bleeding from a wound, some knowledge of the nature of blood and its circulation by the heart and blood-vessels is absolutely necessary. To the naked eye the blood drawn from an artery is a bright red fluid, but if a drop of such blood be placed on thin glass and another piece of glass pressed on it, and then examined under the microscope, it will be seen that the blood consists of a transparent and perfectly colourless liquid, which is known as the *plasma*, with innumerable red particles—the *corpuscles*—floating in it.

Chiefly by the action of the heart, the blood circulates in tubes known as *blood-vessels*, of which there are three kinds, the *arteries*, *capillaries*, and *veins*. Arteries have thick walls, and not only convey the blood from the heart to all parts of the body, but assist in driving it on.

When a large artery is divided, the blood issues in separate abrupt jets, with well-marked intervals between; but from very small arteries it flows continuously.

If we could trace the course of any artery we should find that branches were continually being given off, and that at last we should be compelled to use a microscope, for our artery at last breaks up into a network of minute tubes called *capillaries.* These are the smallest blood-vessels, and vary from $\frac{1}{2000}$ to $\frac{1}{3500}$ inch in diameter. The blood flows in them more slowly than in either arteries or veins, and they have walls so thin and permeable that the fluid of the blood can easily soak through them into the flesh in which they lie.

Arteries, then, become capillaries, while these again, becoming larger and larger, unite to form the *veins.* The walls of the veins are much thinner than those of the arteries, and give little or no assistance to the flow of blood. Venous blood travels from the capillaries towards the heart, and is of a dark purple hue. From a cut vein it simply flows in a continuous stream.

Wounds are divided into several kinds, the distinctions being founded either upon the kind of weapon with which the injury is inflicted, or upon the circumstance of a poisonous matter having been injected into the part, or lastly, upon the particular situation of the wound, and the nature of the wounded parts themselves.

Thus we have *clean-cut* or *incised wounds,* produced by sharp-edged instruments; *stabs,* or *punctured wounds,* caused by the thrust of pointed weapons; *poisoned wounds,* from the introduction of venomous matter into the part; *contused wounds,* in which bruising accompanies the cut; and *lacerated,* where the parts are torn.

Treatment of a Clean-cut Wound.—In any simple clean-cut wound, provided the edges are not gaping, cover it up with any piece of linen that comes handy; but do not tie anything over it tightly, or a painful throbbing will ensue, which might lead to serious results. If the wound gapes, gently press the edges together before covering.

Bleeding.—Bleeding may generally be stopped by the application of cold and pressure. There are two kinds of bleeding: the one, arterial, the blood being bright red in colour, and coming from the wound in jets; the other, venous, the blood being dark, and simply flowing out. In either case, when the bleeding is moderate, place your finger on the cut and keep it there. If, after a few minutes, the bleeding has ceased, cover up the wound, and tie the bandage so that you feel a little pressure over the cut. As blood soon clots in a wound, it should be borne in mind that when once formed a clot should never be disturbed.

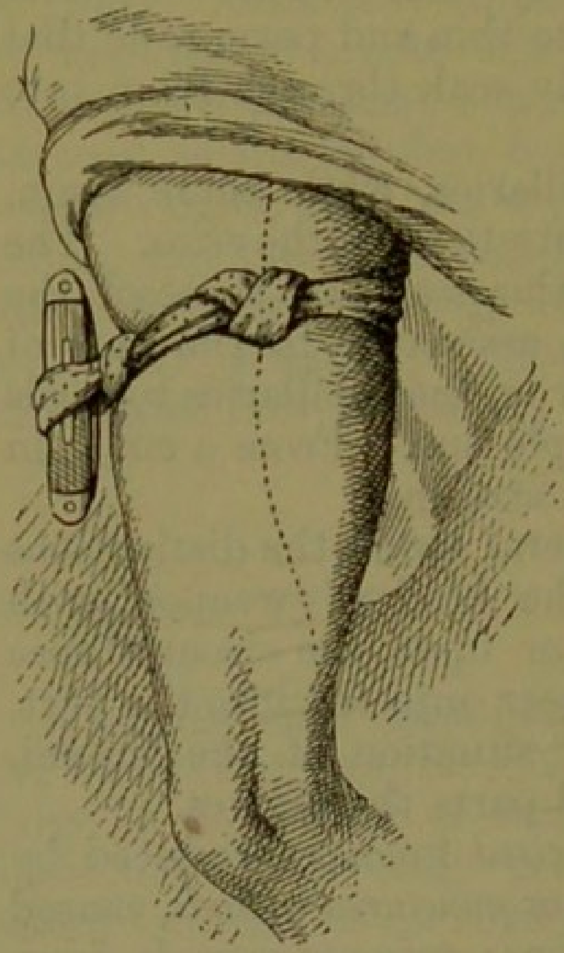


Fig. 39.—Arrest of Bleeding from Foot or Leg by knotted handkerchief twisted by means of a pocket knife, the knot pressing in the proper place.

When a main artery is wounded, pressure must be applied at once *between the wound and the heart* to save the loss of blood. As considerable pressure will be required, it is necessary to employ some form of a *tourniquet.* A simple one may be made with a handkerchief, a length of rope, or anything that can be knotted. This is then placed in position and firmly tied, the knot acting as a compress above the cut. The pressure may be increased at will by twisting the bandage by means of a piece of stick. A stone or a piece of wood is sometimes used as a compress instead of a knot. Fig. 39 shows a tourniquet applied to a limb.

As a rule there is little danger to be feared from venous bleeding, unless the vein is a large one. To arrest the bleeding we may apply pressure on the wound itself, and if this does not succeed, the pressure may be applied *below* the wound and the limb raised.

One of the most frequent troubles with the veins of the legs is their becoming *varicose,* or enlarged and swollen. The stretched wall of one of these suddenly gives way, and the blood pours out in a continuous stream. In these injuries, place a pad over the bleeding point and fasten by a bandage, then keep the patient quiet in the recumbent position with the limb raised.

With contused and lacerated wounds there is usually not much bleeding, not even when the largest arteries are divided, as must be the case when whole limbs are torn away by machinery. This may be due to the clotting up of the vessels by the violence and suddenness of the wrench, or to that "other help" of the surgeon—*faintness.* The treatment consists of the removal of any foreign matters by careful washing, the replacing of parts as much as possible in their natural position, and the conveyance to the nearest aid.

Bleeding from the Nose.—The patient should be placed on his back, a wet sponge applied to the back of the neck, and ice or cold-water cloths placed on the nose and forehead. If this should fail to bring about the desired result, the nostrils should be plugged with sponge or cotton-wool.

Poisoned Wounds: Bites and Stings.—In the treatment of poisoned wounds, our first aim is to prevent the passage of the poison into the system. This may be accomplished (1) by the excision of the poisoned part, or destroying it with caustics; (2) by the application of a ligature between the wound and the heart; and (3) by sucking the wound so as to extract the poison.

As to the mode of treatment of a poisoned wound, common sense must guide us in determining whether the injury calls for excision or the use of caustics. Thus, in the case of a scratch by a rusty nail or dirty needle, the mere sucking of the wound is sufficient. Even the bite of an adder, which is the only poisonous snake in Great Britain, rarely produces effects severe enough to justify any further proceedings. But the bites of many foreign species of snake would require prompt and vigorous measures.

The bite of a rabid dog or other animal is one of the commonest kinds of poisoned wounds met with in this country, and is to be treated essentially on the same lines as the bite of a snake. It should, however, be borne in mind that "rabies" in a dog is a comparatively rare disease. Of the numberless persons who are bitten by dogs, only a small number suffer from hydrophobia; for many dogs which are said to be "mad" are really not so, but are simply either excited by being teased, or in ill-health.

Stings.—The stings of wasps, bees, or hornets rarely produce any serious trouble. They only become really dangerous when they occur on the tongue, or in the throat, on account of the great swelling which follows, and which threatens suffocation. In all cases where the *sting* has been left behind, press the barrel of a watch-key over the part, so as to expose the sting, which must be removed, and then apply an alkaline lotion, such as a weak solution of ammonia, or carbonate of soda.

Burns and Scalds.—A *burn* is the effect of the action of concentrated heat upon the tissues. A *scald* arises from the application of a hot or boiling fluid to the skin. These injuries are serious and dangerous in proportion to their extent and the regions of the body they occupy. The momentary action of very hot water on the surface of the body produces pain and redness, followed by a degree of swelling. The severity of a scald depends upon the length of time the hot or boiling fluid is applied, and the kind of fluid itself. Thus boiling oil, greasy soups, and other liquids not only take a higher temperature than boiling water, but adhere longer to the parts. Hence burns and scalds may be divided into several kinds or degrees, which depend upon the intensity and duration of the heat applied to the parts.

When a burn or scald has been inflicted, remove the clothes expeditiously and promptly, but with great care, so as to avoid pulling off the skin with them. Where the clothing is found sticking to the skin, cut the garments away with a pair of scissors as near to the burn as possible. The injured part should be bathed with a strong solution of carbonate of soda to relieve the pain, and strips of linen which have been saturated with *carron-oil*—a mixture of equal parts of linseed or olive oil and lime-water—are then placed over the wounds, the whole being covered with a sheet of cotton-wool and fastened on by bandages. Do not dust any powder, such as flour, upon the wound. If no lime-water is handy to add to the oil, use the latter alone.

One of the most distressing forms of scalds is that caused by children attempting to drink boiling water from the spout of a tea-kettle. In such an event, the child should be wrapped in a blanket and allowed to breathe an atmosphere moistened with steam, while the doctor ought to be sent for at once.

In all cases of severe burning and scalding there is great depression; hence we must apply warmth and give stimulants, such as very strong and very hot coffee.

The Apparently Drowned.—In treating cases of the apparently drowned, our efforts must be twofold: (1) *to restore breathing*, and (2) to promote warmth and circulation of the blood. Do not waste time by running for help, but at once commence treatment on the spot, in the open air. On no account roll the patient's body on a cask or hold him up by the heels with the idea of getting rid of any water he may have swallowed.

The return of breathing will be best promoted by following the method of Dr. Marshall Hall or Dr. Sylvester. In the former method the patient is laid face downwards, so that any water that may be in the mouth and throat will clear out and the tongue fall forward. Then as the chest is pressed against the ground, air is driven from the lungs, and if a half-turn of the body be then made air will be drawn into them. Repeat these operations fifteen times per minute, varying the side on which he is turned every minute or so.

Sylvester's method, the one recommended by the Royal Humane Society, is as follows:—

1. Cleanse the mouth and nostrils of all dirt; draw forward the tongue, and keep it so by an elastic band passed under the chin.
2. Place the patient on his back on a flat surface, inclined a little

from the feet upwards, and support the head and shoulders by a small firm cushion.

3. Now stand behind the patient; grasp his arms above the elbows, and draw them steadily upwards above the head, keeping them there for two seconds. This raises the ribs and produces inspiration.

4. Bring down the arms and press them firmly against the sides of the chest for two seconds, and thus produce expiration.

5. Repeat these movements fifteen times per minute, taking care not to perform them hurriedly, and for not less than half an hour, unless the heart has quite ceased to beat.

Whichever method be adopted, the means for restoring warmth should be going on at the same time. The wet clothes may be gradually removed and the skin dried. Then wrap the patient in dry blankets, and commence rubbing the limbs upwards under the blankets. Hot flannels, bottles of hot water, heated bricks, &c., may be placed on the pit of the stomach, under the arm-pits, between the thighs, and to the soles of the feet.

As soon as consciousness returns give small quantities of hot wine, brandy and water, or coffee. The patient should be kept in bed and a disposition to sleep encouraged.

Suffocation.—In addition to drowning, suffocation may be caused by *hanging*, by the *inhalation of poisonous gases*, by some foreign body being *pushed into the throat*, or by *smothering*, as in the *overlaying* of children by drunken parents. In all these cases the breathing is interfered with and probably stopped. Our treatment will be therefore directed towards restoring respiration. All tight clothing must be removed from the neck and chest; cold water dashed over the face, pungent substances applied to the nostrils, and, if need be, artificial breathing resorted to as recommended in case of drowning.

Fainting.—Fainting, or *syncope*, is the result of a temporary cessation of the heart's action, brought on by violent mental emotion, fatigue, the sight of or loss of blood, and frequently by tight lacing. When a person faints, lay him flat on his back, with the head low, and unfasten the clothing around the neck, chest, and waist.

Bathe the forehead with cold water, and perhaps dash a little on the face. Smelling-salts may be applied to the nose.

Epileptic Fits.—Epileptic fits may seize men and women at any time. The seizure is usually very sudden, and after uttering a cry or shriek the person seized loses consciousness and falls. As epilepsy is a nervous disease, it behoves the friends of an epileptic subject to carefully watch him between the attacks. On no account ought such a person to be allowed to mount the scaffolding of buildings, or other dangerous places, without an attendant.

The symptoms of these fits cannot be mistaken. The teeth are clenched, the tongue often bitten, froth forms at the mouth, and the body is convulsed. After a time the convulsions cease, and the patient opens his eyes.

The treatment of the epileptic fit consists, firstly, of removing all tight clothing from the neck, and then inserting a piece of india-rubber or a cork between the teeth to prevent any further injury to the tongue. The wrists and ankles should be grasped firmly, but gently, in order to prevent the patient from knocking himself against the furniture or other objects. After the attack has passed away the patient should be allowed to sleep, to enable the brain to recover from the shock.

Hysteria.—The hysterical fit is chiefly confined to women, and especially excitable girls. Unlike epilepsy, the loss of consciousness is invariably preceded by a fit of laughing or crying.

The treatment of such fits is very simple. Do not sympathize with the patient, for the fits increase in frequency as kindness is forthcoming. A firm, but not unkind rebuke before consciousness is lost will frequently ward off an attack. Should this fail, the application of a cold-water douche to the head is almost certain to revive the patient.

Apoplectic Fits.—The nature of apopletic fits is very different to either of the preceding ones. Here we have to deal with the rupture or plugging of some blood-vessels in the brain. They occur most frequently with old persons, owing to the blood-vessels becoming brittle, and with persons of excessively intemperate habits. The symptoms are loss of consciousness, stertorous breathing, flushed face, and paralysis of one side or the whole of the body.

Send at once for medical aid, and in the meantime loosen the clothing of the neck and chest; raise the head, and apply cold cloths or ice to it.

Apoplectic fits are frequently mistaken by the ignorant for drunkenness, and are wrongly treated in consequence. In drunken fits there is always a strong smell of liquor in the breath; but no matter how insensible a man may be from drink, it is seldom that he cannot be at least partially roused. An emetic of sulphate of zinc, 20 or 30 grains in a pint of water, and cold water douches over the head, will be found beneficial to a man "dead drunk."

Uræmic Convulsions.—Uræmic convulsions are caused by the retention of urinary matters in the blood, arising from kidney disease. Sometimes a state of stupor comes on rather suddenly and passes into a complete coma; in other cases convulsions of an epileptic character occur. As these fits frequently prove fatal, medical aid must be obtained at once.

Infantile Convulsions.—Infantile convulsions may arise from improper feeding, giving *artificial* food instead of breast-milk, teething, whooping-cough, bronchitis, and inflammation of the lungs. In the majority of cases they are caused by stuffing the child with too much farinaceous food, or worse still with suet dumpling and a host of other indigestible foods. The treatment had better be left in the hands of a medical man.

Concussion.—In concussion or stunning from blows on the head, the body is cold and pale, the pulse weak, the breathing slow and gentle, and the pupils of the eyes contracted. When vomiting occurs it may be regarded as a good sign, for this tends to lessen the pressure on the brain. The treatment of cases of this kind consists of putting the patient to bed and wrapping him in warm blankets. Hot-water bottles may be applied to the feet. It sometimes happens that the loss of consciousness comes on slowly after the blow. This points to hæmorrhage on the surface of the brain, and the pressure of the effused blood upon that important organ will give rise to the most imminent danger. A surgeon should be sent for at once, and pending his arrival the patient should be put to bed, the head slightly elevated, and kept cool by cold cloths or ice.

Poisons and their Remedies.—Under the head of poisons we include all those substances which possess the power, when introduced into the blood, of effecting some chemical change, either upon the components of the blood, or on the tissues which it nourishes, and are thus capable of destroying life.

In all cases of poisoning, our first duty is to send to the nearest medical man, and as it is seldom that no clue can be found as to the nature of the poison, acquaint him with all the particulars, so that he may know what instruments and antidotes to provide himself with. However, in order that valuable time may not be lost before he arrives, the following general treatment may be adopted:—

In the first place, *get the poison out of the system as quickly as possible.* This may be done by giving *emetics*, or by using the stomach-pump. Emetics are substances which cause vomiting, and their administration will depend upon the nature of the poison taken. For example, emetics would not be given in cases of poisoning by *corrosives* such as strong mineral acids, caustic alkalies, &c., as the vomiting may bring away portions of the eroded walls of the stomach. The emetics which are usually at hand are mustard (a table-spoonful in a pint of warm water), a strong solution of salt, and warm greasy water. If the desired effect of emptying the stomach is not soon produced, repeat the dose. The best emetic of all is half a tea-spoonful of sulphate of zinc in water. The action of emetics may be greatly increased by irritating the throat with a feather or even with the fingers, together with copious draughts of warm water. The use of the stomach-pump should be left in the hands of a medical man.

Where it is considered unadvisable to administer emetics, we proceed to neutralize the poison by means of *antidotes.* Thus, for the mineral acids we may give powdered chalk, magnesia, or carbonate of soda in a quantity of water; whilst the alkalies—potash, soda, or ammonia—call for vinegar and water, or lemon-juice.

Antidotes for the Chief Poisons:

Mineral Acids.—These include sulphuric acid (vitriol), nitric acid (aqua fortis), and hydrochloric acid (spirit of salt). Do not use emetics. Give baking-soda dissolved in water. Better still, magnesia and water. If these are not at hand, common whiting and water will answer.

Oxalic Acid.—Give chalk or magnesia in milk. Whiting or whitewash scraped off the walls or ceiling may be administered.

Carbolic Acid.—Give either olive or castor oil. Apply warmth to the feet, and if the patient shows signs of collapse, warm water and brandy may be carefully administered.

Prussic Acid.—Little can be done in way of antidotes for this acid, as its action is very rapid. Dash cold water over the back and chest, and apply smelling-salts to the nose. Artificial respiration should be carried out until a medical man arrives. If the patient can swallow, brandy may be given.

Alkalies.—The commonest alkalies are potash, soda, and ammonia. Give vinegar freely diluted, or lemon-juice, alternately with olive-oil.

Antimony.—A constituent of tartar emetic. Strong boiled tea and the white of eggs beaten up with milk are the best remedies.

Arsenic.—Give an emetic at once, and then a mixture of equal parts of oil and lime-water frequently.

Belladonna.—An English plant better known as the "deadly nightshade." Induce vomiting at once. Apply hot-water bottles to the feet, and give hot coffee to drink.

Opium.—Emetics at once. Patient should be roused from stupor by small doses of brandy and water, hot coffee, &c., and kept awake by walking him about.

Strychnine.—This substance enters largely into the composition of many vermin-killers. Poisoning by strychnine is a case entirely for a medical man, but if the mistake is discovered early an emetic should be given.

Phosphorus.—Give an emetic of sulphate of zinc, and keep the body warm with hot bottles.

APPENDIX.

SYLLABUS OF THE BOARD OF EDUCATION.

SUBJECT XXV.—HYGIENE.

In the examination paper for the Elementary and Advanced Stages of Hygiene a certain number of questions on Elementary Human Physiology will be set, and no candidate who fails to satisfy the Examiners in this Elementary Human Physiology can pass in the Elementary Stage or in the Advanced Stage of Hygiene.

ELEMENTARY HUMAN PHYSIOLOGY.

1. The form, position, and use of the bones constituting the skeleton, with a general idea as to the build of the body, as well as the boundaries and position of contents of the various body cavities.

2. The structure and arrangement of the heart, chief blood-vessels, and the circulation, with a knowledge of the general composition, uses, and phenomena of blood.

3. The structure and arrangement of the lungs, with a knowledge of the theory of respiration and the changes resulting therefrom in the blood and air.

4. The general structure and uses of the teeth, stomach, and intestines, including a knowledge of the process of digestion and assimilation.

5. The position, general structure, and uses of the liver, spleen, pancreas, kidneys, and bladder.

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1. WATER.—Properties of water, sources of natural water; causes of hardness in water; method of demonstrating the salts; common sources of contamination of water supplies; storage and distribution; cisterns, wells, and reservoirs.

2. FOOD AND DIET.—Classification and uses of food substances. Animal food, vegetable food, condiments; diets required for maintenance; composition and characteristics of milk, eggs, butter, sugar, cheese, and cereals. Cooking; roasting and boiling; purposes of cooking; cooking apparatus. Composition of tea, coffee, cocoa, and

lime-juice. Nature of fermentation. Composition and preparation of vinegar, beer, aerated waters, and wine.

3. AIR.—Composition of the atmosphere. Combustion and its effects on the atmosphere; respiratory impurities found in air. Coal gas, its composition and impurities. Different kinds of flames and burners; gases produced by combustion of candles and gas. Principles of ventilation. Natural and artificial ventilation.

4. REMOVAL OF WASTE.—Washing and soap; removal of parasites; danger of dirt; removal of house refuse.

5. Materials of clothing; sufficiency of clothing for infants and adults.

6. LOCAL CONDITIONS.—Soil, and its drainage; "made" soils; aspect; elevation. Hill, plain, and valley; distance from the sea; influence of surrounding objects; winds.

7. PERSONAL HYGIENE.—Habits; exercise, rest, and sleep, cleanliness, attention to the action of the skin and bowels.

8. TREATMENT OF SLIGHT WOUNDS AND ACCIDENTS.—Treatment of cuts, burns, scalds, bleeding, fits, drowning, suffocation, poisoning, bites, and stings.

EXAMINATION QUESTIONS.

A.

Elementary Human Physiology.

(*a*) Describe the structure of the stomach, and the process of digestion in it.

(*b*) Give a brief description of the pancreas (with sketch), and explain its function.

(*c*) Describe the difference between an artery, vein, and capillary; explain how these differences affect the circulation of the blood.

(*d*) Where and how is saliva formed? What is its composition and uses?

First Stage or Elementary Examination.

1. Explain the changes which meat undergoes in cooking, and indicate the essential differences between the processes of boiling and stewing.

2. What is arrowroot? Explain its value as an article of food.

3. What are the precautions necessary to secure a pure supply of drinking-water from a well? What diseases are believed to be propagated by drinking-water?

4. Describe three efficient methods of purifying water, and explain the action in each case.

5. What is carbonic acid? What are its sources? What part does it play as a sign of good or bad ventilation?

6. What animal parasites may be found on the surface of the human body? How may they be got rid of?

7. What influence has distance from the sea upon the climate, air, and water-supply of a place?

8. What materials are used for clothing? Mention the advantages or disadvantages of each.

9. A person has been run over by a cart, his leg is apparently broken and bleeding fast; what would you do?

Second Stage or Advanced Examination.

21. Explain the preparation of cheese. What is its value as an article of diet, and what is its average composition?

22. Life can be sustained on milk alone longer than on any other single article of food; explain the reason for this. Why is malted food good for very young children?

23. What waters have (*a*) the greatest, and (*b*) the least action on lead? What conditions favour their plumbo-solvent action?

24. Explain the various ways in which drinking-water may become contaminated within a dwelling, and mention the means to be adopted for preventing such contamination.

25. What is ventilation? Why is it necessary? How would you ventilate a schoolroom, and how much space would you allow to each pupil?

26. Contrast the sanitary advantages and drawbacks of the following materials for roof-coverings: slates, Brosely tiles, zinc, lead.

27. What forms of water-closet are most suitable for labourers' dwellings and for factories? Under what conditions may they be expected to work satisfactorily?

28. What are the objections to stoves as means of heating dwelling rooms? Describe any two forms with which you may be familiar, and point out their respective advantages or disadvantages.

29. What are the causes of scrofula and rickets? In what class of the community are these diseases most common, and what principles should be observed to prevent their excessive prevalence?

B.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) Describe the vertebral column, and a single vertebra.

(*b*) What is the external appearance and position of the lungs? Explain their structure.

(*c*) Describe the phenomenon of blood coagulation.

(*d*) Give a short account of the teeth, more particularly with reference to their situation, number, names, and structure.

FIRST STAGE OR ELEMENTARY EXAMINATION.

1. Give a classification of food substances, with examples, and explain their respective uses.

2. How should beef-tea be made? What food substances does it contain, and what value has it as a dietetic?

3. Enumerate some sources of water-supply, and point out the objections or advantages of each.

4. Compare and contrast tea, coffee, and cocoa as beverages.

5. What are the causes of natural ventilation? Explain their action.

6. What animal parasites may be found on the surface of the human body? How may they be got rid of?

7. Why do children need to be well clothed? Explain the im-

portant points to be borne in mind in constructing clothing generally.

8. How should an ash-pit be constructed, and how is it likely to become a nuisance?

9. What assistance should you give to a person whose clothes have caught fire? Explain briefly the general management of scalds and burns.

SECOND STAGE OR ADVANCED EXAMINATION.

21. How would you recognize wholesome and unwholesome butcher's-meat? What diseases may be produced in man by the consumption of meat from diseased animals?

22. How is bread prepared? Explain its value as a food, and contrast its general composition with that of cheese.

23. Explain how you would heat and ventilate a room without causing a draught.

24. Describe briefly the essential points to be observed in the construction and arrangement of water-closets for a house.

25. How may drinking water be contaminated in a dwelling-house after delivery? Explain the precautions to be taken to guard against this contingency.

26. How is the amount of moisture in the air usually determined and expressed?

27. Explain the difference between a disinfectant and an antiseptic, giving examples of each. How would you disinfect books, pillows, and bed-sheets?

28. Describe the dry-earth system for the treatment of the excreta. Point out its advantages and disadvantages.

29. What are the causes of tuberculosis? Explain the chief hygienic measures to be adopted for its control and prevention.

C.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) Give a brief description of the structure and functions of the liver.

(*b*) What are the changes that the blood undergoes in its passage through the lungs, and how are they effected?

(*c*) Describe the structure of a tooth. Why are teeth necessary for the processes of digestion?

(*d*) Where is the bladder situated? Describe briefly its structure and functions.

FIRST STAGE OR ELEMENTARY EXAMINATION.

1. What is the usual classification of food substances? Why is meat so largely used as an article of food?

2. What is cocoa? Explain its value as an article of food.

3. What are the characteristics of river-water, and what are the dangers attending its use?

4. What are the chief ways in which drinking-water may become contaminated with lead? How can this be obviated?

5. What is meant by the *diffusion of gases*? How does it affect the question of ventilation?

6. How is house refuse best dealt with? Describe the construction of a good ash-pit.

7. What precautions should be taken to secure a healthy site for a dwelling-house to be erected upon (*a*) the side of a clay hill; (*b*) fen land; (*c*) a sandy soil containing springs?

8. What effect has exercise upon the heart, respiration, and the skin? Why is exercise essential to health?

9. What "first aid" could you give to a man suffering from a ruptured vein in the leg?

SECOND STAGE OR ADVANCED EXAMINATION.

21. What amount of proximate alimentary principles should be supplied in a diet for ordinary work? What are the physical and chemical characteristics of the carbo-hydrates?

22. Describe in detail a method for the filtration of river-water on a large scale, and the results produced by it. Discuss the advantages and disadvantages of rivers as a source of drinking-water.

23. Describe in detail any method you would adopt to make a quantitative estimation of the oxygen in a given sample of air.

24. What are the important points as regards the materials, construction, dimensions, positions, and course of a soil-pipe? Give your reasons for considering them important.

25. What forms of water-closet are most suitable for labourers' dwellings and factories? Under what conditions may they be expected to work satisfactorily?

26. State the best position for a "damp course" in walls, and name the various materials in general use. Describe any method of construction you prefer.

27. Contrast the advantages and disadvantages of heating a building—

(*a*) By hot-water pipes.
(*b*) By closed coke stoves.
(*c*) By open fire-places.

28. What are the conditions which favour the spread of enteric fever? Discuss the question of the origin and diffusion of this disease.

D.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) Enumerate the bones which form the framework of the thorax. Explain how the movement of the ribs causes changes in the size of the chest.

(*b*) Describe the course of the pulmonary artery, and explain in what respect it differs from the arteries of the body.

(*c*) Explain the changes which occur in the blood during its circulation through the lungs.

(*d*) Describe the structure and functions of the kidney.

FIRST STAGE OR ELEMENTARY EXAMINATION.

1. What is lime-juice? Explain its uses.

2. What are the characteristics of rain-water? How should it be collected and stored for use?

3. Under what conditions is the water in a shallow well liable to pollution?

4. How much fresh air per hour is required for a man doing ordinary work? Describe a good method of introducing the necessary fresh air into a work-room.

5. What is a soil-pipe? What are the different kinds of refuse which require removal from a dwelling-house?

6. What do you understand by (*a*) healthy, and (*b*) unhealthy soils?

7. What is the effect of exercise on the skin? Explain the advantages of woollen underclothing.

8. What are the essentials of a good dust-bin?

9. How would you resuscitate a person apparently drowned?

E.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) What bones enter into the formation of the hip-joint? Explain how this joint is adapted so as to carry the weight of the body and still permit the various movements required.

(*b*) Describe the position of the pancreas, and explain the action of its secretion on the process of digestion.

(*c*) Describe briefly the main structural differences between arteries and veins, and point out the reasons for the difference in structure.

(*d*) What do you understand by "milk teeth" and "permanent teeth"? Describe briefly the structure of a permanent incisor tooth.

1. What food elements or constituents must be present in every diet so as to maintain health? Upon which of the constituents does the power of performing work chiefly depend?

2. What are the chief sources of drinking-water? Which sources give the purest waters?

3. What materials are usually employed in the construction of cisterns? Mention their advantages and disadvantages.

4. Explain how the physical properties of air affect the question of ventilation. Illustrate your explanation by the action of a fire-place in a sitting-room.

5. How should an ash-pit be constructed so as to cause as little nuisance as possible?

6. What special precautions should be taken as to the clothing of young children and old people?

7. How do the physical characters of the soil affect the health of those living on it?

8. What effect has exercise on the heart, respiration, and skin? Why is exercise essential to health?

9. What is the best treatment for a severe burn?

F.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) Give a brief description of the heart, and its mechanism.

(*b*) Explain the changes which take place in food before reaching the stomach. By what agencies are these changes effected?

(*c*) Describe the mechanism of respiration, and the changes which take place in inspired air.

(*d*) What bones form the hip-joint? Compare its structure with that of the shoulder-joint.

1. What are the advantages of cooking meat? Compare the effects of roasting and boiling.

2. What is the difference between "hard" and "soft" water? How can you *practically* distinguish between them? Compare their advantages and disadvantages for various purposes.

3. Give the composition of atmospheric air. Show how it is affected by (*a*) breathing, and (*b*) artificial lighting. How can you demonstrate the changes?

4. What are the best materials for the construction of cisterns? How may drinking water become polluted within a house?

5. Why is cleanliness of skin essential to health?

6. What are the comparative advantages of a water-supply from shallow and deep wells?

7. Explain the importance of rest and sleep. How is this influenced by age?

8. What would you do for a person in a fit of epilepsy? How would you recognize it?

G.

ELEMENTARY HUMAN PHYSIOLOGY.

(*a*) What are the chief forms of joints found in the lower extremity of the human body? How are they adapted to the movements performed in walking?

(*b*) What do you understand by voluntary and involuntary muscular fibres? Where are they chiefly found in the human body?

(*c*) What is the composition of gastric juice? Describe its action on proteids, fats, and carbohydrates respectively.

(*d*) Where are the salivary glands situated? What action has the juice secreted by these glands on food taken into the mouth?

1. How does rain-water differ from spring-water and well-water? How should rain-water be collected and stored?

2. What is the composition of "Expired" air? Why is the re-breathing of expired air supposed to be dangerous to health?

3. What do you understand by the term "Siphonage" when applied to a trap? Under what conditions is it usually found? Explain how it can be prevented.

4. What is wheat flour? Explain the changes produced in flour during the baking of a loaf of bread.

5. What is a "Made Soil"? Why should houses not be built on soils of this nature?

6. What are the impurities in the air of inhabited rooms? What is understood by natural ventilation? Give illustrations of its mode of working.

7. How is house-refuse best dealt with? Describe the construction of a good ash-pit.

8. What are the advantages of woollen clothing? Explain its action in preventing chill.

9. How would you arrest hæmorrhage from a ruptured varicose vein of the leg?

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