PHYSIOLOGY, PUBLIC HEALTH

. AND

PSYCHOLOGY

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PHYSIOLOGY PUBLIC HEALTH AND PSYCHOLOGY

BY

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PREFACE

THE subjects with which this book deals are those recommended, in 1927, by a Committee of the Board of Education of the United Provinces Government, India, as a course of study for the Intermediate Examination of Allahabad University, and the book is primarily intended for the use of students preparing for that examination. If it should be found useful to them or to other students in India the writer will have the satisfaction of knowing that his labour has not been in vain. Every effort has been made to write in simple and intelligible language, and where the use of scientific terms has been unavoidable the derivation of most of them has been given.

Much of what is contained in the chapters on Physiology and Public Health has been reproduced from the author's "Manual of Hygiene and Domestic Economy"; but a considerable amount of new matter has been added to make the present volume conform with a syllabus presc ibed by the Committee mentioned above.

Beginners may find it somewhat difficult to follow the description of the minute structures of the eye and ear—more especially those of the middle and inner ear—unless large models of these important sense organs are available for their use. But if the diagrams are closely examined in conjunction with the text, readers may be able to grasp at least the more important and essential details of their structure and mechanism.

I do not wish to claim any originality for that part of the book which deals with Psychology, because, like most other books upon the subject, it is based largely on the work of earlier writers. But I desire especially to acknowledge gratefully my debt to Professor Robert S. Woodworth, Ph.D., of Columbia University, and Mr. Benjamin Dumville, M.A. (Lond.), F.C.P., formerly of the Educational Department of the London County Council, from whose books, "A Study of Mental Life" (Woodworth) and "Child Mind—An Introduction to Psychology for Teachers" (Dumville), I have freely drawn. A list of other books from which quotations have been made will be found in the Bibliography which is appended.

I owe a deep debt of gratitude to my cousin, the Rev. Robert H. Jack, M.A. (Oxon), B.Sc. (Lond.), Rector of Wivenhoe, Essex, for having written the three last chapters on Psychology and for his painstaking and careful revision of other chapters, and many valuable suggestions, in the way of amendments and additions, for their improvement.

I am greatly indebted, also, to the Publishers, Messrs. Macmillan and Co., for the kindness, courtesy, and help received from them.

CHARLES BANKS.

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PART I

PHYSIOLOGY

Physiology is the science of the nature and processes of life, and its study begins with the consideration of cells.

CELLS

Cells are small particles of semi-fluid living substance, or *protoplasm*, the outer surface of which may sometimes become sufficiently firm to form a limiting membrane or *cell wall*. It nearly always contains a denser kernel-like body or *nucleus*.

Amœba (Gr. *amoibē*, change) is the term applied to the lowest form of animal life. It belongs to a group of animals called *protozoa* (Gr. *protos*, first; *zōon*, an animal). Amœbæ consist of single cells, some of which are only about $\frac{1}{2000}$th part of an inch in size. When examined by a microscope they are seen to be constantly changing their shape and position by alternately projecting and retracting portions of their protoplasm. These projections are called pseudopodia (Gr. *pseudēs*, false; *podos*, foot). Amœbæ have neither a mouth nor a stomach. But, when moving about, any particles of food that come in their way are surrounded by the pseudopodia which then coalesce. The food is thus taken into the cell-mass, where it is digested. The waste products are, thereafter, got rid of by extrusion. Amœbæ require *oxygen* for their existence. They are sensitive, and respond to cold, electric, and other shocks. They can produce, by division and subdivision, cells exactly like themselves. Amœbæ may, therefore, be said to perform the functions of locomotion, digestion and nutrition, excretion, breathing, reproduction, and to possess a nervous system, although of a primitive kind (Fig. 1).

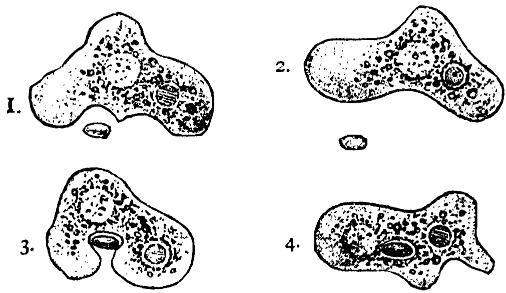


Fig. 1.—Amœba and Food Particle.

Amœbæ grow and multiply in water, mud, and moist earth. They are also found, at times, in human excreta. Changes of shape, similar to those which occur in amœbæ,

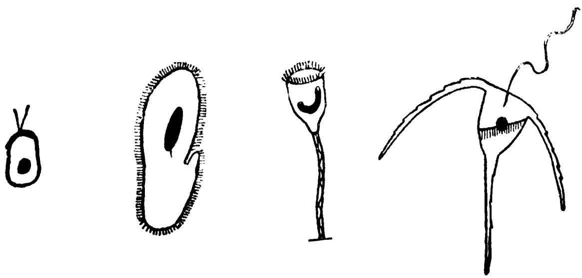


Fig. 2.—One-celled Animals (Highly Magnified).

take place also in the white cells of the blood and in the pigmentary layers of the retina of the eye.

Some protozoa consist of one cell only (Fig. 2).

Others, of a higher type than amœbæ, are composed of numerous cells. They are, nevertheless, regarded as unicellular or one-celled organisms, for the simple reason that all the cells of which they are formed are contained within *one definite limiting membrane* or *cell wall* (Fig. 3).

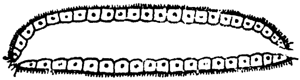


FIG. 3.—AN ANIMAL FORMED OF ONE LAYER OF CELLS.

The so-called giant amœba, for example, contains within its cell wall spore-like young amœbæ, and may be about $\frac{1}{16}$ inch in size, and can be seen with the naked eye.

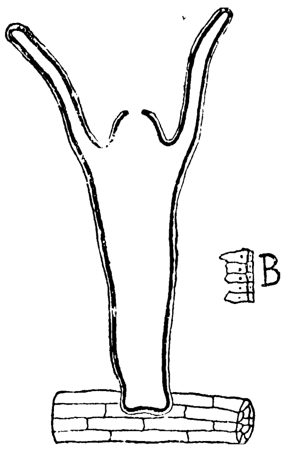


FIG. 4.—HYDRA: AN ANIMAL FORMED OF TWO LAYERS OF CELLS (COMMON IN PONDS).

B, Part of body more highly magnified.

A number of these may clump together and form masses. Other examples of the kind are (*a*) the *hydra*, a fresh-water animal, which multiplies in a marvellous manner when cut into pieces, and (*b*) the *sun-animalcule*, in which the unit-mass or cell reproduces itself by dividing into two, or by forming buds which become detached and live an independent existence, or by the formation of spores or germs within the cell by fission or cleavage. These spores can develop into fully formed sun-animalcules. Most sun-animalcules live in fresh water, but some are found in the sea (Fig. 4).

Metazoa (Gr. *meta*, after; *zōon*, animal) is the term applied to *multicellular* or many-celled animals, to which group all highly organised animals belong, and in which reproduction is effected by the *fertilisation* or impregnation of the *ovum* or egg-cell of the female by the spermatozoon

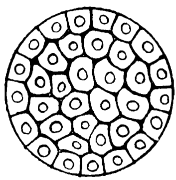


FIG. 5.—MORULA, SHOWING OVUM AFTER COMPLETE SEGMENTATION.

or male cell. The human ovum is about $\frac{1}{120}$ inch in diameter, and contains a nucleus. A spermatozoon measures $\frac{1}{200}$ inch in length. The fusion of these two microscopic cells is the starting-point in the growth and development of the body and bodily organs. When the ovum is fertilised the nucleus undergoes *segmentation* or division into two, and by repeated division and subdivision numerous cells are formed, all of which, in the early stages of their development, resemble each other (Fig. 5).

Later on the cells begin to show marked differences in size and shape, and, in the fully developed body and bodily organs, the cells are arranged with mathematical precision in compact form. Each organ has its own special function to perform, and if the cells of any individual organ cease to function properly, other organs of the body may suffer in consequence. This is particularly observed in the case of

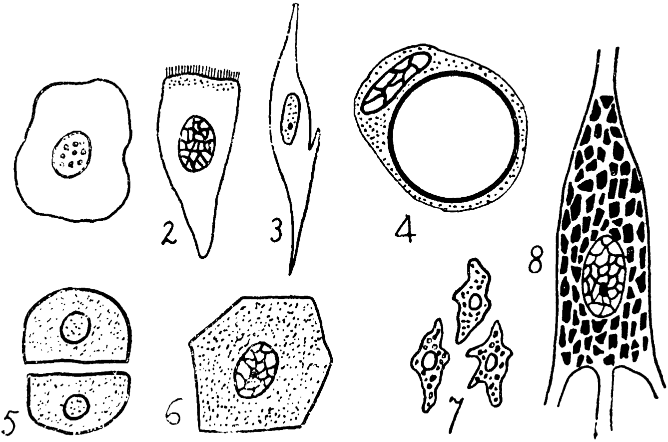


FIG. 6.—CELLS FROM THE HUMAN BODY (ALL HIGHLY MAGNIFIED).

1, From lining of mouth; 2, ciliated cell from the wind-pipe; 3, connective tissue cell; 4, fat cell; 5, cartilage cell; 6, liver cell; 7, pigment cells from eye; 8, nerve cell.

the secretory glands of the body when they fail to function in a normal manner (Fig. 6).

THE SKELETAL SYSTEM

THE skeleton forms the framework of the body, and is composed of more than 200 bones. For the purpose of description it may be divided into three portions—viz., the head, the trunk, and the upper and lower extremities or limbs (Fig. 7).

The Head consists of the cranium or skull, which is composed of eight bones forming a protected cavity for the brain. Fourteen bones enter into the formation of the face.

The cranial or skull bones are as follow:

(*a*) The *occipital* bone, situated at the back and lower part of the head.

(*b*) Two *parietal* bones forming the sides and roof of the skull.

(*c*) The *frontal* bone which forms the forehead.

(*d*) Two *temporal* bones at the sides and base of the skull.

(*e*) The *sphenoid* bone (Gr. *sphen*, *sphenos*, a wedge; *eidos*, form), situated at the base of the skull and in front of the temporal bones. It resembles a bat with its wings extended.

(*f*) The *ethmoid* bone (Gr. *ethmos*, a sieve; and *eidos*, form), situated in the front part of the base of the skull between the two orbital cavities. It forms the roof of the two nasal passages.

The bones of the face are as follow:

(*a*) Two *nasal* bones, situated in the middle and upper part of the face, forming the "bridge of the nose."

(*b*) Two *superior maxillæ* or upper jawbones which are united. They help to form the roof of the mouth, the floor and outer wall of the nose, and the floor of the orbits. Each bone has a large cavity, known as the *antrum of Highmore*, in which abscesses, caused by septic gums and decayed teeth, sometimes form.

(*c*) Two *lachrymal* bones, one situated at either inner corner of the orbits adjacent to the nose. Two glands, which secrete the tears of the eyes, are found, one on either side in this region. They are called *lachrymal glands* (Lat. *lacrima*, a tear).

(*d*) Two *malar* or cheek bones. These are so prominent that their situation needs no description.

(*e*) A *palate* bone, situated at the back part of the nose and between it and the mouth. The palate bone forms the roof of the mouth, the floor of the orbital cavities, and the floor and part of the outer wall of the nose.

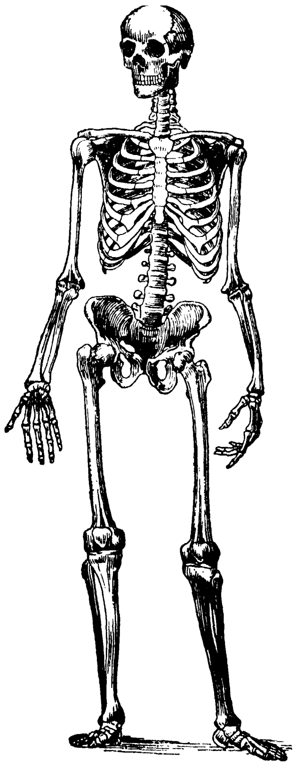


Fig. 7.

(*f*) Two inferior, two middle, and two superior *turbinated* bones, situated along the outer wall of the nasal passages (Lat. *turbo*, a whirl).

(*g*) The *vomer* or septum separating the two nasal

(*h*) The *mandible, inferior maxilla,* or lower jaw. This is the largest and strongest bone of the face. It articulates with the temporal bones on either side, and its movements can be felt in front of the ears.

The Trunk includes the spine or backbone, the ribs and the sternum or breast bone, and the bones of the hips which help to form a cavity called the *pelvis,* in which some important organs are contained. *The spine* is also called the vertebral column because it is made up of small bones called vertebræ, of which there are thirty-three in the spine in infancy. In grown-up persons the lowest nine coalesce forming two bones known respectively as the sacrum and coccyx.

The Sacrum forms the keystone to the pelvic arch. It is composed of five vertebræ.

The coccyx (Gr. *kokkyx,* the cuckoo), so called from its resemblance to the beak of a cuckoo, is composed, as a rule, of four vertebræ of a rudimentary kind; but, in some instances, there may be five, and in others three only.

The Vertebræ (Fig. 8) have been classified as *cervical, dorsal, loin* or *lumbar, sacral,* and *coccygeal.* The cervical, of which there are seven, are found in the neck. The dorsal, twelve in number, are those to which the ribs are attached behind. The loin or lumbar vertebræ, five in number, are situated at the lower part of the spine between the dorsal vertebræ and the sacrum. The vertebræ are supported by strong ligaments and muscles, and thus a solid pillar is formed which enables heavy loads to be carried on the shoulders, or even on the head, with comparative safety. And, in order to prevent injury to the spine from falls or sudden jerks, rings of cartilage, which act as buffers, are

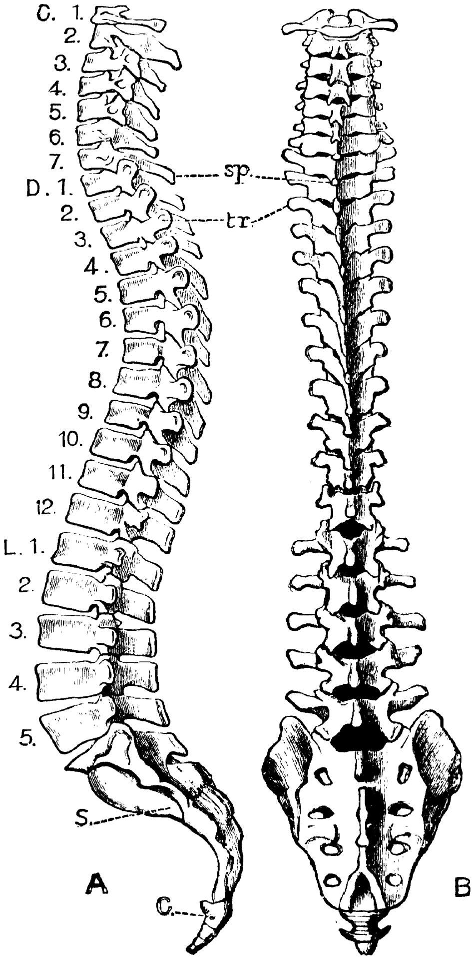


Fig. 8.—The Vertebral Column.

interposed between the vertebræ. Running through the greater part of the length of the spine is a tube called the vertebral canal, in which the *spinal* cord, connected with the brain, is situated and protected from danger.

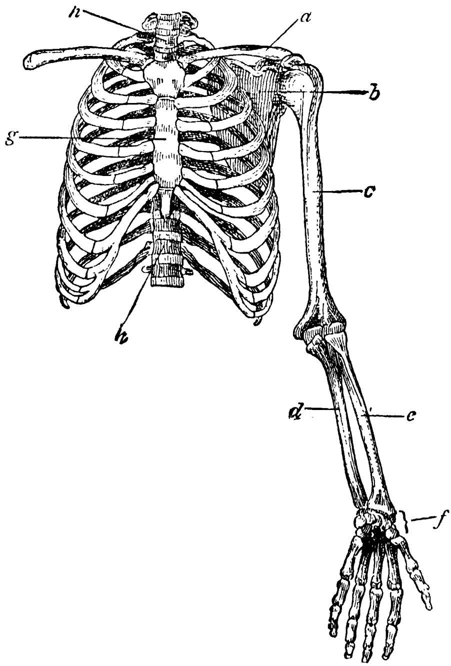


FIG. 9.

The Ribs are twelve in number, on either side of the body. They are all attached to the spine. The first seven are connected with the breast bone directly by means of long pieces of cartilage. The next three are attached to each other in a similar way, and indirectly to the breast bone. The last two ribs have no connection with each other or with the other ribs, and are not attached to the breast bone. They are, for that reason, called *free* or *floating* ribs. The ribs, breast bone, and the part of the spine with which the ribs are united form the *thorax* or chest cavity. It will be seen that the chest walls have been so constructed as to secure the greatest freedom of movement and, at the same time, protect the structures contained in the chest cavity, namely, the lungs, heart, and the large blood-vessels connected with these organs (Fig. 9).

The Limbs consist of the arms and legs, which are usually spoken of as the upper and lower extremities or limbs. The upper limbs comprise the shoulder blade, collar bone, arm, forearm, and hand, and the lower limbs the haunch bone, thigh bone, knee-cap, leg, and foot. The shoulder possesses great freedom of movement. The range of movement of the arms, however, is much greater because the head of the *humerus*, or upper arm bone, which is rounded, moves in a cup-shaped socket or cavity in the shoulder blade (scapula), thus forming what is known as a "ball-and-socket" joint.

The forearm contains two bones—*radius* and *ulna*. By means of the muscles attached to them the palm of the hand can be *pronated* or directed downwards, or *supinated* or directed upwards at pleasure.

The wrist contains eight bones, the palm of the hand five, and the fingers fourteen. In the order given they are known as *carpal* (Gr. *karpos*, the wrist), *metacarpal*, and *phalangeal* bones respectively. The phalangeal bones are so called because they are arranged in lines (Gr. *phalanx*, a line of battle). The upper limbs have been called "the faithful ministers of the mind."

The haunch bones are the strongest in the body. They unite with the sacrum and, together, form what is called the *pelvic cavity* or basin.

The thigh contains one bone only—viz., the *femur*—which is the longest and thickest bone in the body. It, like the humerus, has a rounded head which fits into a cavity in the haunch bone with which it articulates, thus affording another example of a "ball-and-socket" joint. The movements in it, however, are not so free as those of the shoulder joint (Fig. 10).

The patella, or knee-cap, is embedded in the firm dense tissues in front of the knee-joint. The ends of bones which

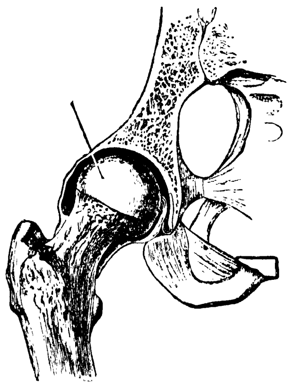


FIG. 10.—UPPER END OF THIGH BONE.

enter into the formation of joints are covered with layers of cartilage which, like the cushions between the vertebræ, act as a kind of protective buffer. In some diseases of joints the cartilage may get completely destroyed, and the ends of the bones become polished through friction. In such cases pain of a most intense kind occurs, and is increased when the ends of the bones come into contact, as while standing or during movements of the joints.

Ligaments are firm bands of fibrous tissue forming a bond of union between movable bones. Besides being provided with ligaments, the largest joints, such as the hip, knee, and ankle, have additional support given to them by being surrounded by layers of firm membrane covering the ligaments. Some of the internal organs are also provided with ligaments for their support, and to prevent their displacement, and, as will be seen later, even the minutest bones in the body, which are situated in the middle ear, are provided with tiny ligaments for the same purpose.

THE MUSCULAR SYSTEM

Muscles (Fig. 11) form the fleshy parts of the body by means of which we are able to stand erect, run, walk, play games, lift weights, and perform most of the ordinary acts of life. They are divided into two kinds—viz., voluntary and involuntary muscles.

Voluntary Muscles are those whose action is under the control of the will—*e.g.*, the muscles of the arms and legs.

Involuntary Muscles are those which perform their functions without our being conscious of the fact, and whose action cannot be controlled by the will—*e.g.*, the muscles which regulate the action of the heart, and the muscles of respiration, and of the gullet, stomach, intestines, and the alimentary tract generally.

Structure of Muscle. *Voluntary Muscles* are made up of thin fibres of fine structure, some of which may be about 2 inches in length. They are about $\frac{1}{500}$ inch thick and arranged in bundles, held together by layers of connective tissue with which the complete muscle is itself surrounded, and the whole muscular structure thus strongly supported. The characteristic features of voluntary muscular fibres, as shown by microscopic examination, are (*a*) the presence of nuclei which indicate their origin from cells, and (*b*) that they show dark and light *striæ* or stripes running across

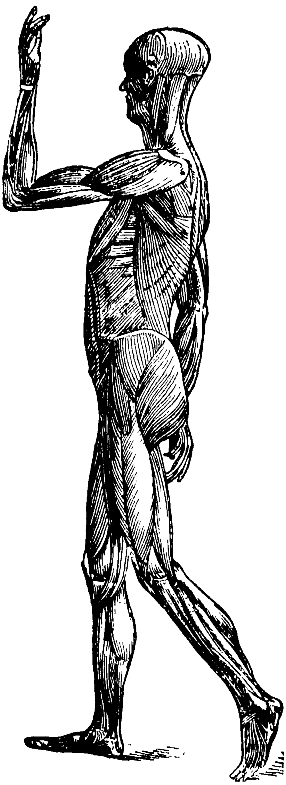


FIG. 11.

them. Voluntary muscles are, for this reason, sometimes spoken of as *striated* or *striped* muscles.

Involuntary Muscles are composed of long cells, thick in the middle and tapering at the ends, and are described as spindle-shaped cells. The fibres of involuntary muscles have no cross marks, and are sometimes called *unstriated* or *unstriped* muscles on that account (Fig. 12).

Blood-vessels and sensory and motor nerves ramify in all directions throughout muscles, and give off branches to their most minute structures.

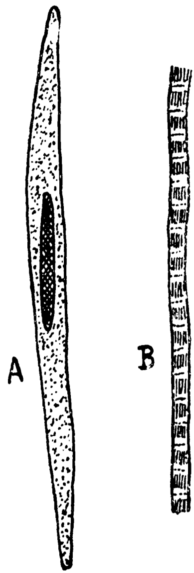


FIG. 12.—MUSCLE (HIGHLY MAGNIFIED).
A, Unstriped muscle; B, part of a striped muscle.

Muscular Action. By virtue of their structure muscles can stretch or contract under the influence of *stimuli.* All their movements are under the control of the nervous system. The ends of the muscles, although they may be attached to other structures, are, as a rule, attached to bones by *tendons* consisting of white fibrous tissue.

This firm tissue not only adds to the strength of the muscles, but covers a considerable portion of the ends of them, and thus prevents the soft muscular fibres from being torn when the muscles are in use. Muscles have two attachments—a point of *origin* and a point of *insertion*. The

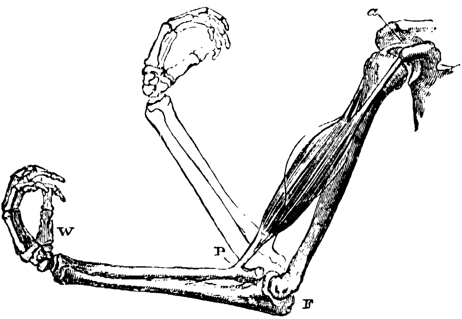


Fig. 13.—The Bones of the Upper Extremity, with the Biceps Muscle.

The two tendons by which this muscle is attached to the scapula, or shoulder-blade, are seen at *a*. P indicates the attachment of the muscle to the radius, and hence the point of action of the power; F, the fulcrum, the lower end of the humerus on which the upper end of the radius (together with the ulna) moves; W, the weight (of the hand).

point of origin is the more fixed attachment. The more movable bone is selected for the point of insertion. Regular and moderate use of muscles causes them to increase in size and strength, while excessive use or disuse has the opposite effect (Fig. 13).

THE CLASSES OF FOOD-STUFFS

FOOD may be either liquid or solid in form. Whatever its form, a good nourishing diet must contain a certain quantity of *water*, *albumen*, *carbohydrates*, *fats*, *salts*, and *vitamins*.

Water. The greater portion of solid food consists of water. Potatoes, for example, contain 75 per cent. In addition to the water contained in our food, 4 pints or more of drinking water are required daily to keep our bodies in good health. In hot countries very much more is required to make up for the loss of fluid through the skin.

Albumen. The white of egg consists chiefly of this substance; so also does the *curd* of milk. Albumen is also found in muscle and blood, and in peas, beans, dal and all cereals, such as wheat, oats and rice. Foods containing albumen are called *albuminates* or *nitrogenous foods*, because they contain nitrogen, which is not found in any other class of food except in minute quantities. Albuminous food is used chiefly for the repair of the tissues and the growth and development of the body, and for maintaining it in a healthy and vigorous condition. Albuminates are sometimes called *proteids* or flesh formers. Their general composition is roughly as follows:

Oxygen	21 to 23·5	per cent.
Hydrogen	7	,,
Nitrogen	15 to 17	,,
Carbon	51·5 to 54·5	,,
Sulphur	3 to 2	,,
Ash	Variable.	

Legumes, such as peas, beans and dal, contain more albumen than lean meat.

Carbohydrates contain carbon, hydrogen and oxygen. They contain hardly any nitrogen, and are for this reason called *non-nitrogenous* foods. Starches and sugar belong to this group. Rice, sago, potatoes, arrow-root, wheat, millets, Indian corn, cane sugar and beat sugar are the best-known examples. Rice contains no less than 83 per cent. of carbohydrates. Starchy food is converted into a form of sugar called *grape sugar* through the action of the saliva, which continues for a short time after the food has passed into the stomach. Food of this kind should be well chewed and mixed with the saliva before being swallowed. Infants under six months old cannot digest starchy food, because no suitable ferment is formed in the digestive system until the age of nearly one year. Heat and energy are obtained from carbohydrates.

Fat. Butter and oil, such as mustard and cocoanut oil, are the best-known forms of fat. The fatty covering under the skin and the fat deposited elsewhere in our bodies are got to some extent from the starchy and fatty foods we eat. Albuminous foods, however, it has been contended by some writers, are the chief source of the fat stored up in the body. Fats taken as food produce twice as much heat as carbohydrates, and are therefore extremely useful in cold climates. They also help to strengthen the body and are a source of energy. The digestion of albumen is very much helped by the presence of fat. The white of an egg is thus more easily digested when taken with butter. Cod-liver oil in small doses is given where the stomach is weak and digestion bad. Cod-liver oil is, moreover, highly nutritious, and being readily oxidisable is useful in consumption of the lung and other diseases of a tubercular nature.

Salts. A salt is a chemical substance formed by the combination of an *acid* with a *base*. *Common salt*, which is a combination of sodium and chlorine, is the most useful and the most largely used salt and the best example. *Lime salts* are consumed to a large extent in India with *pan*. *Salts* of different kinds are contained in varying amount in vegetables and fruits. Bones would become soft without them. The disease, known as *rickets*, is, for the most part, due to a deficiency of lime salts in food or water, and it is mainly due to a deficiency of iron salts in the blood that anæmia is so common. Salts are required for the formation of the juices with which food is digested.

The best salts are the malates, citrates, or tartrates of potash, or fresh or dried fruits which contain them. The lactates, oxalates, and acetates come next in value.

Malates are the chief salts in fruit. They contain malic acid. In unripe apples and gooseberries the acid is free. These fruits, when ripe, are full of juice containing neutral salts of potash and lime. The term "neutral" means neither acid nor alkaline.* Other fruits which contain them are pears, currants, raspberries, pineapples, etc.

Citrates contain citric acid, which is found in the fruit of the citron tree which grows in northern India and southern European countries. The fruit is edible, and used for making syrups and refreshing drinks, such as lemonade. Lemons and melons are sometimes included in this category. Other fruits containing them are oranges, grape-fruit, and limes.

Tartrates contain tartaric acid which is found in pine-apples and grapes. It is used for baking purposes when mixed with baking soda. It is also used as a purgative, as in the well-known "Seidlitz powder." Tartaric acid is found in grapes.

Lactates contain lactic acid, which is found in large amount in sour milk (Lat. *lac* or *lactis*, milk). It can be prepared from cane sugar by a chemical process. It is

* Chemically speaking, "neutral" means there is just sufficient acid and alkali for each to counteract the effect of the other.

produced in the fermentation of vegetables—*e.g.*, the German Sauer-kraut. Lactic acid is also found in the stomach and intestines.

Oxalates. The acid contained in oxalates is derived from plants, shrubs, trees and their roots, which are edible and antiscorbutic—that is to say, they prevent scurvy. The plants, etc., belong to a genus or group called oxalis of the order Oxalideæ. Oxalates are sometimes added to salads, and are used for making cooling drinks and may be pickled. Cucumbers belong to this class, and so also does the wood sorrel which is found throughout Europe, Central Asia. North America, and Lapland.

Acetates contain acetic acid, of which vinegar is a form. Its formation is due to fermentation caused by vegetative spores. With the exception of vinegar, acetic acid and its derivatives are mainly used for trade and commercial purposes.

Fruits consist largely of water. Grapes and cherries contain 75 to 80 per cent.; plums, pears, and peaches 82 to 87 per cent; and water-melons 95 per cent. The rest consists of skin, seeds, and cellulose—a carbohydrate contained in the cells of fruit. Unripe fruit contains starch in large amount, but during the process of ripening it is converted, by chemical change, into sugar, by an ingredient or active principle called *pectose* contained in the pulp and juice (Gr. *pêktikos*, congealing or making solid). The carbohydrate thus formed is called *pectin.* It is due, mainly, to the presence of pectin that the juices of fruit solidify to form jellies. This process, however, is helped by the presence of another ingredient, in the juice, which for the want of a better name is called *gum.*

Plantains or bananas, the fruit of the *bread-fruit* tree, and the fruit of the baobab or monkey-bread tree, and the bread-nut fruit of Jamaica are the only fruits which contain starch in comparatively large amount. The fruit of the bread-fruit tree, when roasted, is used as a substitute for bread at times, and so, also, is the bread-nut fruit when either roasted or boiled. The minute seeds which form the core of plantains are somewhat indigestible and disagree with some persons. This can be avoided by splitting plantains, in their skins, in a longitudinal direction and removing the seeds. If removed in this way it saves waste of the fruit.

Raisins, dates, and dry figs, owing to the presence of a large amount of sugar, are of high nutritive value. The proportion of sugar contained in certain fruits is as follows:

Raisins	.. 56	per cent.
Dates and dry figs	.. 48	,,
Grapes	From 12 to 18	,,
	Sometimes 26	,,
Cherries	From 8 to 12	,,
Apples	,, 6 to 8	,,
Pears	,, 7 to 8	,,
Plums	.. 6	,,
Red currants	.. $4\frac{3}{4}$	,,
Greengages	.. $3\frac{1}{2}$	,,
Peaches and apricots	.. $1\frac{1}{2}$	,,

The olive is the only fruit which contains oil in sufficient quantity worth mentioning.

The quality of fruit depends upon the proportion of pectin, gum, sugar, free acid, and the soluble and insoluble material contained in the fruit and on its aroma. It also depends, to a large extent, upon its cultivation and selection. For further information about fruit see "The Illustrated Chambers's Encyclopædia."

Vitamins.—Vitamin is a substance, existing in foods, which is necessary to proper *metabolism* or the chemical changes in digestion and nutrition. Its absence from food causes what are known as "*deficiency diseases*," a good example of which is beri-beri due to eating rice from which the husk or outer covering, which contains most of the vitamin in rice, has been removed by milling and polishing. The following history of the discovery of vitamins and other facts relating to them have been derived from a brochure, entitled, "Vitamins: Their Function," recently issued by Burroughs, Wellcome and Company:

"It had for a long time been observed that a diet, which was regarded as sufficient from the point of view of its chemical composition, did not provide all that was needed for the proper nutrition of the human body, and that diseases due to malnutrition occurred in consequence. A little over thirty years ago experiments were begun to try to solve the mystery. In 1897 Eijkman fed pigeons on a diet of polished rice only. In course of time the pigeons began to develop symptoms like those of beri-beri in the human being. He arrived at the conclusion that the removal of the husk of the rice was the explanation. Funk, in 1910, applied the term 'vitamine' to an indefinite group of substances in food which he considered necessary to health. Later, McCollum and Davis showed that pure butter fat increased growth greatly as, also, did yolk fat. They found, however, that the addition of lard and olive oil to the diet resulted in little growth and early failure. Butter fat and egg-yolk were, for this reason, considered to contain *something* which was necessary to growth which lard and olive oil did not contain. Hopkins, in 1912, adduced proof of the existence of unknown substances considered absolutely necessary in a diet suitable for proper nutrition. He further showed that animals could not live on a diet of correct 'energy value'—a term applied to the difference in the power of food-stuffs to produce energy—unless fresh milk were added. It was naturally concluded that, if the health of animals suffered in consequence of insufficient vitamin supply, human beings must be affected, similarly, in the matter of their health."

As the result of these observations and experiments five different kinds of vitamins are now known to exist, and these have been classified as vitamins A, B, C, D, and E respectively.

" *Vitamin A.* The chief function of vitamin A, it has been suggested, is that of an anti-infective agent, and that deficiency of it is associated with widespread bacterial invasion. Vitamin A is found in butter, milk, fats, egg-yolk, green leaves, the germ portion and outer covering of seeds, and in cod-liver oil.

" *Vitamin B* is obtained from cereals, pulses, nuts, green leafy vegetables, milk, eggs, and liver; but cereals are the main source of its supply. A deficiency of this vitamin in food is believed to be the cause of beri-beri. The writer might here mention that the late Sir Pardy Lukis was inclined to think that beri-beri was infectious. That idea, however, was not accepted.

" *Vitamin C* is obtained from fruits, green leaves, egg-yolk, and seed germs, and is contained in small amount in milk. The absence of vitamin C from food or its deficiency is the cause of scurvy, and, in part, of a disease in children called *scurvy rickets.*

" *Vitamin D* is found in fats, such as cod-liver oil. It is mainly necessary for the development of bone, and its deficiency in food is the cause of rickets. The deficiency of both vitamins C and D is the cause of scurvy rickets mentioned above. *Small quantities* even of cod-liver oil, given to children, will prevent rickets or cure the complaint if it is not far advanced.

" *Vitamin E*, about which little is known yet, is supposed to promote fertility and the secretion of milk " (Brochure, Burroughs, Wellcome and Company).

In the latest annual report of the Medical Research Council a warning is given that overdoses of vitamins might do harm. Referring to this report, the following is an extract from a London periodical on the subject of vitamins:

" A continual source of surprise to me is the way in which what may be called old-fashioned ideas in medicine are constantly being proved to be correct scientifically.

" For example, a distinguished physician of thirty years ago contended that the way to get the best value from cod-liver oil was to begin with very small doses and gradually increase them. He, of course, had never imagined the constituents now named vitamin D.

" Even more important than the question of over-dosage of vitamins is the prevention of bacteriological infection by diet, which the Research Council is to investigate further on a large scale.

" The theory is that certain foods contain constituents specifically antagonistic to particular bacteria. If actual connection between the two is established a great new power for the prevention and cure of disease will be available.

" It is an interesting coincidence that at this moment an Essex farmer, Mr. John Hepburn, advances the theory that cancer is caused by impure foods, and claims that he can foretell the outbreak of diseases by the state of certain crops. If we assume, as seems reasonable, that diseased crops do not contain their usual vitamins, we have the theory of the Research Council and the practical knowledge of Mr. Hepburn in complete accord."

THE ORGANS AND PROCESSES OF DIGESTION

The object of digestion is to render the food which we eat fit for the nourishment and growth of our bodies. The digested food is absorbed by the small bloodvessels and other structures in the walls of the stomach and intestine.

The Digestive System consists of the mouth, in which are the teeth, tongue, salivary and numerous other small glands which secrete or form the *saliva* or spittle, the soft palate which forms the back part of the roof of the mouth and ends in the *uvula* or small tongue-like body which is seen at the back of the throat. The *tonsils* on either side of the throat, the *œsophagus*, *gullet* or *food pipe*, which conveys the food to the stomach, the stomach itself, the large and small intestines, the pancreas and the liver are also included in the digestive system. The digestive system is also called the *alimentary system* and the route along which the food travels the alimentary canal or tract.

Teeth. Teeth begin to appear in infants when they are about six months old. The first set, called the *temporary* or *milk* teeth, are twenty in number. The second set, called the *permanent* teeth, are thirty-two in number. The last of the molars, or wisdom teeth, do not appear until

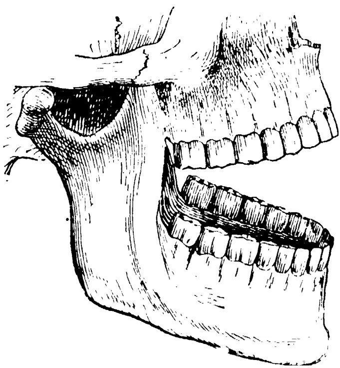


FIG. 14.—THE TEETH.

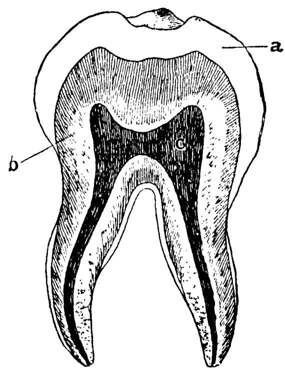


FIG. 15.—SECTION OF TOOTH SHOWING STRUCTURE.

a, Enamel; *b*, dentine; *c*, cavity.

adult life. They may not appear until the age of thirty years even. The front teeth, four in number in each jaw, are called *incisors* or cutting teeth. Next to them come the *canines*, which are narrow and blunt-pointed. There is one canine tooth on either side of the incisors in both jaws. Next to the canines on either side and in both jaws are two *bicuspids*; and, lastly, in grown-up people are three *molars* or *grinders*, also on either side in both jaws, situated at the back (Fig. 14).

Teeth have a *crown*, *neck* and *fangs* (Fig. 15). The crown is covered with enamel, which is very brittle, since it contains 2 per cent. only of animal matter. The teeth, however, are made chiefly of a substance called *dentine*, which is hard like bone but different in structure. The fangs of teeth are coated with a substance of a bony nature called *cement*. The inside of the fangs and crown is filled with a substance called *pulp*, in which are a large number of small branches of bloodvessels and nerves, the main trunks of which enter at the tip of the fangs. This accounts for the severe pain felt in decaying teeth.

The Tongue consists almost entirely of muscular tissue, by means of which it can be moved in every direction. It is by these movements that the food is rolled about in the mouth and mixed with the saliva during *mastication* or chewing. The tongue is also of great help during the act of swallowing. The small bodies which project from the surface of the tongue, and which are best seen at the back, are called *papillæ*. In the papillæ are small delicate structures called *taste bodies* or *taste bulbs*.

The Salivary Glands. The large glands of the mouth are situated at the angle of the lower jaw, under the jaw, and under the tongue. The mouth is also provided with numerous smaller glands which secrete a substance called *mucus*. The larger glands secrete the saliva. The chief constituent of saliva is a ferment, called *ptyalin*, which converts starch into grape sugar. The saliva also dissolves solid bodies, such as sugar and salt, and assists in swallowing. Over 20 ounces of saliva are secreted daily.

The Œsophagus, Gullet or Food Pipe (Figs. 16, 18) is about 10 inches in length and situated behind the windpipe.

Our food does not drop into our stomachs suddenly. It is carried down the gullet by a series of what are called vermicular or worm-like movements caused by the action of the muscles in the walls of the gullet. It is by this action that water and food can be swallowed by persons while standing on their heads, and that horses and cows can swallow while grazing.

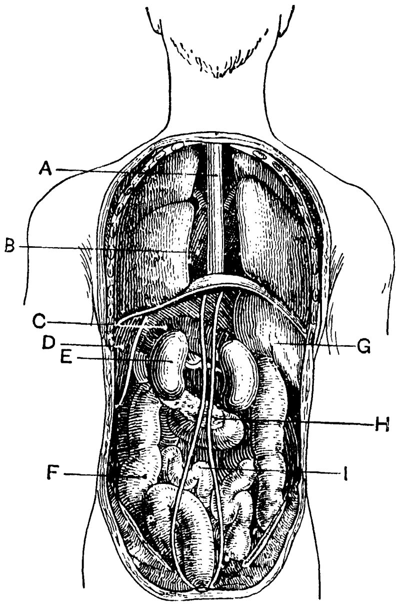


FIG. 16.—THE ORGANS OF THE CHEST AND ABDOMEN SEPARATED BY THE DIAPHRAGM, SEEN FROM THE BACK.

A, tube where the food passes through (œsophagus); B, heart; C, stomach; D, the spleen; E, kidneys; F, main intestine; G, liver; H, pancreas; I, small intestine.

The Stomach (Fig. 18) is merely a bag, which is larger at the one end than the other. The entrance to the stomach is near the heart, and is called the *cardiac* opening. The outlet is called the *pyloric* orifice or opening. The stomach is about 12 inches long. The œsophagus opens into it near the middle. The interior of the stomach is lined with minute *peptic glands*—which secrete a liquid called the *gastric juice.* The gastric juice, among other ingredients, contains *hydrochloric acid* and substances called *pepsin* and *rennin,* both of which are *ferments.* It is chiefly by means of these substances that digestion is carried out in the stomach. The food is mixed with the gastric juice by the movements of

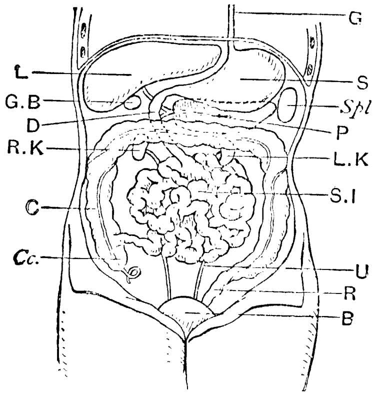


Fig. 17.—Diagram of Organs in Abdomen.

G, gullet; S, stomach; D, duodenum with bile and pancreatic ducts opening on inner side; S.I, small intestines; *Cc*, cæcum with vermiform appendix; C, colon or large intestine; R, rectum; L, liver; G.B, gall-bladder; P, pancreas; *Spl*, spleen; R.K and L.K, right and left kidneys; B, bladder with two ureters opening into it at the upper end.

the stomach walls caused by the action of certain layers of muscles in the same way as the food is mixed with saliva in the mouth by the movements of the tongue. Gastric juice digests *nitrogenous food,* such as the white of egg, meat, etc., but stops the digestion of starch. When food is digested in the stomach it is converted into a substance called *chyme,* which has a sour smell and taste. During digestion in the stomach the nitrogenous food-stuffs are converted into bodies called *peptones*. These peptones and salt, sugar, and other substances are partly absorbed in the stomach and partly in the intestines.

The Intestines are divided into the small and large intestine respectively. The small intestine comes first, and

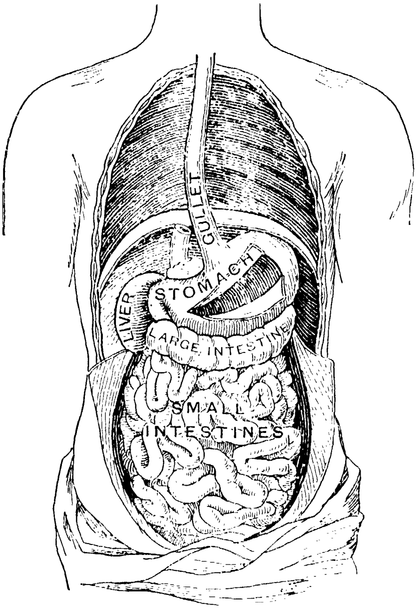


FIG 18.

is about 18 feet roughly, while the large intestine is only 5 or 6 feet, in length. The first portion of the small intestine is called the *duodenum*, which is about 10 inches long (Fig. 18).

The duodenum has numerous small glands, in its walls, which secrete a fluid resembling saliva. This fluid helps to digest the starchy food which escapes the action of the saliva in the mouth and stomach. The duodenum is an important structure, also, from the fact that it is into this part of the small intestine that the *bile*, which is formed in the liver, and the *pancreatic fluid*, which is formed in the *pancreas*, both enter. The pancreas is an

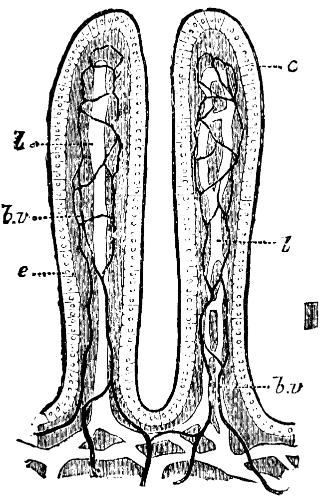


FIG. 19.—TWO VILLI (HIGHLY MAGNIFIED).
e, epithelium; *b.v*, bloodvessels; *l*, lacteals.

organ 7 inches long and $1\frac{1}{2}$ wide. When the chyme passes out of the stomach into the duodenum it becomes mixed with the pancreatic fluid and bile. The pancreatic fluid helps to complete the digestion of starchy food.

The Pancreatic Fluid, besides acting on starchy and nitrogenous food, contains a substance (*steapsin*) which mixes with fats and oils in food making a fine emulsion which is easily absorbed. Bile, as will be pointed out presently, has a similar action. *Trypsin* is the name given to the ferment, in the pancreatic fluid, which converts nitrogenous food into peptones; while that which converts starch into sugar is called "*amylopsin.*"

The small intestines have numerous minute structures called *villi*, containing bloodvessels and *lacteals*, which absorb the digested food, and also numerous small glands, which secrete a fluid called the *intestinal juice.* The fluid in the lacteals is called *chyle*, which has a milky appearance. Hence the term "lacteals." The chyle, after being absorbed, enters a channel called the *thoracic duct*, which passes along the spine in an upward direction, and pours the chyle into a vein under the left collar bone. This vein conveys it to the heart, and thus the chyle finds its way into the general blood supply of the body.

The Liver is situated on the right side of the body behind the lower ribs and below the *diaphragm* or *midriff.* It extends in health to about $\frac{1}{2}$ inch below the ribs and can be felt during inspiration. A healthy liver weighs from 40 to 60 ounces. It sometimes, however, becomes greatly enlarged and heavier from disease. The liver is made up of cells each about $\frac{1}{800}$ inch in size. The small cells secrete bile from the blood carried in the bloodvessels which pass through the cells. The amount of bile secreted daily is about 40 ounces. The bile, when secreted, is conveyed in numerous small tubes, called *bile ducts*, into a single larger duct which, as has been stated, pours its contents into the duodenum. If there is any obstruction in this large duct the bile, which should pass into the duodenum, gets absorbed by the blood-vessels in the liver and is carried in the circulation to all parts of the body, giving rise to what is called *jaundice.* Bile emulsifies, that is to say, liquefies fat, prevents food from decomposing and forming gas, and helps the digested food to pass easily along the alimentary canal. It is afterwards partly absorbed by the intestine, gets into the blood and helps to keep up the heat of the body. A substance called *glycogen* or animal starch is formed in the liver in large amount. Glycogen becomes converted into sugar. Sometimes the sugar formed

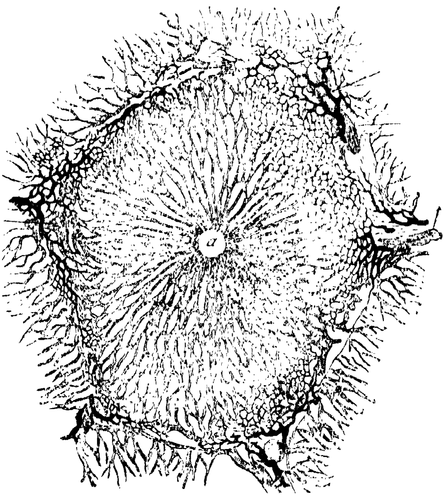


FIG. 20.—CAPILLARY NETWORK OF THE LIVER.
The deep black network represents the bile ducts. (Luciani.)

in this way is so great in amount that it cannot all be made use of and the excess quantity passes out of the system in the urine. The disease called *diabetes* is due to this cause.

The large intestine absorbs much of the fluid which remains after digestion, collects its waste products and ultimately passes them out of the system through the outlet of the alimentary canal.

THE FOOD NEEDS OF THE BODY UNDER VARIOUS CONDITIONS

Occupation. A diet which consists of 5 ounces of nitrogenous food, 15 ounces of carbohydrates, 3 ounces of fat, and 1 ounce of salts daily, is the most suitable diet for a man doing an ordinary amount of work. Some writers, however, would allow only 4 ounces of nitrogenous food, 8 ounces of carbohydrates, 2 ounces of fat, and ½ ounce of salts.

Very much larger quantities of carbohydrates are sometimes consumed by Indians besides dal, vegetables, flour and fish. In Bengal, rice is the chief article of diet. For an adult doing an ordinary day's work the following quantities of various kinds of food would be sufficient for two or three meals daily.

Unpolished rice	10	chattaks or	20	ounces.
Flour	2	,,	4	,,
Dal	2	,,	4	,,
Fish or meat	2	,,	4	,,
Vegetables	2	,,	4	,,
Oil and ghee	½	,,	1	ounce.
Milk	8	,, about	1	pint.
Salt	¼	,,	½	ounce.
Spices	⅛	,,	¼	,,

Wheat or maize flour enters largely into the diet of the inhabitants of Behar, the United Provinces of Agra and Oudh, and in the Punjab. Less rice is consumed.

A liberal allowance for an adult person, in these provinces doing a hard day's work would be:

Flour	7 or 8	chattaks.
Rice	4 or 5	,,
Dal	2	,,
Vegetables	2	,,
Ghee and oil	½	chattak.
Salt	¼	,,
Spices	⅛	,,

The diet of Europeans differs very considerably from that of Indians. An ample allowance for any ordinary European would be ½ pound meat, 1½ pounds of bread, 1 pint of milk, 1 ounce of butter, 1 ounce of fat, and 1 pound of potatoes.

Age. Milk is one of the most valuable articles of food in both sickness and health. It is the best food for infants, because it contains all the elements of a perfect diet in the right proportion, and is easily digested. Infants should be fed solely on milk until they are nearly one year old. Grown-up people may be kept alive by milk during sickness for several weeks at a time. Several pints, however, may be required daily in these cases. The addition of a little sugar makes milk more suitable as an article of diet. The natural food of infants is human milk. Cow's milk, made as much like human milk as possible, is, however, by dilution with water and the addition of a little sugar, sometimes given to very young children. Ass's milk, which more closely resembles human milk than does that of the cow, is also of great use, but expensive. Older persons use cow's milk a great deal. The use of goat's and buffalo's milk is common in India.

So far as children are concerned, it has been demonstrated that they can be reared and grow up healthy and robust on a diet consisting of vegetables and fruit, butter, milk and cream, and that meat is not essential to their proper nutrition. In the case of adults they, as a rule, eat far too much food of all kinds, especially meat, and if they ate much less it would be greatly to the benefit of their health. They would be less corpulent than so many are, their weights would not be such a burden to them as it is, they would be less indolent, and more inclined to take exercise, which is so essential to keeping the organs of the body functioning properly.

Old people should revert to the diet given to children;

but, as a rule, they do not unless they are carefully and tactfully handled and their dietetic errors pointed out to them.

The Best Diet for Schoolboys. The results of experiments, extending over a period of five years, made by Dr. H. C. Corry-Mann, to determine the best diet for schoolboys, are given in a report which he submitted to the Privy Council Medical Research Council in 1926. Eight houses, with an average number of about thirty boys, were selected for the purpose of carrying out the experiments, and trained nurses were employed to assist in doing so.

Among the results obtained, it was found that the nutritive value of the dietary in use when the experiments were begun could be improved in a striking manner by the addition of small quantities of other food-stuffs.

The basic diet supplied to the boys over the period of four years, during which the investigations were being made, was:

BREAKFAST:

Porridge	10 to 16 ounces.
Treacle	1 ounce.
Bread	3 to 3¼ ounces.
Margarine	⅛ to ¼ ounce.
Cocoa	10 ounces.

(Margarine is the solid ingredient of animal fat, olive oil, etc.)

DINNER:

Fish (herring)	2½ to 3½ ounces.
or	
Fish (kipper)	2 to 3 ,,
Bread	3 to 3½ ,,
Rice pudding	10 to 12 ,,

(Kipper is herring split open, seasoned and dried.)

TEA:

Bread	6 to 6½ ounces.
Margarine	¼ to ½ ounce.
Jam	¼ to ½ ,,
Cocoa	10 ounces fluid.

The experimental diet was:

House	No. 1	Ordinary diet.
,,	No. 2	Milk 1 pint as extra diet.
,,	No. 3	Castor sugar 3 ounces.
,,	No. 4	Butter $1\frac{3}{4}$ ounces.
,,	No. 5	Watercress $\frac{1}{12}$ to $\frac{3}{4}$ ounce.
,,	No. 6	
,,	No. 7	Casein (principal protein or albumen of milk) $\frac{3}{4}$ ounce.
,,	No. 8	Margarine $\frac{3}{4}$ ounce.

Results of the experiments are thus summarised:

Boys receiving only the basic diet gained an average of 3·85 pounds per boy and grew an average of 1·84 inches in a year.

Boys receiving daily an additional pint of fresh cow's milk gained 6·98 pounds and 2·63 inches per boy.

Boys receiving an additional 3 ounces of castor sugar daily gained 4·93 pounds and 1·94 inches per boy.

Boys receiving an additional $1\frac{3}{4}$ ounces of grass-fed New Zealand butter gained 6·30 pounds and 2·22 inches per boy.

Boys receiving an additional $1\frac{1}{4}$ ounces of vegetable margarine gained an average of 5·21 pounds and 1·84 inches per boy.

Boys receiving an additional $\frac{3}{4}$ ounce of edible casein gained an average of 4·01 pounds and only 1·76 inches per boy.

Boys receiving an additional $\frac{3}{4}$ ounce of fresh watercress gained 5·42 pounds and 1·70 inches per boy.

The report adds:

"It is of the first importance to notice that the improved gains in weight and height, taken as the measurable characters in this inquiry, were found to be accompanied regularly by improved general health and by improvement in what may perhaps be called 'spirit.'"

In the case of the boys who were given milk as extra diet, the benefit in nutrition was shown to be due not to the relatively small increase in the fuel value of the dietary, nor to the extra protein supplied in the milk, but rather to the more specific qualities of milk as food.

The boys became known as milk, butter, or sugar boys, according to the special article of food allowed them in their dietary. As for the butter boys, they are reported to have become little terrors in the best boyish meaning of the word. They had more high spirits than the occupants of any other house in the place, and were just brimming over with good health.

In an interview with a Press correspondent, an official is reported to have said:

"But you must not think that the lads made any sacrifice, or that they were in any way martyrs to science. Most of them do not know what it is to receive a hamper from outside, although all of them have a certain amount of pocket-money.

"When parents sent sweets and 'extras' to the boys the matron had to exercise a kindly supervision. No doubt the lads who were on such foods as milk and butter cast many a longing look at the toffee. They were not, however, absolutely forbidden to eat sweets, but a certain amount of regulation was necessary for the scientific data to be drawn from the experiment.

"All the time the boys lived their normal life, eating the usual food except for the additions stated. No boy was given a type of extra diet which he did not like."

And a Press report on the experiments ended:

"Never before had an experiment like this been on such a scale or over such a period. Certainly no other ever had such striking results."

On February 18th, 1930, 10,000 children in sixty-seven schools in Lanarkshire, Scotland, began a test in dietetics.

The children were to be fed on Grade A milk for four or five months, and their progress at intervals compared with that of boys and girls not getting the diet. Each child was to get $\frac{3}{4}$ pint of milk each school day. It has been estimated that the cost will amount to about £100 each day. Interesting and valuable results will no doubt be got from this test also.

Climate. In countries in which, owing to excessive heat, the functions of the bodily organs are impaired, and especially the function of digestion, it is necessary that heavy meals should not be indulged in. Nor is it desirable to take alcoholic drinks during the hottest part of the day, if at all. Failure to observe this rule adds to the general languor and drowsiness produced by the heat, and tends to induce sleep, and sleeping after a heavy meal is detrimental to digestion and, consequently, to health.

Small meals, taken twice or three times daily at proper intervals, are preferable to one huge meal which overloads the stomach. And very little meat or rich foods of any kind should be eaten in tropical countries or in cold countries during very hot weather. Fruit and vegetables should, for the most part, enter into the dietary of all classes of people, no matter where they live, during hot and trying seasons of the year.

Sickness. In cases of sickness the patient's appetite is as a rule poor. It is therefore necessary that food given to a sick person should be fresh and as appetising as possible. Milk and light soups form the chief dietary of the sick. The milk has sometimes to be diluted with aerated or barley water when the stomach is weak. The patient should receive small quantities of food at short intervals. During convalescence clear soup, a light milk pudding, boiled or steamed fish, or a lightly boiled or poached egg may be given.

MALNUTRITION AND ITS DETECTION

MALNUTRITION is induced when, from any cause, the blood on which the growth and maintenance of the body depends is deficient in any of the substances which are necessary for the restoration of the tissues of the body, or, in other words, does not make up for the loss of tissue involved in the performance of the functions of the various organs.

The causes of malnutrition are innumerable, and to attempt to discuss all of them would be a formidable and hopeless task to undertake. Some of the causes may be classified as follows:

1. **Insufficient food or some deficiency in the quality of the food consumed.** Scurvy, rickets, and beri-beri have already been referred to as examples of "deficiency diseases" in which malnutrition is evident.

2. **Functional disorders of the digestive system** due to errors of diet, such as overeating, unwholesome or badly prepared food, improper mastication, due, perhaps, to decayed teeth or loss of teeth, or hurried eating and return to work immediately afterwards, irregularity of meals, sedentary habits, insufficient exercise and fresh air and sunshine, the abuse of tobacco, tea, and alcohol, and chronic constipation.

3. **Organic diseases of the digestive system,** in which food cannot be retained or even swallowed, as in cases in which there may be an obstruction in the gullet or stomach. The intestinal tract may also be the seat of some obstruction. This prevents the passage of digested food through the intestine, and causes it to decompose and produce poisonous gases which become absorbed by the blood, which is thus rendered impure and unsuitable for proper nutrition. Constipation has this effect. Chronic appendicitis is one of the most common causes of digestive disorder, and

patients may suffer from it and be treated for years for what is regarded as simple indigestion before the real cause of the trouble is discovered.

4. **Infectious fevers and other diseases,** with a high temperature, and chronic wasting diseases, such as tuberculosis and cancer, and all inflammatory and suppurative diseases attended with profuse discharge.

5. **Diseases of the blood,** such as anæmia, due to the want of iron, improper food, sedentary living and want of fresh air, digestive trouble, the destruction of the red blood corpuscles by toxic substances, loss of blood in diseases of the organs of the digestive system, lungs, or other organs, and bleeding from severed arteries in cases of accident.

6. **Diseases of the excretory organs** with failure of function and the accumulation of waste products in the blood. Failure of function in the secretory organs may also cause malnutrition.

7. **Parasites in the intestine,** such as the hook-worm of ankylostomiasis, and ordinary worms, such as the tape-worm, round-worm and thread-worm, and the amœbæ of dysentery.

8. **Parasites in the blood,** such as those of malaria, kala-azar, and yellow fever. In the case of malaria the parasite lives and develops in the red blood corpuscles which are completely destroyed. Hence the extreme anæmia and malnutrition observed in cases of chronic malarial fever.

The main indications of malnutrition in children are slow growth and development of the body and mental faculties, and, in many instances, bodily deformities, as is particularly the case in rickets and adenoids so common in England and some other countries; although, perhaps, they do not occur, often, in India. In children and grown-up people alike, malnutrition causes loss of weight, wasting of muscles, the loss of muscular and nerve power, and general debility. The prevention of malnutrition can, to a large extent, be effected by the use of diets of correct nutritive value and observing the ordinary rules of health, and if these precautions are taken, many of the diseases which cause malnutrition will be prevented also.

COOKING OF FOOD AND ITS EFFECT

When cooked, food is softened, made more attractive and palatable, and more easily digested than when eaten in a raw state. Cooking also destroys small parasitic animals and their eggs and the germs of infectious diseases, and enables certain kinds of food, such as milk and meat, to be kept for a considerable length of time without becoming tainted and dangerous to use. *Pasteurisation*, which is a method of arresting fermentation in milk, etc., was introduced by a French scientist, Louis Pasteur, who died about thirty-five years ago. It is a partial form of *sterilisation* which implies the destruction of bacteria by heat. In pasteurising milk the temperature is maintained at 158° Fahrenheit for thirty minutes. The milk is then rapidly cooled to 55° F. and kept in a cool place. If protected from dust, etc., it will keep fresh for two or three days. It has been stated that all disease-producing organisms and the bulk of other organisms are effectually removed by the pasteurisation of milk. " The process may be, approximately, carried out by plugging convenient-sized bottles filled with the quantity for one meal, heating in a pan surrounded with water to nearly boiling-point. Then remove from the fire, cover with a clean cloth, and allow to stand for half an hour, and, as above stated, rapidly cool and store in a cool place " (Martindale and Westcott).

Methods of Cooking. Food may be boiled, steamed, stewed, roasted, baked, fried, grilled, or braised. The method of cooking food should be varied as much as possible, otherwise it will lose its relish. Every attention should be paid to cleanliness. Cooking pots which are made of copper should be regularly tinned, otherwise there is danger of some of the copper being dissolved and causing poisoning. Cooking vessels made of aluminium are to be preferred to those made of copper. Rice and other starchy foods should be cooked slowly, and green vegetables quickly. Well-cooked rice is soft and free from lumps. Each particle should be separate. Mustard oil is often used in India for cooking purposes, chiefly because it is cheaper than butter. Dal should be very carefully husked and then cooked, otherwise it will cause irritation of the bowels.

Root Vegetables, such as potatoes and carrots, should be thoroughly washed with clean water before being cooked. Cauliflowers, cabbages, etc., should be carefully and repeatedly washed in salt water to get rid of all dirt, insects and worms which are often to be found in such vegetables, and all old leaves and decayed portions should be removed. Potatoes, when peeled, should be peeled thinly, turnips thickly, while carrots should be scraped. Beetroot should be peeled after boiling it. Root vegetables should be cooked in a pot covered with a lid. Green vegetables should not be covered, as in cooking these the steam should be allowed to escape. Always use plenty of water in cooking green vegetables. This helps to keep their colour from being lost. Some vegetables have a bitter taste. Put these into cold water to which a little salt has been added, and boil, and then pour the water off and add fresh clean boiling water. This will remove to a large extent the bitter taste. Note, however, that vegetables are best cooked by *steaming*, and taste much better when cooked in this way. There is a great saving, moreover, in the nutritive value of vegetables when cooked in this way and more especially in rice.

Meat. Boiling for five minutes coagulates the albumen in the outer portion of meat. The nourishment is thus retained and the meat made tender. When this object has been secured a little cold water should be added, and the cooking continued about boiling-point.

Roasting. In this method of cooking the meat should be exposed to heat of a fire, so as to harden the outer portion. The meat should then be removed some distance from the fire and allowed to cook slowly. During roasting the juice which escapes should be collected and poured over the meat, occasionally, in order to prevent it being burned.

Speaking at Cambridge recently about roasting, Colonel P. S. Leleau, of Edinburgh University, said: "So bad is the cooking of unsuitable food—largely by the frying-pan—that digestion troubles rank second in the list of ailments causing lost work. . . . The frying-pan bakes and dries up food. It makes it hard and thoroughly indigestible, and is one of the causes of the decay of teeth."

Steaming is the best method of cooking, and should be adopted whenever possible.

Preparation of Vegetables for Cooking. Vegetables, before being cooked, should be properly cleaned, because they frequently contain small parasitic animals or their eggs and germs of infectious diseases. Tubers such as potatoes and carrots should be first well rubbed and then cleaned in fresh water. All decayed portions of vegetables should be removed.

New potatoes need not be peeled, but they should be well washed.

Preparation of Rice for Cooking. As every Indian villager knows, rice is obtained from the paddy. The paddy is soaked in water for a day, then boiled for ten or fifteen minutes and dried in the sun or spread out on a mat if the weather is cloudy. When dry it is husked *and the chaff separated from the grain by a winnowing fan. The cleaned rice is then stored and used as required.* In some cases the paddy is sun-dried and husked by a husking machine. Rice, before being cooked, should be repeatedly washed in fresh water to get rid of dust and other impurities, and small stones, which are often found in bazaar rice, carefully picked out.

Full preparation of rice in all stages from the paddy:

1. The paddy is kept in water in an earthenware vessel (Gamla) for a day. It is then boiled for ten to fifteen minutes in an earthen cooking vessel (Hanri or Handi) and then dried in the sun. It is afterwards husked by a husking machine (Dhenki) and the chaff removed by a winnowing fan (Kula). This is the process adopted by most Bengalis. The grain thus obtained is called "cured rice."

2. There is, however, another process by which "uncured rice" (Atap Chàul) is obtained, and this form of rice is used by orthodox Brahmins and Hindu widows. Paddy, of a special variety, is dried in the sun or kept for some time in the open air. It is then husked and winnowed to free it from the chaff. This is known as Atap Chàul, uncured, or sun-dried rice.

A large quantity of water should be used for boiling rice. The rice should be boiled quickly by putting the cooking utensil over a hot fire. When the rice begins to boil the lid of the cooking utensil should be kept open and the rice stirred to keep the liquid from overflowing. The fire should then be lessened. When the rice is soft the cooking utensil should be removed from the fire and some cold water added. All this liquid should then be dried off and the utensil placed over a gentle fire in order to dry the rice slowly and thoroughly. The rice, while drying, should be well shaken now and again or stirred gently with a spoon. Boiling for half an hour usually suffices. Each grain, in well-cooked rice, should be separate. There should be no lumps and the rice should be soft and dry. Cooked rice should be eaten when hot. If allowed to stand it becomes hard and indigestible and soon ferments. The water in which rice has been boiled is highly nutritious and should be given to cattle or goats.

Time needed to cook certain vegetables:

Beans, 15 to 30 minutes.
Beetroot, $1\frac{1}{2}$ to 2 hours.
Cabbage, 15 to 20 minutes.
Carrots, 20 minutes to one hour if old.
Cauliflower, 15 to 20 minutes.
Vegetable-marrow, 10 to 20 minutes.
Potatoes, 15 to 30 minutes.
Green peas, 10 to 20 minutes.

TREATMENT OF MINOR DIGESTIVE AILMENTS

Dyspepsia (Gr. *dys*, hard; *pepsein*, to digest), or indigestion, is the most common of the functional disorders of the digestive system. Its treatment depends, mainly, on the removal of the cause. These causes have already been mentioned. Tea drinking, after meals consisting largely of meat, interferes with proper digestion and should be avoided, as should, also, liquid of any other kind in large quantity taken during meals. A moderate amount is permissible when the meals are dry; but, except in such circumstances, liquid should only be taken two hours, or so, after eating, when the partially digested food is ready to pass out of the stomach into the intestinal tract, where digestion is completed. Regarding dietetic errors as the cause of digestive ailments. the late Sir William Osler wrote: "The platter kills more than the sword," and mentioned as exciting causes of dyspepsia the persistent use of very fat substances or carbohydrates, such as hot bread, hot cakes and pies. He further wrote: "*Iced-water plays no small part in the prevalence of dyspepsia in America.*" The treatment of some of the chief symptoms of dyspepsia is as follows:

Flatulent Distension, causing pain and discomfort in the stomach and round the heart, due to the fermentation of indigestible food in it, may be relieved by one or other of the carminatives mentioned under spices (p. 56). In extreme cases warm water may be taken in large enough quantity to induce vomiting and thus wash out the stomach. If carbonate of soda—a teaspoonful or more even—is added to the water, it will get rid of some of the mucus secreted as the result of the irritation of the stomach walls by the food, or anything else that may be the cause of the trouble.

Nausea, Vomiting, and Diarrhœa are symptoms which usually occur when tainted meat or fish or any other kind of unwholesome food-stuffs are eaten. And there may also be severe abdominal pain and collapse. In such cases a saline purgative should be given at once. This helps to remove rapidly the toxins in the intestinal tract, to which the symptoms are due. Thereafter, a bismuth and soda mixture should be taken as a sedative. If there should be much pain, the application of heat to the abdomen will give some relief. In no case should chlorodyne or any preparation of opium, such as morphia, be taken unless under medical advice. In all such cases it is advisable to send for a doctor.

Pyrosis (Gr. *pyr*, fire) or water-brash is the regurgitation or flowing back of the acid contents of the stomach into the upper part of the gullet or mouth. This complaint is attended with burning pain in the pit of the stomach. Hence its derivation. In all such cases the use of alcohol and spices and irritants of any kind should be strictly avoided. As palliatives bismuth and soda are sometimes efficacious. Bismuth lozenges which contain chalk and bicarbonate of soda have been highly recommended. They should be taken an hour or two after meals, and only when the pain and uneasiness are present (Roberts).

Constipation. The palliative treatment of constipation is by aperients such as rhubarb, sulphur, and senna, or laxative mineral waters. A grain of calomel, at night, followed by a saline medicine, such as a Seidlitz-powder in the morning, is useful in cases of biliousness. The calomel helps the excretion of bile which is the natural purgative of the body. It is also an antiseptic, and prevents the bile from becoming decomposed and losing its purgative effect. All sorts of liquid paraffins and emulsions of it are largely used nowadays. These act as lubricants of the intestinal tract. They are of use particularly in the case of old people suffering from atony or weakness of the bowel owing to decay of its muscular layers. A reliable, effective, and convenient aperient in cases of chronic constipation in young adults and middle-aged persons is a laxative vegetable tabloid (Burroughs, Wellcome and Company). The use of purgatives, however, should be avoided, if at all possible; but it is better to take them occasionally than remain constipated for days on end. When the habit of using them is acquired, the bowel acquires the habit of laziness, and depends on their use for the stimulation of its activity. The preventive treatment of constipation is careful dieting, regularity of meals, proper mastication, regularity in attending to the calls of nature and taking time to empty the bowel thoroughly, and regular and sufficient exercise daily.

ALCOHOL, DRUGS, SPICES, AND TOBACCO, AND THEIR EFFECT ON THE DIGESTIVE SYSTEM

Alcohol. The late Professor Victor Horsley, many years ago, in a lecture at the London Institution embodying the results of investigations by Professor Kraepelin, found himself compelled to declare that "alcohol as a dietetic item is harmful and not beneficial," and that while it stimulated temporarily, the forces accelerated became paralysed or benumbed even when small quantities are taken. A report on the lecture concluded, "As in so many matters one grain of fact is here worth bushels of theory and *ex parte* disputation." Investigations have been carried out during recent years by committees of all kinds, more or less with regard to social problems. The following extract from one report is a statement made by a witness: "People who have not enough food turn to drink to satisfy their cravings and also to support their enfeebled hearts by alcohol." Another witness said, "The poor often drink to get the effects of a good meal. They mistake the feeling of stimulation after alcohol for the feeling of nutrition. They turn to it to blunt their sensibility to squalor, and it reacts in deadening all desire for improvement." In medical circles, opinions differ as to the general effect of alcohol on the system. Some doctors contend that it is a food, that it prevents the waste of body tissue, strengthens the muscles, and in small quantities improves digestion. Others contend that it is not a food; that it prevents the waste products of the body being got rid of, and in this way increases the weight of the body; that it simply paralyses the muscles so that the person who takes it does not know that he is tired; that it protects against neither cold nor heat, but that the temperature on the other hand falls below normal after taking alcohol; and that it is in no sense of the term a stimulant to digestion or other function of the body.

The following is a summary of some of the effects of alcohol on the digestive system gleaned from what is contained in Bastedo's exhaustive and interesting chapter of thirty-eight pages on alcohol, in his treatise on "Materia Medica, Pharmacology, and Therapeutics." The facts have been established through experiments made by physiologists and clinical observations.

1. Alcohol, unless well diluted, is an irritant to the lining of the stomach and alimentary canal generally.

2. Brandy or whisky which contains 50 per cent. of alcohol, if not diluted, precipitates the proteins of food and, slightly, the pepsin in the gastric juice, and retards digestion.

3. The influence of moderate quantities of properly diluted alcohol upon the processes of digestion is a negligible factor.

4. Distilled liquors with 10 per cent. alcohol only are harmless.

5. Wines and malt liquors, even when well diluted, retard pepsin digestion, and in large quantities check it. Red wines, because of the tannic acid in them, precipitate proteins. White wines have little effect of this kind.

6. Alcohol dilates the bloodvessels in the stomach and creates a feeling of warmth. When diluted to 10 per cent., and in small quantity, this is the only effect produced in the stomach. If taken at a strength of 50 per cent. or thereabout, it is a powerful irritant. Small quantities even, if taken neat, have this effect.

7. Alcohol diluted is absorbed from the stomach in about half an hour. (Cushing says "20 per cent. is absorbed from the stomach and 80 per cent. from the intestine.") If taken on an empty stomach, in small quantities even, alcohol may have an intoxicating effect. When mixed with food the absorption of alcohol is delayed. The digestive

products are helped in their absorption by alcohol when it is well diluted. Alcohol over 20 per cent. in strength injures the cells of the stomach and causes a secretion of thick mucus, or may act as an astringent on the tissues or, in other words, contract them.

8. Very little is known about the effect of alcohol on the movements of the stomach. When given medicinally, however, it acts as a carminative and relieves flatulence and pain caused by it, probably by stimulating movements.

9. In the mouth strong alcohol produces a large flow of saliva and mucus, which is Nature's method of protecting the delicate lining of the mouth.

In the stomach large quantities of thick, sticky mucus are secreted to prevent injury to its walls. The mucus also slows the absorption of the alcohol, and in this way prevents the liver being irritated. Further, it helps to lessen the intoxicating effects of the alcohol.

10. The action of alcohol on the secretion of the gastric juice has been divided into three periods.

(i.) The first gastric juice has been called *appetite juice* or *psychic juice.* The sight and smell of food are the factors in the production of this juice.

(ii.) The second period is manifested in the stomach. Alcohol up to about 10 per cent. strength has practically no effect on the secretion of gastric juice. At about 20 per cent. its secretion is distinctly retarded. Malt liquors and red wine of a strength of between 10 and 20 per cent. interfere, to some extent, with the secretion of gastric juice, not because of the alcohol they contain, but because of the extractives in the malt liquor and of the tannic acid in the red wine.

(iii.) Alcohol, when given by the mouth or rectum, causes a large flow of gastric juice containing hydrochloric acid greatly in excess of the normal amount. The secretion continues after all the alcohol has been absorbed into the blood and until all the food in the stomach has passed into the intestine. For this reason, "when rectal feeding in an irritant stomach condition, such as ulcer, is adopted for the purpose of saving the stomach from irritation, it is advisable to omit alcohol from the enema" (Bastedo).

The foregoing observations pertain, mainly, to the effect of alcohol on the stomach. Other organs of the digestive system, however, are also affected by it, and these will now be considered.

Intestines. When the stomach is in a healthy state diluted alcohol is rapidly absorbed, and little, if any, passes into the intestines. If taken in large quantities, and its use be long continued, some of it escapes and acts as an irritant to the duodenum, which is the first portion of the intestine, and into which the bile and pancreatic ducts open.

Pancreas. Alcohol, when introduced into the stomach, the small intestine, the large intestine (colon), or the lower intestine (rectum), increases the secretion of the pancreatic juice to even five times its normal amount. In physiological experiments, conducted *in vitro* (Lat. *vitrum*, glass)—that is, in a glass such as a test-tube—alcohol of 5 per cent. strength completely inhibits—that is, checks—the action of *trypsin* which is secreted in the pancreas, and is the main ferment which acts on albuminous food-stuffs. It also checks the action of *amylopsin*, the ferment of starchy food (Gr. *amylon*, starch). This ferment is also secreted in the pancreas. Alcohol, in any strength up to 90 per cent., increases the action of *steapsin*, a third pancreatic secretion, which saponifies or converts fats and oils into a soap-like emulsion by breaking up the fatty particles. Small amounts have no such effects on the pancreas because, as has been stated, all the alcohol is absorbed in the stomach.

Liver. Alcohol absorbed by the stomach or duodenum passes directly to the liver, to which it is conveyed by the bloodvessels, which constitute the *portal circulation.* When used in excessive quantity and continuously the blood, passing through the liver, sets up changes in the cells of the liver and their supporting structures. The cells are impeded in their action and their proper functioning interfered with. This induces congestion and enlargement of the liver and also fatty degeneration. But, as Bastedo observes, "A single excessive dose does vastly more harm than the same amount taken a little at a time." He adds, "Good-sized doses of liquor, frequently repeated during many years, tend to establish permanent changes in the liver—either fatty degeneration or connective tissue invasion (cirrhosis)."

Whatever may be said in favour of or against the use of alcohol, it cannot be denied that a craving for it is easily and far too often acquired, and that much of the poverty and distress and mental and physical illnesses that exist in the world are due to the abuse of alcohol, to say nothing about the crimes committed under its influence. They are well advised who avoid its use altogether, unless in emergent circumstances as a stimulant, *in small doses*, when no other stimulant is available. Water, from a pure source, is not only unattended with any of the dangers to health mentioned above, but is the best of all liquids for enabling the functions of the organs of the body to be performed normally, and for maintaining the body in a healthy condition.

Opium is the milky juice of the capsules and seeds of a poppy—the *Papaver somniferum.* Although the plant was cultivated extensively in China itself, large quantities of opium used to be exported to that country from India. Restrictions, however, have been imposed on its exportation with a view to stopping the practice of smoking opium, which was formerly indulged in, to a serious extent, by many classes of the Chinese population. Opium is an expensive drug, and with the object of adding to their profit on its sale traders are known to adulterate it with all kinds of foreign material, including "vegetable debris, sand, earth, and even nails and bullets, in order to add to its weight" (Bastedo). Opium, when dried, may be converted into *powdered opium*, or what is called *granulated opium*, in which the particles are larger. No less than nineteen *alkaloids* are derived from it, but morphia and its derivative, *codeine*, are the only two which are used medicinally. The chief use of opium is to allay pain and act as a sedative to the mind and body in cases in which nervous symptoms are the chief feature. Codeine, *e.g.*, is of great value in irritable coughs. Opium, no matter in what form it may be used, has no local effect in allaying pain, cough, or anything else. When applied locally, anywhere, the effect is produced by its absorption into the circulation in which it is carried to the brain centres, which regulate all the functions of the body and interprets the sensation of pain and all other sensations. Hence morphia is given by the mouth or, when the pain is agonising, by injecting it into the circulation through the skin in order to give speedy relief.

The use of opium, in any form, should never be resorted to, except in cases of sickness in which the medical attendant prescribes it, and the instructions given should be strictly carried out. In no case should opium be given to children under one year old.

Effect of Opium on the Digestive System. Some of these may be summarised as follows:

(*a*) The stomach loses its tone and tends to dilate, and its movements are impaired.

(*b*) The passage of the digested food, from the stomach into the intestines, which usually takes place two or three hours after eating, may be delayed for many hours. Digestion is thus, as it were, overdone, and the waste products may not be sufficient in bulk to stimulate the involuntary muscles of the intestine and bring about, by their contraction, enough power to force the contents along the intestinal tract. In consequence of this constipation is induced.

(*c*) Nausea and vomiting invariably follow the use of morphia, and yet when vomiting is caused by certain kinds of stomach irritation, it may be checked by morphia given in suitable doses, owing to its sedative effect in such cases.

(*d*) Morphia is used after abdominal surgical operations, and in inflammatory diseases of the bowels to keep them at rest, and for this reason it has been called the *bowel-splint.*

(*e*) In colicky spasm, due to constipation, the bowel may act freely after morphia has been given to relieve the pain, the spasm being relieved at the same time.

(*f*) Constipation, due to long-continued use of opium or other causes, may be followed by severe diarrhœa, due in many cases, no doubt, to the decomposition of retained waste matters in the intestine.

Cocaine is an alkaloid or basic substance obtained from the leaves of the coca shrub (*Erythroxylon coca*), which is grown extensively in the Andes Mountains. It is cultivated to some extent also in the East and West Indies and elsewhere. The coca shrub should not be confused with the chocolate plant (*Theobroma cacao*), from the seeds of which chocolate paste is made, and from which cocoa, so much used as a food of high nutritive value, is derived.

Coca leaves are sometimes chewed, and the natives of the Andes Mountains, it is said, can continue to work for days, without taking food, by chewing coca leaves. The effect of the leaves is to take away the appetite, so long as food is kept out of sight. The appetite, however, returns at the sight or even the smell of food. This is believed to be due to the sensation in the mouth and stomach being lessened by the leaves when chewed, while the psychic or mental effects of smell and sight remain undisturbed or unimpaired.

Cocaine is largely used for medical and surgical purposes, because it produces insensibility to pain (anæsthesia). Some large surgical operations are performed under what is called *spinal anæsthesia* produced by substitutes all chemically related to but safer than cocaine. Those in use are eucaine, stovaine, alypine, novocaine, and tropococaine. Each has its own special qualification for use, whether in eye operations, dentistry, or other cases in which the anæsthesia has not to be maintained for any considerable length of time.

Effect of Cocaine on the Digestive System. When given in small and carefully regulated doses, cocaine, in certain cases of stomach irritation, prevents vomiting. Spinal anæsthesia is sometimes followed by nausea, vomiting, and diarrhœa. Its effects on the digestive system, however, can be observed better in habitual cocaine-eaters. These are loss of appetite, disorders of the stomach, constipation, anæmia induced by these, malnutrition and wasting of the body, paralysis of the throat and tongue, and in the end death. "The blackened teeth, with the white cutting edge, are regarded as a characteristic feature in the cocaine-eater."

Spices are aromatic vegetable substances of an oily or resinous nature with a pungent taste. They were in ancient times called the "spices of Arabia," because traders conveyed them from the tropical countries, in which they are produced, to Arabia, from which they were exported to other countries. Spices are derived from the seeds, roots, and bark of trees and other plants. Ginger, *e.g.*, is obtained from the roots of a tree, and cinnamon from the bark of the laurel tree. The cinnamon gardens, in the outskirts of Colombo, are famous for the aroma imparted to the atmosphere by the laurel trees which are grown in them.

Cassia, which is a coarser form of cinnamon, is referred to in one of the psalms of David, the second king over Israel, in a verse which reads, "All thy garments smell of myrrh and aloes and cassia" (Psa. xlv. 8). *Senna* is derived from the pods of one species of the cassia tree. Spices which relieve flatulent distension of the stomach and intestine are called *carminatives*. The water, oil, and spirit of peppermint are the most commonly used and efficient of the carminatives; but ginger, cloves, and cardamoms are often used also. Spices used for seasoning food are called *condiments*—*e.g.*, bitter almonds, caraway seeds, cummin, cinnamon bark, lemon, nutmeg, which is obtained from the kernel of the nuts of an East Indian tree, orange peel, lemon, peppermint, derived from the dried berries of the pepper-plant by distillation, and vanilla, which is derived from the dried pods or fruit of a tropical orchid. Vanilla is generally used in the form of an essence, although the pods are sometimes put into food during cooking.

Dill, which is got from a plant belonging to the parsley family, is extensively used in the form of "dill-water" as a carminative in cases of colicky pain and flatulent distension in children. *Anise*, derived from the seeds of the fruit of a plant (*Pimpinella*), was formerly much used also. The essence of ginger is an efficient carminative in adults, as is also aromatic spirit of ammonia (sal volatile), which contains ammonia water and the aromatic oils of lemon, lavender flowers, and nutmeg. The dose is half a teaspoonful well diluted. Spices are frequently added to purgative medicines to prevent griping pains—*e.g.*, the oils of anise, caraway, cloves, fennel, and peppermint.

Oil of Turpentine, which is derived from an *oleoresin*, which is a natural combination of a resin and a volatile oil, contained in coniferous or cone-bearing trees, such as pines and firs, is of much value as a carminative in extreme forms of distension of the bowel, in enteric fever and other diseases, and after surgical operations.

The effect of spices on the digestive system depends on the strength in which they are used. When taken in moderate strength they increase the flow of saliva in the mouth, and at the same time they are believed to increase the secretion of the gastric juice. "It is doubtful whether they have any direct effect on the secretory cells of the stomach. So far as mustard and pepper are concerned, it has been shown that they actually diminish the secretion of the gastric juice" (Korczynski). "It is generally believed, however, that the secretion of gastric juice is increased by some spices. Persons suffering from excessive acidity of the stomach should, therefore, avoid using spices of any kind" (Bastedo).

Spices, when used in great strength, excite heat and redness in the tongue, and but for the fact that they cause a profuse flow of saliva, which acts as a protection, the lining membrane of the mouth might be seriously injured. And if swallowed, the lining of the stomach would be similarly affected. Spices in moderate strength cause the blood-vessels of the stomach to dilate, and thereby the absorption of the products of digested food is increased. If too strong they cause the stomach to become inflamed, and might even produce ulceration of the lining membrane. Spices, further, stimulate the muscular tissue of the stomach and increase its movements (peristalsis) during digestion, and by their propulsive action gas is expelled from the stomach and distension relieved. The movements of the stomach due to the influence of carminatives can be observed during an X-ray examination.

Tobacco is the cured leaf of a plant—*Nicotiana tabacum.* The curing is effected by fermentative changes which remove some of the dangerous substances contained in the raw leaf. The plant is grown largely in South America, India, and other countries, and extensively used everywhere.

It is, as a rule, smoked. It is, however, occasionally chewed. Like the chewing of pan, the chewing of tobacco is an exceedingly dirty and unhealthy practice. Tobacco is also used, but less frequently, in the form of snuff. Snuff-taking used to be a fashionable practice.

Composition of Tobacco. The chief constituents of tobacco are nicotine and albuminous and fatty substances. Nicotine is one of the most powerful poisons known, one drop being sufficient to kill a dog. Two drops placed on the tongue or rubbed in the gums of a small dog or cat will produce death in two or three minutes. Tobacco smoke is sometimes used for destroying small insects which infest plants. The amount of nicotine contained in different kinds of tobacco varies considerably, and depends to a large extent on the method of curing the leaf. As a rule, not more than four or five drops are contained in an ounce of tobacco which has been sufficiently cured. Most of it is destroyed and rendered innocuous during smoking, and, if this were not the case, the use of tobacco would be most dangerous to life. During the curing of the leaf 25 to 30 per cent. of the amount of nicotine contained in it is removed.

Bastedo states that Havanna tobacco contains only 1 to 3 per cent. of nicotine; some of the Virginia and French tobaccos as much as 6 or 7 per cent.; and Turkish tobacco (*Nicotiana rustica*) about 2·5 per cent." (*Kew Bulletin*). He adds: "It is due to nicotine and albuminous and fatty matter that old and dirty pipes and the ends of large cigars, in which they collect during smoking, have a bitter taste. This is due to the fact that the heat causes the nicotine and other volatile substances to escape from the tobacco of a pipe or the end of a large cigar before they have been completely destroyed by combustion and rendered less poisonous. Thin cigars and cigarettes are, therefore, safer." The moral, therefore, is: "Do not smoke a cigar to its bitter end, and do not use the tobacco, left in the bowl, after smoking a pipe, for refilling the pipe, and keep pipes as clean as possible."

Effect of Tobacco on Digestion. Even $\frac{1}{7}$ grain of nicotine produces burning pain in the mouth, gullet, and stomach, great nausea, vomiting and purging, and extreme collapse. Over-indulgence in the use of tobacco impairs the appetite, interferes with the proper digestion of food, and frequently causes excessive acidity of the stomach. The end results of excessive smoking are loss of flesh and weight and general ill-health. When inveterate smokers, suffering in this way, abandon the use of tobacco altogether, or use it in strict moderation, they immediately begin to add to their weight and improve in their general health.

That smoking may be the exciting cause of disease of the lips, tongue, and throat through continued irritation of their delicate lining membrane, should not be overlooked. Luckily the habit of chewing specially prepared tobacco, which causes gastritis through the swallowing of saliva containing tobacco juice, is not so common as it was formerly.

How the Poisonous Products of Tobacco get into the System. When tobacco is smoked the products of combustion get into the system through the lungs. Since it is known the interior of the lungs has an absorbing surface of no less than 1,400 square feet, we cannot be surprised at the effects on the system when poisonous gases, such as those contained in tobacco smoke, are inhaled in large quantity. The poisonous substances in tobacco can also be absorbed by the skin when tobacco is applied to it, or through the lining membrane of the mouth, stomach, or nose when it is chewed or taken as snuff. The effect of the poison on the system is exactly the same, no matter how it finds its way into the blood.

THE EXCRETORY SYSTEM

Excretion means the removal from the blood of carbonic acid gas, water, urea, and other waste products which are formed during the performance of the various functions of the body. Special excretory organs have been provided for this purpose. These are the skin, kidneys, and bowels chiefly. But the lungs also act as excretory organs, and are the principal means whereby carbonic acid gas contained in impure blood is got rid of. The manner in which this is effected is described under Respiration.

The Skin.

The Structure of the Skin. The skin consists of two chief layers (Fig. 21). The first or outer layer is called the *epidermis*, *cuticle*, or *scarf-skin*. This layer is made up of numerous small cells, which vary in shape at different depths. The uppermost cells, which are flat, are being continually cast off. The deepest layer consists of round or cubical cells, and contains pigment or colouring matter. The pigment accounts for the differences in colour of different races of people and the degree of colour in people of different caste or type who belong to the same country. Congenital absence of pigment is called *albinism* and excess *negrism*. There are no blood-vessels in the epidermis. The second layer, called the *dermis*, *cutis*, or *true skin*, is thick and tough. It is from this layer of the hides of animals that leather is made. The small blood-vessels which nourish the skin, the roots of the hair, and the sweat and oil glands are all found in the dermis. The dermis also contains elastic and connective tissue, and numerous small and delicate muscular fibres. When the epidermis or upper layer is rubbed off, the dermis or lower layer bleeds freely.

The Sweat Glands. The sweat glands have openings or pores all over the body. There may be two or three millions of them. The sweat flows throu h coiled tubes in the skin which are $\frac{1}{4}$ inch in length and $\frac{1}{300}$ inch in diameter.

The Oil Glands. The oil glands secrete an oil which keeps the skin and hair soft and pliable, and prevents them from becoming dry and unhealthy.

The Elastic Tissue. The elastic tissue in the dermis causes the furrows which appear in the skin in old age.

The Muscular Fibres. The muscular fibres during contraction force the oil out of the oil glands. They also stop the flow of sweat from the sweat glands when the body is exposed to great cold, and in this way help to prevent loss of heat. On the other hand, these small muscles become relaxed during active exercise or exposure to great heat, and more sweat than usual then escapes from the skin. The sweat rapidly evaporates or dries up, and in this way the body is kept cool. If this were not the case the temperature of our bodies would become so great as to make it impossible for us to live.

Perspiration or Sweat. Sweat consists chiefly of water. It also contains some salts and oil. Sweat is acid in its normal condition. When alkaline it smells badly. Two pints or more of sweat escape from our bodies daily. In hot countries the amount is much larger than in cold countries. It is sometimes more than 25 per cent. greater. When much oil is poured out the skin looks dirty and greasy. If we do not keep our skins clean, the pores become blocked up, the sweat cannot escape, and the health suffers. Our bodies and clothes begin to smell, and people who are cleanly in their habits will object to our presence. Skin diseases are often caused by dirt and neglect.

Cleanliness and how to Cleanse the Skin. Warm water and soap are best for this purpose. Soap is used to make the removal of fat easy. Soap which dries up the skin or makes it tender should never be used. Hard water is not good for cleansing purposes. It takes up the fat, and makes the skin dry and harsh. Boiling makes hard water more fit for use. Rain water, which is soft, is the best water to use for bathing. A nail brush, a piece of flannel or a sponge, may be used with advantage. In hot

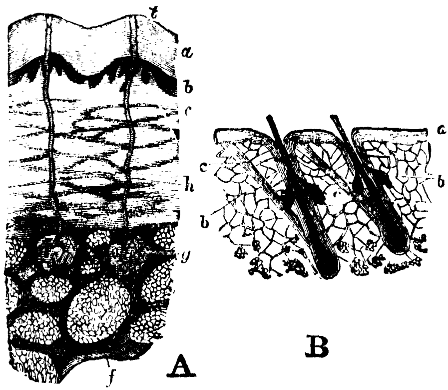


Fig. 21.—The Skin.

A. Section of skin showing sweat glands: *a*, epidermis; *b*, its deeper or Malpighian (pigment) layer; *c*, *d*, dermis; *f*, fat; *g*, sweat glands; *h*, ducts; *i*, opening of duct on surface.
B. Section of skin showing hairs and sebaceous glands: *b*, fine muscles connected with the hair sheaths, *c*.

countries, such as India, the whole body should be washed thoroughly once a day at least; and those parts of the body, such as the hands and feet, which are exposed, should be washed several times daily. When special cleansing is desirable, as, for example, before commencing surgical operations, turpentine is of the greatest service. It removes all traces of fat and smell. Blackheads which are the secretion of the glands of the skin and a layer of dirt can be removed by gentle rubbing and pressure; a piece of thin hard smooth substance, such as ivory, is useful for this purpose. Afterwards, a little alcohol, eau-de-cologne, ichthyol soap, or pomade with tannin may be applied. Ether or hydrogen are sometimes used to dissolve black-heads.

Bathing. A cold bath is very refreshing, but we should not remain in it too long. A plunge into cold water and out again is sometimes sufficient, and may be taken even when the skin is hot and perspiring. If the skin begins to glow immediately afterwards it is safe to take cold baths. If, however, shivering occurs, and the tips of the fingers and toes remain blue and cold, they are hurtful. After bathing, the body should be well rubbed and dried with a thick heavy coarse towel.

When a bath cannot be taken the body may be rubbed with a towel which has been dipped in cold or tepid water, or a sponge may be used. A warm bath brings the blood to the skin, and the air abstracts some of its heat. A warm bath is healthful and agreeable when one feels cold and chilly.

Turkish Baths cause profuse sweating, and are thus a very useful means of helping to clean the skin. Bathing, either in cold or hot water, should not be done after eating a heavy meal. The cold water drives too much blood to the walls of the stomach, while the hot draws the blood away. In both ways the proper digestion of food is interfered with. "Baths may be roughly classified as follows: cold bath, 60° to 70° F.; tepid bath, 85° to 95° F.; warm bath, 96° to 104° F.; hot bath, 104° to 114° F. A warm bath for a child should have a temperature of 96° to 98° F. The water of a cold bath should never have a temperature less than 59° F., that is, about forty degrees lower than the temperature of the healthy human body" (Simmons and Stenhouse).

✓**Effects of Sudden Chilling of the Skin.** Sudden cooling of the body, after hard exercise or exposure to great heat, is very dangerous. It often causes colds, and, owing to the blood being suddenly driven from the skin, inflammation of the lungs, liver, kidney, and other organs often results. Chills, too, often cause diarrhœa.

The Kidneys.

The kidneys are two in number, one of which is situated on either side of the body, at the back near the vertebral column and just below the ribs.

Each kidney has a small artery passing into it and a small vein passing out of it, and a tube, known as the *ureter*, which conveys the waste matter or urine excreted by the kidney, to the bladder, from which it is discharged at intervals.

The minute structure of the kidney is somewhat complicated. Besides blood-vessels, there are numerous small dilated structures, situated at the beginning of the uriniferous or small tubes which enter into the formation of the ureters. These structures are known as *Malpighian bodies* or *capsules*. Inside these capsules are clusters or tufts of small bloodvessels called *glomeruli*. These structures, and the uriniferous tubes, are lined with cells, which, by a process of filtration and secretion, remove from the blood the waste matters of which the urine is composed.

Composition of Urine. Urine is a yellowish-coloured fluid consisting chiefly of water and urea. It also, however, contains some chloride of sodium (common salt) and other mineral substances, such as lime and magnesia, and some gases, chiefly carbonic acid gas. From 40 to 60 ounces of urine are excreted daily. The amount excreted, however, depends very much upon the quantity of liquid consumed, and the amount of blood which circulates through the kidneys. During hot weather the skin is unusually active and gives off a large amount of sweat, while the kidneys excrete very little urine indeed. Cold, on the other hand, drives the blood from the skin to the internal organs, and

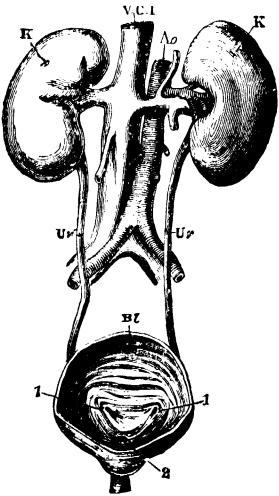


FIG. 22.—THE URINARY ORGANS.

K, Kidneys; *Ur*, ureters; *Bl*, bladder; 1, openings of ureters, and 2, opening of urethra in the bladder; *Ao*, aorta; *V.C.I.*, inferior vena cava.

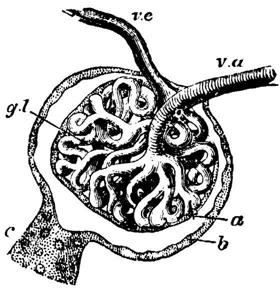


FIG. 23.—A MALPIGHIAN CAPSULE.

v.a, Small artery entering and forming the glomerulus *gl*, and finally leaving in a small vein, *v.e*; *c*, tubule; *a*, epithelium over the glomerulus; *b*, epithelium lining the capsule.

the kidneys in consequence act freely, and a large quantity of urine is eliminated, while the skin hardly acts at all.

While it may not be humanly possible to avoid some of the many forms of kidney trouble, some of the simpler causes can, and should be, avoided, such as exposure to cold and damp, the habit of overeating, which gives the kidney too much work to do in getting rid of waste products, and alcoholism. It is important also that the kidneys should be well flushed, by drinking water in sufficient amount for the needs of the body, that proper clothing should be worn, and that exercise should be taken, during cold weather particularly, to keep the skin active and thus avoid imposing too much strain on the kidneys.

The Bowels.

The structure of the bowel has already been described under Digestion. The discharges from the bowel, known as the fæces or excreta, are mainly the residue of undigested food. In normal conditions they are expelled by the peristaltic movements of the muscular tissue in the bowel walls. These movements are induced by reflex nerve action, and more especially when the lower part of the large bowel is loaded. In this condition all the muscular layers of the bowel are induced, by a special nervous arrangement, to contract strongly. In some cases of extreme constipation the muscles are not equal to their task, and the difficulty is added to by every meal that is partaken of. The act of defæcation, or emptying the bowel, in a state of health is a voluntary one. In functional and other disorders of the digestive system it may be involuntary. The habit of regularity in attending to the calls of nature is also voluntary. The habit of neglect to do so, on the other hand, is easily acquired, and may cause constipation to a severe and dangerous degree. In some diseases the nerve centres, which regulate the excretory function of the bowel, may fail to respond to impulses, and the muscles, which control the external opening of the bowel, may, in consequence, also fail to act, and thus cause the excreta to escape involuntarily. "Stimulus and response" have been explained in discussing the nervous system (p. 248).

THE ORGANS AND MECHANISM OF BLOOD CIRCULATION

BLOOD which escapes from a cut artery is of a bright red, and that from a cut vein of a dark purplish colour. The colouring matter of the blood is called *hæmoglobin* (Gr. *haima*, blood; Lat. *globus*, a ball) or *oxyhæmoglobin*. It is deficient in amount in persons who are pale, and in many diseases, such as malaria, cancer, consumption, and chronic lead poisoning. When a drop of blood is placed under a microscope it is found to consist of innumerable yellowish-looking small flat bodies called *blood corpuscles*, which float about in a colourless liquid called the *liquor sanguinis* (blood liquid). There are two kinds of blood corpuscles—red and white (Fig. 24).

Red Blood Corpuscles are only about the $\frac{1}{3200}$th part of an inch in diameter and the $\frac{1}{12000}$th part of an inch in thickness, so that in one drop of blood we may have several millions of them. When observed under a microscope they are seen to run together in the form of rolls of coins. These corpuscles vary in size, shape, and structure in different animals. They take up oxygen from the air in the lungs, which they convey to all parts of the body. This is their chief use. The blood also contains the elements of nutrition for the tissues of the body and carries waste products to the different organs which excrete them. It is from the blood, moreover, that the saliva, gastric and other juices are formed. The blood also helps to keep the body warm.

White Blood Corpuscles. In healthy blood there are usually one or two white to about every five or six hundred red corpuscles. In some diseases the number of white corpuscles may be very great. White blood corpuscles are globular in shape and larger than the red, or about the $\frac{1}{2500}$th part of an inch in diameter. In the living state they keep changing their form and move about, picking up food particles. Each white corpuscle is nucleated. The nucleus can be brought into view when a little water or *dilute acetic acid* is added to blood when it is being examined by a microscope. Certain colouring matters do the same thing. There is a nucleus in the white blood corpuscles of all animals. The red blood corpuscles of human beings

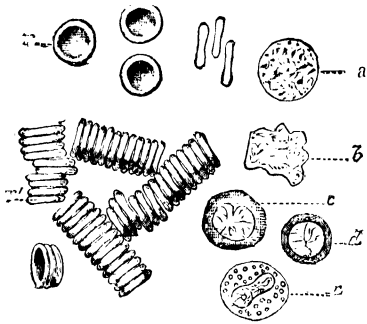


FIG. 24.—BLOOD CORPUSCLES.

r, Red corpuscles seen on the flat; *r'*, red corpuscles seen on edge, and run together into rows; *a*, *b*, colourless corpuscles, nucleus not seen; *c*, *d*, *e*, colourless corpuscles, nucleus seen; *e*, containing also granules.

and animals which suckle their young have no nuclei. The red corpuscles of birds, fishes, and some other animals have, however, large nuclei.

Coagulation of the Blood. In clotted blood the red solid portion consists chiefly of the red blood corpuscles caught in a net-work of a substance called *fibrin*. The liquid portion is called *serum*. This is the substance which escapes from a blister of the skin when it is opened. Blood always clots when it comes in contact with any outside object. If this did not happen we might bleed to death from even small wounds. The blood serum contains a large quantity of *albumen*. It also contains *soda* and *potash* and other mineral substances obtained from the food which we eat. Soda is one of the chief constituents of blood serum, and is got chiefly from the common salt which we use. These mineral substances are *alkalies*. They keep the fat, which is liquefied in the *alimentary* or digestive system, in the same liquid state in the blood, and thus makes it more fit for the nourishment of our bodies. All the other solid mineral matter which we consume, such as lime and iron salts, are similarly dissolved and made fit for nature's use. Blood also contains gases, such as carbonic acid gas, nitrogen, and oxygen. The blood weighs over one-thirteenth part of the entire weight of the body, while the gases in solution represent, in their free state, about one-half of the entire volume of the blood, of which about $\frac{2}{3}$ are carbonic acid, and about $\frac{1}{3}$ oxygen. There is also a little nitrogen.

The Circulation. The circulatory system consists of the heart, arteries, capillaries, and veins.

The Heart is a muscular organ containing four cavities separated from each other by partitions. The two upper cavities are called the right and left *auricles*, and the two lower the right and left *ventricles*. The right auricle opens into the right ventricle, and the left auricle into the left ventricle. Each of these openings is provided with little valves or doors, which open and shut alternately. The heart is situated within the chest cavity (Fig. 25), and is inclined more to the left than the right side. The pointed end of the heart, called the *apex*, may be felt beating a little below the left nipple between the fifth and sixth ribs. The sounds produced when the heart beats may also be heard if the ear is applied to this part of the chest wall.

Arteries are the tubes through which the pure blood from the heart is distributed to the different parts of the body. They are of an elastic nature, so that when the blood passes into them they yield, become distended, and afterwards contract, and thus force the blood onwards. It is this action which causes the pulsation at the wrist and elsewhere. The heart beats from 70 to 90 times per minute

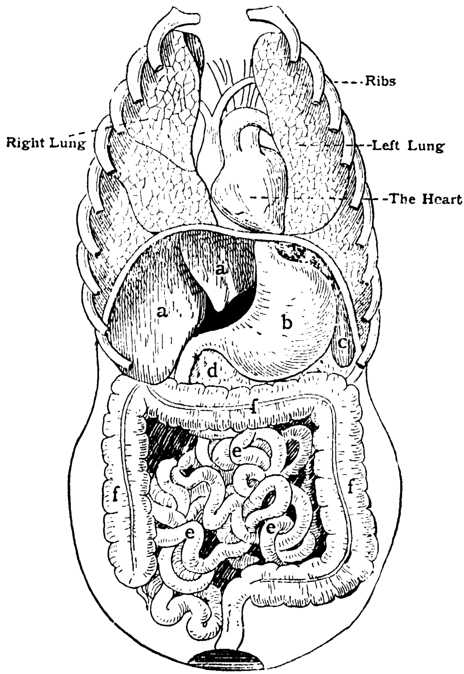


FIG. 25.—SHOWING THE POSITION OF THE APEX OF THE HEART.

in healthy adults, but much more quickly in children. The number of the beats varies in disease, and under numerous other conditions, such as during rest, exercise, and sleep.

The Main Artery of the body is called the *aorta* (Figs. 26, 27). It begins at the left ventricle, passes up a little way behind the breast-bone, then makes a curve and passes downwards alongside the backbone, dividing lower down into two branches, which again subdivide into two branches, one of which pass down either leg. The latter give off still smaller branches to supply nutrition to the muscles and other tissues. The aorta also gives off branches to supply the head, neck, and arms.

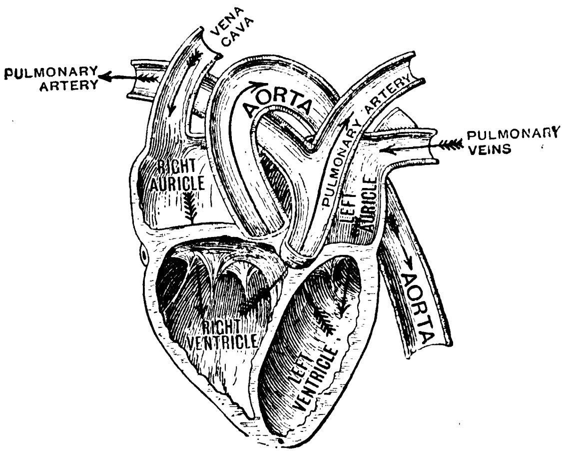


Fig. 26.—The Heart.

Capillaries are the smaller tubes in which arteries end. They are of microscopic size, and so numerous that noportion of the skin can be punctured without causing an effusion of blood.

Arteries have three different layers or coats. Capillaries have only one coat, which is exceedingly thin, and consists of small delicate cells through which the elements of nutrition contained in the blood pass to the tissues. At the same time waste matters escape from the tissues and pass into the blood circulation through minute veins which begin where the capillaries end.

Veins are tubes which convey the impure blood to the heart, from which it passes to the lungs to be purified. They are provided with valves at intervals, which serve the same purpose as those of the heart. When the valves fail to act

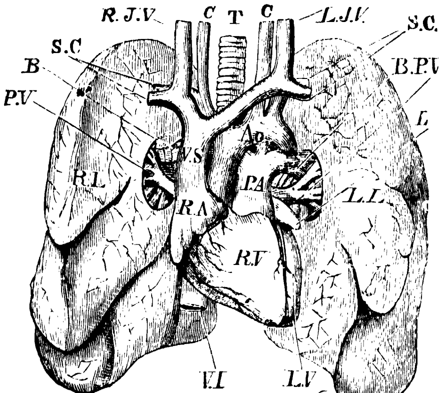


FIG. 27.—FRONT VIEW OF THE HEART, GREAT VESSELS, AND LUNGS.

The lungs have been drawn aside in order to show the other structures fully. The outer layers of the pericardium and the pleuræ have been removed.

R.V. Right ventricle; *L.V.* left ventricle; *R.A*, right auricle; *L.A*, left auricle; *Ao*, aorta; *P.A*, pulmonary artery; *P.V*, pulmonary veins; *R.L*, right lung; *L.L*, left lung; *V.S*, vena cava superior; *S.C*, subclavian vessels; *C*, carotids; *R.J.V* and *L.J.V*, right and left jugular veins; *V.I*, vena cava inferior; *T*, trachea; *B*, bronchi.

All the great vessels but those of the lungs are cut.

properly the circulation is slowed by the increased weight in the column of blood behind them and partly by gravity. This causes the blood to accumulate in abnormal amount in the veins and dilate them. Varicose veins, which sometimes occur in an extreme form in the legs and elsewhere, are caused in this way (Fig. 28).

The large veins, which receive the impure blood from the small veins of the upper and lower parts of the body, empty themselves into the right auricle or auricular cavity. Hence they are called the *venæ cavæ*. The impure blood passes from the right auricle into the right ventricle, from which it passes through the *pulmonary artery*—which has two branches—to the lungs, where it is purified by the oxygen contained in the air cells and by the escape of waste matters in expired air. In its purified state the blood is then conveyed to the left auricle through the *pulmonary veins*, and from the left auricle to the left ventricle. The left ventricle, in contracting, drives the purified blood into the aorta to

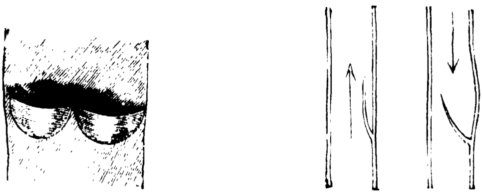


FIG. 28. A VEIN SLIT OPEN, SHOWING VALVES.

be distributed throughout the body, as has already been described.

Valves are placed at the various openings leading from one cavity to another, to ensure that the blood passing through them will not flow back. A backward flow of the blood does occur, however, in some diseases of the heart, which affect the valves and render them incompetent to fulfil their purpose—a condition which is sometimes of serious moment, and requires careful and skilled treatment. The circulatory movements of the blood in the heart are caused by the alternate contraction and dilation of its cavities, due to reflex action of their muscular structure. The term *diastole* means dilation or dilatation as opposed to *systole*, meaning contraction. The terms are used by doctors in describing blood pressure and other conditions relating to the heart and the circulation of the blood.

Lymphatics. The capillary blood-vessels, as has been previously stated, consist of a single layer of delicate cells. They ramify throughout the tissues of the body and run between the cells of which the tissues are composed. The capillaries and cells are separated and do not come into contact anywhere. The space between them is filled with *lymph*, which is a colourless or faintly yellowish fluid, consisting of serum and albuminous constituents of the fibrin of the blood, fat globules, granules, and, sometimes, blood cells. These substances exude through the walls of the capillary vessels. Coursing through the lymph-filled spaces are vessels which also contain lymph. These are the vessels which are known as *lymphatics*. One of their functions is to drain the spaces of any excess lymph that may be present in them. "Lymphatic vessels have been found in nearly every texture and organ of the body which contains blood-vessels. Such non-vascular structures as cartilage, the nails, cuticle, and hair have none" (Gray's Anatomy). Whether in the outer parts of the body, or its inner organs or other structures, all lymphatic vessels are linked up with glands through which they pass in their course to their destination. These are known as *lymphatic glands*. "They vary in size from that of a hemp seed to that of an almond" (Gray). Groups of them are found in the arm-pit, groin, and in the cavities of the chest and abdomen. Those in the groin can be felt with the fingers. Considered as a whole, the lymphatic vessels and glands constitute the "*lymphatic system*."

The functions of the glands are to produce white blood corpuscles and to filter and remove impurities from the lymph. If septic matter is conveyed to them the glands become swollen, inflamed, and extremely painful, and may suppurate. Sores on the fingers or toes, for example, not infrequently induce such occurrences in the glands in the arm-pit, or behind the knee, or in the groin. Tubercular

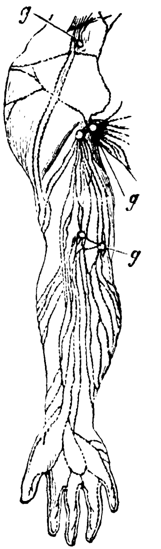


FIG. 29.—THE LYMPHATICS OF THE FRONT OF THE RIGHT ARM.

g. Lymphatic glands, on the course of the lymphatics.

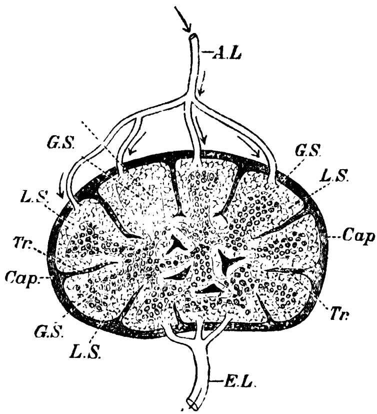


FIG. 30.—DIAGRAMMATIC REPRESENTATION OF A LYMPHATIC GLAND SEEN IN SECTION. (AFTER SHARPEY.)

Cap., capsule; *Tr.*, trabeculæ; *G.S.*, glandular substance; *L.S.*, lymph sinus. In the alveolus marked 1 all the leucocytes are supposed to have been washed out; in the rest of the gland they are shown in the glandular substance, but washed out of the lymph-sinuses. *A.L.*, afferent lymphatic; *E.L.*, efferent lymphatic. The arrows show the direction in which the lymph enters and leaves the gland.

glands are another example of septic infection of the lymphatic system. All the lymphatics of the body ultimately pass in their course into the chest cavity. "The thoracic duct is the common trunk of all of them except those of the right side of the head, neck, and thorax, and the right arm, right lung, right side of the heart, and the convex surface of the liver" (Gray's Anatomy).

The lymphatic vessels of both legs, the left arm and left side generally, and those conveying the *chyle*, from the lacteals in the intestine, discharge their contents into the thoracic duct, which, in turn, empties its contents into large veins beneath the left collar-bone, in which they are conveyed, with their other contents, to the heart, and, finally, from the heart to the lungs, where the venous blood is purified and afterwards passed into the arterial circulation.

The circulation of the lymph in the lymphatic vessels is effected by the pressure at which it exudes from the capillary bloodvessels and by the contraction of the skeletal muscles, such as those of the arms and legs, and by the presence in the lymphatic vessels of valves which make the lymph flow in one direction—*i.e.*, towards the thoracic duct and great veins.

The following extract from Starling's "Physiology" describes clearly how the lymph is caused to flow: "We may look upon muscular exertion as the greatest factor in the circulation of lymph. The flow of lymph, from the commencement of the thoracic duct in the abdominal cavity to the main part of it in the thoracic cavity, is materially aided by the respiratory movements; since, with every inspiration, the lacteals and abdominal part of the duct are subjected to a positive pressure, and the part of the duct in the thorax to a negative pressure, so that lymph is continually being sucked into the latter."

The nutrition of the tissues and their cells is derived from the lymph which exudes from the capillary bloodvessels and not directly from the vessels, which, as stated above, do not come into direct contact with the cells in any part of the body.

HÆMORRHAGE AND HOW TO ARREST IT

The blood from an artery escapes in jets with every beat of the heart. Blood from a vein does not spout out, but has a steady and constant flow, and can be more easily arrested than bleeding from an artery. The loss of blood depends, of course, on the size of the artery or vein that is wounded and the duration of the flow.

General Observations on how to stop Bleeding. The finger, a pad, a piece of sponge, a piece of cork or something of the kind may be firmly applied over the spot from which the blood comes. If the bleeding is from a vein, the limb should be raised, and pressure applied over and below the wound. If from an artery, pressure should be applied above the wound. The pressure, however, must not be kept applied too long or the structures pressed on may suffer seriously owing to the blood supply being cut off. If the main artery of a leg or an arm, for example, were compressed too long gangrene would ensue. If, on the other hand, the bleeding were not stopped temporarily, until the vessel could be tied or otherwise dealt with, death would inevitably follow. Cold water, or water several degrees above blood-heat, is sometimes used to stop bleeding. Their effect is produced by the contraction of the vessels. Astringent medicines—*styptics*—may also be used. Their effect is to cause the blood to clot and block the ends of the wounded vessels, and thus prevent further loss of blood. In some cases medicines taken inwardly are of much value in arresting hæmorrhage.

Internal Hæmorrhage. In cases of bleeding from the lungs, stomach, or other organs of the body, patients should be kept lying down, perfectly quiet, and should not be allowed to talk. Small pieces of ice may be given to them to suck, and ice may be applied, with care, over the part of the body from which the bleeding is believed to take place. As cases of the kind are always serious, medical aid should be obtained without delay.

Bleeding from the nose is sometimes alarming and difficult to stop. This is especially so in the case of old people whose arteries are hard and inelastic, and cannot therefore contract properly. In ordinary cases, however, the following procedure, when adopted, usually proves successful:

1. The patient should be made to sit with the head erect and breathe entirely through the mouth, and never be allowed to bend the head over a basin or anything else.

2. The soft part of the nose should be gripped between the index finger and thumb, and pressure maintained for some minutes. A piece of sponge, cotton-wool, a handkerchief, or the corner of a towel, dipped in cold water, may with advantage be used at the same time.

3. If, when the pressure is removed, the bleeding appears to have been checked, the patient must avoid blowing the nose, otherwise the clotted blood, which forms a plug, will be dislodged, and the bleeding may recur. Later on, when it is deemed safe to do so, the nose may be gently douched with boracic or some other simple lotion.

Plugging the nostrils with cotton-wool soaked with peroxide of hydrogen or adrenalin, which induces contraction of the arteries, is an effective means of checking nose-bleeding; but the services of a doctor are usually necessary for their proper application. The writer had recently to deal with a case of nose-bleeding which had gone on for several hours before the patient sought medical help. The bleeding had been controlled to some extent by pressure of an intermittent kind, On examination it was found that the blood was spurting from a small artery at the bottom of a tiny wound on the edge of one of the nostrils, caused by the scratch of a cat's claw. Adrenalin and pressure were found to be of no use; but a little cotton-wool dipped in collodion, when applied, checked the bleeding immediately.

This case is mentioned merely to illustrate the importance of getting medical aid without wasting time.

Bleeding from Wounds of the Skin. A not uncommon cause of this is varicose veins in the legs. Pressure over and below the bleeding-point and rest are all that may be necessary to arrest the bleeding in such cases. In severe wounds of the leg and arm, however, deep-seated arteries may be severed and profuse bleeding take place in consequence. Pressure applied locally may be of no use, and it may be necessary to compress the main artery of the limb until surgical aid can be obtained and the severed artery searched for and tied. *Tourniquets* are employed for this purpose, but firm pressure with the thumb can be applied temporarily by anyone who knows where to apply it. How to render first aid in such cases is of the utmost importance, and yet comparatively few of the general public know anything about what to do in even the simplest cases.

Bleeding from the gums is a common occurrence after the extraction of teeth, and is by no means, at times, easy to control. This is due to the fact that the ends of the wounded arteries which are fixed inside the bony structure of the jaw cannot contract, and the blood escapes from their open ends in consequence. While it should be the dentist's duty to apply the treatment in such cases, it not unusually falls to the lot of the doctor to have to do so. In such cases prompt action should be taken to get help as quickly as possible, as personal effort to arrest bleeding is of no use in many cases. Stuffing the bleeding cavity firmly with sterilised cotton-wool and keeping the teeth firmly pressed over it may be tried, and is sometimes all that is necessary.

In these cases, also, peroxide of hydrogen may be used or, in emergent circumstances, the cotton-wool may be moistened with a weak solution of perchloride of iron, generally known as steel-drops.

RESPIRATION

Respiration is the combined movements of inspiration and expiration or *breathing.*

When as much air as possible is forced out of the lung by expiration, that which still remains in it is called *residual air.* The air which is left in the lung after an ordinary inspiration is called *supplemental air.* The air contained in the lung at any given moment during breathing, and which comprises both residual and supplemental air, is called *stationary air.* In very deep breathing, when the ribs are fully expanded and the clavicles raised, the largest quantity of air is taken into the lungs. This is called the *vital capacity* of the lungs.

The organs of respiration are the lungs, trachea, and larynx, but the nose and mouth assist largely in the process of breathing.

The lungs are situated on either side of the chest cavity. They are covered with a membrane called the *pleura,* which also lines the inner surface of the ribs. The space between the two layers is called the *pleural cavity,* into which fluid exudes in the disease known as pleurisy. Breathing is effected by virtue of the elastic nature of the chest walls and lungs, and by certain muscles, including those of the neck, chest, and belly. The most important muscle is the *diaphragm* or *midriff,* which is situated at the lowest part of the chest cavity, and separates it from the *abdominal cavity.* Two layers of muscles, situated between the ribs—intercostal muscles—assist in ordinary breathing.

In ordinary circumstances the diaphragm, during breathing, plunges up and down like a piston, and does not lose its curve. During inspiration, when the diaphragm is descending, the lungs become distended with air. The ribs are thus pushed outwards and become more level, and the circumference of the chest-wall is increased. During expiration the opposite effects are produced.

The Structure of the Lungs. Each lung receives from the trachea a branch called a bronchus. The bronchus is the first portion of the air-passages or tubes in each lung. By

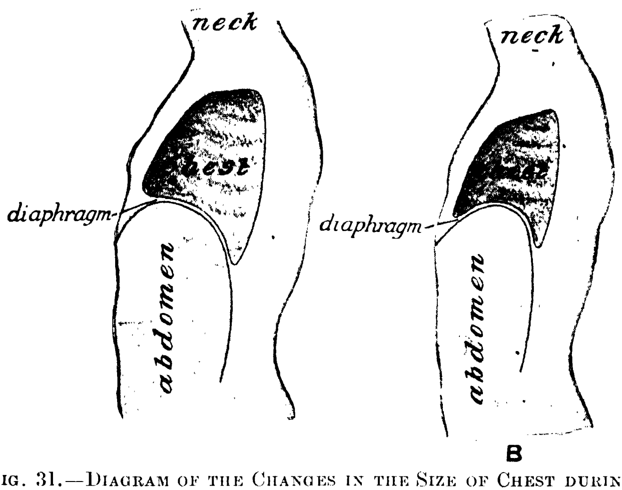


FIG. 31.—DIAGRAM OF THE CHANGES IN THE SIZE OF CHEST DURING BREATHING.

A. After inspiration; B, after expiration.

the branching and re-branching of the bronchus the air-tubes become smaller and smaller, and are of microscopic size when they reach the *air-vesicles* or *air-cells* of the lungs in which they terminate. Because of the variations in size of the air-tubes in different parts of the lung they have been classified as (1) bronchus, (2) bronchi, (3) bronchiæ, and (4) bronchioles.

All these structures, except the bronchioles, consist for the most part of cartilage (Fig. 32).

The air-cells of the lungs are of vital importance. It is through them that oxygen from the air finds its way into

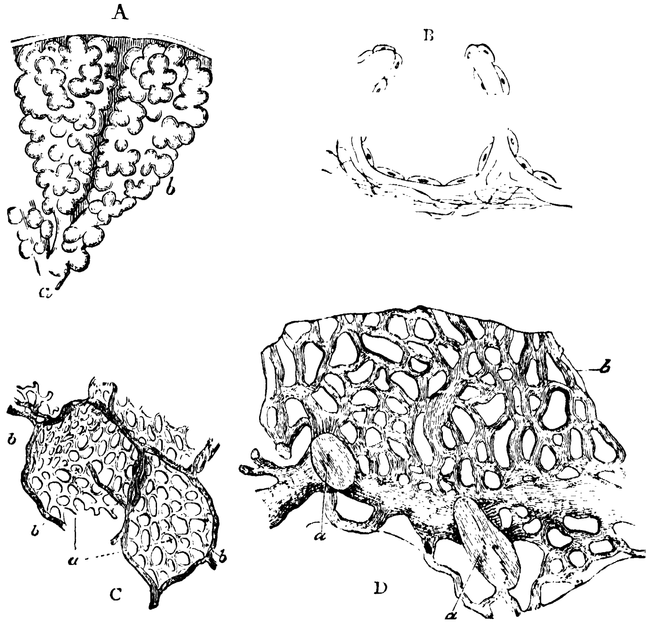


FIG. 32.—DIAGRAMS TO SHOW THE STRUCTURE OF THE LUNGS.

A. *a*, an ultimate bronchial tube opening into two infundibula, each consisting of a number of alveolar chambers, *b*.
B. The wall of an alveolar chamber. *a*, the epithelium; *b*, partition between two alveoli, in which the capillaries lie; fibres of elastic tissue.
C. The blood-vessels of two alveoli. *a*, networks of capillaries; *b*, small arteries and veins.
D. The same very highly magnified.

the blood for its purification and that impurities are removed from the blood and exhaled from the lungs. The air-cells are called *alveoli*.

The air-cells, arranged together like bunches of grapes, are shown in Fig. 33. These bunches of cells are on an average only $\frac{1}{40}$th part of an inch in diameter. Each cell has numerous minute bloodvessels, coursing through its walls, which contain impure blood brought from all parts of the body. It has been calculated that if all the cells were spread out

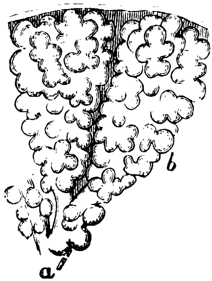


FIG. 33.—A SMALL PIECE OF LUNG.
Highly magnified to show the air-cells, *b*; and minute air tube, *a*.

they would present a surface measuring about fourteen hundred square feet. We breathe sixteen or seventeen times in the minute, and at each breath the cells become filled with pure air.

Every time we breathe we take in about three-quarters of a pint (20 to 30 cubic inches) of pure air, and allow the same amount of impure air to escape from the lungs.

The Trachea is connected with the lungs by two bronchi. It is 5 inches in length and extends from the lower end of the larynx to beneath the sternum, where it passes in a backward direction. If the chin is raised part of the trachea can be felt through the skin and its other coverings, immediately above the sternum. In structure it consists of narrow pieces of cartilage separated by firm membrane. The cartilages extend almost completely round the trachea.

At the back portion a firm but resilient membrane intervenes, which serves a useful purpose. If the cartilages formed complete rings round the trachea swallowing would be difficult, at least, if not impossible, for the reason that the œsophagus passes behind it. The resilient membrane enables the act of swallowing to be performed satisfactorily and without interfering with breathing. Extreme pressure on the trachea may, however, cause death from suffocation. ✓The inner surface of the trachea is covered with a sensitive lining of mucous membrane consisting of cells surmounted with *cilia* or hair-like lashes, which are in a constant and rapid state of motion. The function of the cilia is, as it were, to spray the trachea with a fluid secreted in it. This fluid is sprayed in an upward direction, and dust and other fine substances are thus helped to be got rid of. Cilia are to be found in nearly all the respiratory passages, as also in some other organs of the body.

The Larynx is connected with the trachea and at its upper end opens into the pharynx. It is that part of the respiratory tract in which the vocal cords are situated. It also is mainly cartilaginous in structure. The whole of the front portion of it can be easily felt, and its most prominent part, called the *pomum adami* or Adam's apple, is distinctly visible in the neck. The shape of the two largest cartilages—the *thyroid cartilages*—is quadrilateral and can be made out by manipulating them. So can also a small almost circular cartilage—the *cricoid cartilage*—situated immediately below the thyroid cartilages and separated from them by a very narrow space. All the cartilages of the larynx are connected by joints or membranous structures. The membrane between the thyroid and cricoid cartilages can be felt.

The entrance to the larynx from the pharynx is called the glottis.

The glottis is situated near the entrance to the œsophagus. Above it is a leaf-shaped plate of elastic fibro-cartilage called the *epiglottis*, which is attached by its stalk to the most prominent parts of the thyroid cartilage.

The lining membrane of the larynx is composed of ciliated cells similar to those in the trachea. They are absent from the vocal cords.

Various opinions have been expressed as to the function of the epiglottis. It is stated in some books that it protects the glottis during the act of swallowing, and that during swallowing it is pulled upwards and backwards to form a covering or lid for the glottis and keep particles of food or other substances from passing through it into the larynx. Some regard it merely as a shoot for directing the food into the œsophagus and think the glottis is protected in this way. What may be safely said, however, is that the risk of food passing through the aperture of the glottis is prevented by (*a*) the temporary stoppage of respiration during deglutition or swallowing, and (*b*) by the extreme sensitiveness of the lining membrane of the larynx.

Irritation of the epiglottis, aperture of the glottis, or any other part of the larynx by foreign bodies causes violent coughing, which is nature's method of expelling them. Vomiting even may occur to assist. Persons attacked in this manner, while eating, often use the expression, "something has gone down the wrong way."

The Vocal Cords (Fig. 34), two in number, are ligamentous structures, situated at the upper part of the larynx and extending from the thyroid cartilages in front to two small cartilages at the back of the larynx (*arytenoid cartilages*) to which they are attached. The arytenoid cartilages are joined to the cricoid cartilages behind. When examined with a laryngoscope, by reflected light from a mirror attached to it, the vocal cords can be seen to open widely apart during inspiration and come close together when high notes are uttered. At the front part of the larynx the cords do not separate. The opening and closing are due to rotatory hinge-like movements of the arytenoid cartilages. By using the laryngoscope it is possible to examine the trachea. And by the use of another instrument called the "*bronchoscope*" it is possible even to examine the bronchi, which are the two main branches of the trachea which communicate with the lungs.

Voice is the sound uttered by the mouth, which is produced by the vibration of the vocal cords. *Articulation* is distinct speaking or enunciation of words and sentences

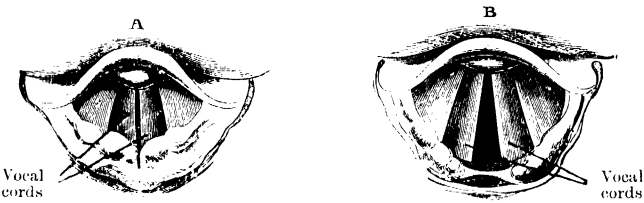


FIG. 34.—VIEW OF THE HUMAN LARYNX FROM ABOVE.
A, In the condition when speaking; B, at rest, silent.

by the proper use of the lips, tongue and palate. The power of speaking is regulated by a nerve-centre in the third left frontal convolution of the brain (Fig. 69).

POSTURE AND BREATHING, BREATHING EXERCISES, AND BREATHING HABITS IN CHILDREN

Posture and Breathing. Children, when reading, writing, looking through picture-books, etc., have a tendency to assume a cramped attitude, with their shoulders bent, their chins touching their breast-bones, and their spines twisted. They are apt, also, when standing or walking, to neglect to keep their bodies straight and evenly balanced. Faulty postures induce muscular fatigue and prevent the free admission of air into the lungs, and their proper inflation and the full expansion of the chest in consequence. If such postures are not corrected in youth, when the bones are pliable, deformities such as round shoulders, flat chest, and

FIG. 35.—X-RAY VIEW OF A CROOKED SPINE CAUSED BY BAD POSTURE.

spinal curvature develop, and become permanent. Such conditions, owing to pressure on the heart, impede its action. They also predispose to disease of the lungs.

When sitting the shoulders should be kept well back and the head erect without, however, raising the chin too high (Figs. 37, 38).

When standing the body should be kept as erect as possible, without producing discomfort, and balanced so that its weight will be equal on both legs (Figs. 39, 40).

Bodily deformities, in the case of school-children, may be induced through defects in the construction of desks and seats and faulty postures in writing. The following rules, suggested many years ago by Mr. T. G. Rooper, one of H.M. Inspectors of Schools, with a view to their prevention, may be usefully included here for reference. They are simple and can be easily understood.

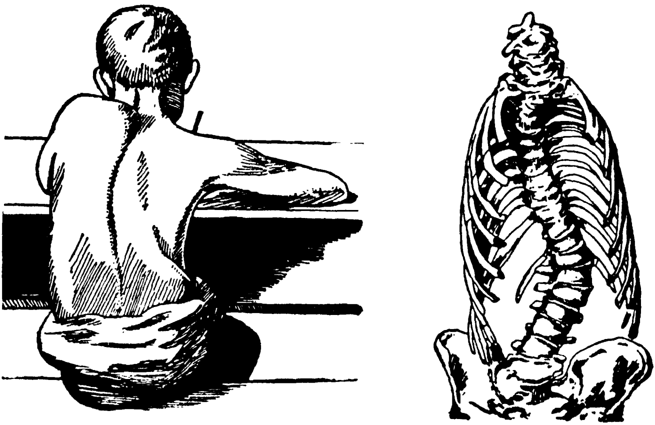


FIG. 36.—BAD POSITION, AND THE RESULT.

1. The Desk and Bench.

" 1. The height of the desk above the bench should be such that when the child is sitting down he can place both his forearms comfortably on the desk, without raising or depressing his shoulders.

" 2. The height of the desk above the floor or surface on which the foot rests should correspond with the length of the child's leg from knee to heel. When the child is sitting down his legs should not dangle in the air, nor should his knees be elevated above the bench.

"3. The bench should be wide enough to give support not only to the seat, but also to the upper part of the thigh. It should be at least 10 inches (but better 12 inches) wide. To prevent slipping forward, the bench should be hollowed out towards the back to the depth of an inch.

FIG. 37.—FAULTY SITTING POSITION.

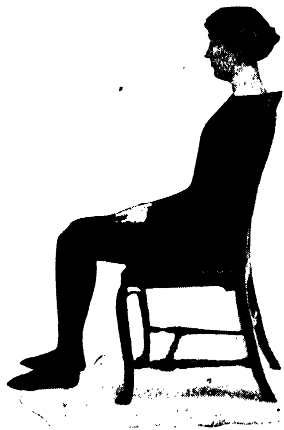


FIG. 38.—CORRECT SITTING POSITION.

"4. Every bench should provide a support for the back of the sitter. This may consist of a board fixed at the back of the bench, at right angles to the seat. The board should be hollowed out in such a way that the upper part of it may fit the concavity of the back. The exact height of the back would vary with the size of the child, but it will be from 6 to 7 inches.

"5. The desk must overhang the bench during the writing lesson, in order that the child may be able to sit upright, and at the same time support his back. This posture is only possible when the desk overhangs the bench from $1\frac{1}{2}$ to 2 inches.

"6. The desk should not be level for the writing lesson, but slightly sloping. The slope should not exceed an angle of 20 degrees. The difference between the upper and lower

Fig. 39. Correct Standing Position.

Fig. 40.—Faulty Standing Position.

edge of the desk, therefore, should be about 3 inches vertically.

"7. As the desk, which is most suitable for writing, is inconvenient for other purposes, the easiest plan of adapting it to all uses is to make the upper part of it movable.

"8. Desks of appropriate sizes should be provided for each class.

2. The Posture in Writing.

" 1. The writer should sit upright, and should lean his back against the support provided for the purpose.

" 2. The shoulders should be kept parallel with the edge of the desk. The writer must not be allowed to screw the

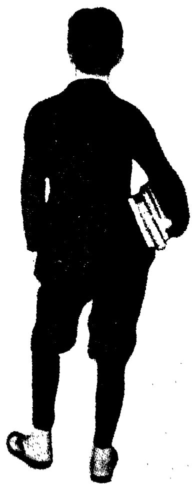


FIG. 41.—ONE WAY TO GET A CROOKED SPINE.

body round or to rest the chest against the desk. There should be a space of an inch or a little more between the desk and the body.

" 3. The weight of the body should be disposed evenly on both bones of the seat.

" 4. The head should not droop forward, much less lean on the arm. It may be slightly bowed forward, and may move a little from side to side as the eye follows the writing.

"5. The forearms, and not the elbows, should rest on the desk. The pen should be passed across the paper by a movement of the hand and not of the arm.

"6. The point of the pen should be at least 10 inches (better 12) from the eye.

FIG. 42. — THIS CHAIR IS TOO HIGH AND THE BACK OF IT NOT RIGHT.

FIG. 43.—WHAT WILL HAPPEN TO THIS BOY IF HE ALWAYS SITS BENT FORWARD?

"7. To make compliance with the above directions possible, the paper or copy-book must lie opposite to the middle of the body.

"8. The paper must not lie square on the desk before the writer, but it must be tilted or askew.

"The lower edge of the paper and the lower edge of the desk should form an angle of from 30 to 40 degrees.

"The paper is rightly placed when the down strokes are being made at right angles to the edge of the desk.

"The common attitude for writing often ordered by teachers with the words, "Half turn right, left arm over slates," is liable to cause injury both to the spine and to the eyesight."

The object of games and other forms of physical exercise at schools, at regular intervals daily during school hours, is to bring the muscles into play, induce full breathing, and counteract the tendency to bodily deformities. In a lecture delivered at Edinburgh recently, Mr. W. A. Cochrane, F.R.C.S., said that "games do not necessarily produce a fully erect attitude, and that a slender build often causes a tendency to droop and relax, so that a person with such a physique has much greater difficulty in maintaining a healthy position than has the broad-backed robust type. Care should be taken that the slender type of child develops properly. Very high heels flex the knees and develop a drooping carriage, which results in weakness of the abdominal muscles, flat chest, and round shoulders." He added: "Physical education is a mental as well as a physical process; an infant takes a long time to learn to stand erect. People of slender build have also to cultivate postural tone in the muscles."

Mr. Cochrane expressed the opinion that correct posture should be taught in schools.

Breathing Exercises. If, for any special reason, strenuous physical exercise to induce free and full breathing is contra-indicated in the case of children or older persons, the following exercises may be taken instead and prove beneficial.

1. Place the hands on the hips. Bend the head backward, lift the chest as high as possible by taking a long deep breath. Then force the air out slowly while bringing the head up again (O'Shea and Kellogg).

2. Stand erect and easily, legs together, arms by sides, palms inwards. Make a full slow inspiratory effort, begin-

ning and ending with the movement of the arms as follows: Carry the arms outwards from the sides, keeping the palms in the same position, until the level of the shoulders is reached. Continue the movement of the arms upwards, and at the same time turn the palms inwards, so that they meet overhead. The elbows are kept stiff. Now turn the palms outwards and bring the arms down slowly to the original position by the sides, exhaling meanwhile. Complete the exhalation at the end of this movement by a general voluntary contraction of all the muscles of expiration, so as to empty the lungs as completely as possible.

Breathe in through the nose with the mouth closed, and endeavour to expand the chest from below upwards. Breathe out through the mouth.

Repeat six to twelve times.*

With a little practice these exercises can be soon learned.

Breathing Habits in Children. The proper way to breathe is through the nose. Children do not know this, and their parents may not either. Consequently some children, apart altogether from any obvious cause, continually keep their mouths open and breathe only in this way, and no notice is taken of it. Nasal obstruction, however, is the most common cause, and in every instance of mouth-breathing in children the throat and nose should be thoroughly examined and suitable treatment employed when defects are discovered. Mouth-breathing leads to serious malformation of the jaws and teeth, and spoils the shape of the face. It also interferes with the proper development of the body, and causes stunted growth. It also retards mental development.

Children should be encouraged to cultivate the habit

* Quoted from "The Culture of the Abdomen," by the kind permission of the publishers, Messrs. William Heinemann (Medical Books) Ltd.

of breathing through the nose, and breathe deeply. They should not be allowed to wear tight clothing round their chest or abdomen when taking exercise or at any other time. And they should be encouraged to acquire the habit of maintaining a correct posture, no matter what they are doing—whether reading, writing, sitting, or standing. If points such as these are attended to children soon acquire the habit, if there is no throat or nasal trouble, of breathing correctly.

VENTILATION AND ITS IMPORTANCE

The term ventilation is derived from a Latin word *ventus*, meaning wind, and "ventilate" means "to fan with the wind" or "to open to the free passage of air." It is to enable this to be done that inhabited rooms and buildings are provided with windows, doors, and other openings which at the same time admit light and sunshine. The want of proper ventilation leads to the accumulation of dangerous impurities in the air, which cause sickness.

Expired air, it has been estimated, gives off about three-fifths of a cubic foot of *carbonic acid gas* every hour.

A light is speedily extinguished when put into carbonic acid gas, and it is due to the accumulation of this gas and loss of oxygen that a burning candle gradually goes out when put into a glass jar from which air is excluded by covering it with a lid.

Expired air also contains a large amount of *organic matter*, which consists of infinitesimally small particles of dead tissue and the foul gases of their decomposition. This is the most injurious impurity in expired air. It is contained in large amount in the watery vapour, which, if collected and kept in a bottle, rapidly decomposes and gives off a most offensive odour. Other impurities, such as ammonia, a substance called urea and mineral matter, are also found in small quantities in expired air.

The peculiar sickly odour of overcrowded and badly ventilated rooms, most noticeable on entering such places from the fresh air outside, is due not so much to the large amount of carbonic acid present as to the foul organic matter. This foul matter, although obtained in large part from the lungs, is also given off from dirty skins, dirty feet, dirty mouths, decayed and dirty teeth, and dirty clothing. The amount of organic matter from these sources present in the air increases in proportion to the increase in the amount of carbonic acid gas. It is for this reason found convenient to judge of the extent of the pollution of the air of a room by estimating the amount of carbonic acid gas present, which is more easily done. The carbonic acid should never exceed 6 parts in 10,000 or 0·6 or three-fifths of a part in 1,000 parts of air.

A simple way of showing the presence of carbonic acid gas in the breath is to breathe into a clean bottle made of clear glass, pour some fresh lime-water into the bottle, and shake it well. The lime-water will turn milky white owing to the carbonic acid combining with it. A chalky compound (calcium carbonate or carbonate of lime) is formed.

Other sources of impurities in the air are fires, gas jets, oil lamps, and candles, which, during combustion, like the lungs, use up the oxygen of the air and give off carbonic acid gas, watery vapour, particles of carbon, and other waste products. It has been estimated that two hard sperm candles, or one oil lamp, consume as much oxygen and give out as much carbonic acid as one man. It has also been estimated that one batswing gas burner consumes as much oxygen and gives out as much carbonic acid as at least two men.

Carbonic acid and other foul and injurious gases, such as sulphuretted hydrogen gas, are also given off in large quantities from decaying waste matter in dirty streets, drains, sewers, cesspools, latrines, stables, cattle-sheds, overcrowded, badly selected, and ill-regulated graveyards, brickfields, marshes, manufactories, and other similar places. The air may also contain portions of human hair, skin, fibres of dirty rags, the eggs of insects, and even the insects themselves. No less than 200 different kinds of living creatures are said to have been found in the air. The air of inhabited places may also be rendered impure by the presence of dust, which may be teeming with germs of disease, such as *tuberculosis* in particular.

Impure air often causes headache, faintness, sickness and vomiting and diarrhœa, and those who live constantly in such air suffer from loss of appetite, sleeplessness, low spirits, and general bad health. The health of children more especially is liable to suffer from the effect of bad air.

Besides tuberculosis, impure air may cause other diseases of the lungs, such as pneumonia and bronchitis, and it is a potent factor in the spread of such diseases as plague, diphtheria, dysentery, and even diseases of the skin and eyes.

Enteric fever and dysentery are often caused by dust getting into milk and water after they have been boiled. It is a well-known fact, too, that far more sickness prevails and more deaths occur in dirty cities, towns, villages, and houses than in places which are kept clean, and where the air is always fresh and pure.

It is said that the death-rate from lung diseases is three or four times greater among working people from the dust caused by the nature of their employment than amongst other people.

From the foregoing observations the importance of fresh air becomes apparent. Before, however, proceeding to discuss the subject of ventilation as a means of purifying air, it may be permissible to say something about the need of air, the kind of air that is best for health, and what can be done by persons themselves to help to keep the air pure and make ventilation an easier matter.

The Need of Air. Fire and lights go out when the air supply is cut off. On the other hand, fires burn more briskly when a liberal supply of air is provided by blowing into them with a pair of bellows or through a piece of hollow bamboo or other tube, or using a punkah or fan. These effects are due entirely to the oxygen contained in the air. Just as combustion is impossible without air, so human beings and animals could not live without it. The oxygen of the air we breathe purifies our blood, enables us to make use of the food we eat, and fits it for the support and growth of our bodies. It also produces heat, and thus helps to keep our bodies warm. Combustible substances burn with great rapidity in pure oxygen. In the same way, if we breathed pure oxygen, our tissues would be rapidly consumed—in fact, it would be impossible to live. The oxygen of the air is therefore mixed with nitrogen gas, which dilutes it and renders it fit for breathing.

The Kind of Air Required. Air must be as pure and fresh as possible. The purest air is to be found in the neighbourhood of the sea, on the tops of mountains, and in country districts. Ozone is found in larger quantity near the sea than elsewhere. The most impure air is to be found in large cities and towns where there is much trade, and where manufactures are carried on to a large extent, and in all places where the removal of dirt is neglected.

How to Keep the Air Pure. Every attention should be paid to the careful construction and cleanliness of houses, streets, roads, drains, latrines, etc. Refuse of all kind should be immediately removed and carefully disposed of. There should be a liberal supply of water for cleansing purposes. We should keep our houses, our bodies, and our clothes clean. An outlet should be made for the smoke in cook-houses. Cooking should not be done in sleeping-rooms. Animals such as cows, buffaloes, goats, cats, and dogs should not be allowed to live in or near rooms occupied by human beings, and there should be free ventilation and sunshine. Attention to matters of this kind will help very considerably to keep the air from becoming contaminated.

Ventilation is facilitated by the natural tendency of gases to mix with each other under the influence of wind and heat. This is known as the "**diffusion of gases.**"

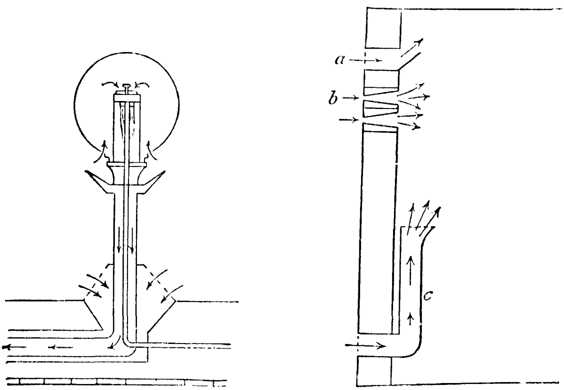
Just as smoke from a chimney or a pipe mixes with the air and gradually disappears, or as coal gas mixes with the air in rooms, so does the impure air of rooms tend to escape and mix with the fresh outside air. The fresh outside air similarly tends to enter the rooms and mix with the impure air inside them.

The heated impure air is drawn in the direction of the fireplace, rushes up the chimney, and its place is taken by the cold pure air from the outside.

Gas flames enclosed in glass globes, open at the bottom and placed near openings communicating with the outside, are sometimes used for ventilating purposes by creating a draught just as fires do.

It is not desirable during cold weather or in cold climates that one large opening only should be used for ventilating purposes. This method of ventilating may cause cold draughts and give rise to chills. Several small openings are better. This not only avoids draughts, but the impurities of the air in every part of the room are thus more easily got rid of altogether or more evenly diluted. European houses, on account of the colder climate, are constructed in an entirely different way from houses in India, and the system of ventilation also differs very much. **Valves** in the walls near the ceiling are sometimes used for ventilating houses in European countries. They act very much like the **jhilmils** of the doors and windows of the houses in India, which not only keep out the glare of the sun and the rain, but help to keep the room cool, and allow the free entrance of air.

Ventilating tubes are also used in European houses. The air is admitted through openings in the wall near the



FIGS. 44 AND 45.—VENTILATION BY GLOBE, GAS LIGHT AND AIR SHAFT.

a, Sherringham valve; *b*, Ellison's bricks; *c*, Tobin's tube.

floor, and carried up the inside of the wall to a height of 6 or 8 feet. The placing high up in the wall of *bricks with conical passages* through them is another method which is sometimes employed. The hot impure air being lighter than cold air rises and is allowed to escape by other openings placed near the ceiling.

Figs. 44 and 45 show two of the methods of ventilation just described. In cold countries the combined area of all the ventilating apertures should be about 24 square inches for each person. In the plains of India much more may be allowed without any risk of cold being caught from draughts. In fact, sleeping-rooms have in many instances as much door and window space as walls, and for many months in the year are kept open all night in order to facilitate the free movement of the air. Electric fans and punkahs also keep the air in motion and cause an indraught of air from the outside.

Where expense has not to be considered rooms in houses in India are large and have high ceilings, which is a great advantage when, owing to the high temperature of the air at certain times of the year, it is necessary during the day to shut doors, windows, and **jhilmils** so as to keep the rooms as cool as it is humanly possible to do so and for protection against the glare of the sun. The larger the room the longer it takes for the air to become dangerously impure.

In the huts of poor Indians there is often no outlet of any kind for the air, except through small cracks in the walls, chinks in doors, through the thatch, or between the tiles of the roof. Thus the air becomes vitiated by smoke from fires during cooking, by the breath of those living in the huts, and in other ways.

It is most necessary that provision should be made for the ventilation of staircases into which foul air from all the adjoining rooms finds its way. An opening made in the roof will serve this purpose, but arrangements must be made to keep out the rain. No house, the staircase of which is not properly ventilated, can be healthy. Well-ventilated staircases help to remove the impurities of the air of adjoining rooms.

Fans driven by steam or otherwise are often used for ventilating the between-decks of passenger ships, engine rooms, large public schools, mills, and other similar buildings. They do so either by supplying fresh air (propulsion) or by forcibly withdrawing the impurities in the air (extraction). Most good is effected by the latter method. The former causes strong draughts, and all the foul air is not purified.

Central air shafts in which fires are kept burning to create an upward draught are also sometimes used for ventilating purposes. Coal mines are ventilated in this way. Compressed air has also been used.

The cubic capacity of a room is calculated by multiplying the length, breadth, and height together. Each person should, if possible, have a cubic space measuring 1,000 feet. A room 10 feet long, 10 feet wide, and 10 feet high would give this amount of cubic space. The air in such a room should be changed three times hourly. In other words, 3,000 cubic feet of air must be supplied hourly to prevent the carbonic acid gas and other impurities accumulating to a dangerous extent. In calculating the cubic capacity of a room the space occupied by furniture should be deducted. A room which affords less than 300 cubic feet of space to each individual is overcrowded. Some years ago the writer inspected and submitted a report on a room in Calcutta, the cubic capacity of which was 540 feet. This room was occupied by eight persons, affording each person only 70 cubic feet of space. There is a case on record, however, where a room in Leicester, in England, contained six persons with only 51 cubic feet of air space each, and with three gas-lights burning (Reynolds).

The superficial area, or the floor space, allowed to each person should not be less, if possible, than 80 or 90 square feet. This is calculated by multiplying length and breadth measurements. Much greater cubic space and floor area are required in hospitals. Where it is not possible to give so much, as, for example, in schoolrooms, mosques, temples, churches, theatres, buildings for public meetings, and all places in which unhealthy occupations are carried on, but which are not continuously occupied, such as printing presses, shops, godowns, and mills, the very best means of ventilation should be provided. *The best test of the impurity of air is smell.* The amount of fresh air admitted into rooms or buildings should always be sufficient to prevent the smallest trace of smell being perceptible on entering them from the fresh air outside.

Concluding Remarks on Ventilation. Doors, windows, and other openings should be kept open as much as possible day and night. Fresh air is especially needed during sickness. The practice of shutting up doors and windows during sickness in Indian families is very common and exceedingly dangerous. The evil is often increased by the smoke arising from burning logs of wood and lamps, for which, as has been already stated, there is no escape, and by the foul matter from the lungs and bodies of the large number of relatives and friends attending the sick. The rooms, grouped round the courtyards of Indian houses, are often badly ventilated, because they depend entirely on openings in one wall facing the yard. The importance of cross-ventilation cannot be too strongly emphasised.

THE STRUCTURE AND HYGIENE OF THE EYE, EAR, AND NOSE

The Eye.

THE eye or organ of vision acts somewhat like a photographic camera. It is globular in shape, situated in the cavity or orbit of the eye, and protected by the bony walls which surround it. The eye, behind, is connected with the brain by the *optic nerve,* which passes through a small opening in the base of the orbital cavity. The white part of the eye-ball is a thick and hard membrane called the *sclerotic coat.* The small round glassy portion in front is called the *cornea.*

Inside the sclerotic coat and surrounding it is the *choroid coat,* which contains a net-work of fine bloodvessels and nerves. The choroid coat, in its turn, is lined with a black layer called the *retina,* a most sensitive structure on which objects looked at are depicted. The *retina* is connected with the brain by extremely delicate nerve fibres which form the optic nerve. If the optic nerve were cut through our sight would be completely lost. It is really, therefore, the brain that sees and interprets the impressions conveyed to the eye from the outside world. Besides the three layers of the eye, which have been mentioned, there is behind the cornea a circular muscular curtain—the *iris.*

The **pupil** of the eye is in the centre of the iris. In a bright light the pupil becomes small owing to the contrac tion of the iris; whereas in a dim light the iris relaxes and the pupil dilates. The iris acts in a similar way when far and near objects are looked at.

Between the cornea and the iris there is a small cavity—the *anterior* or *front chamber* of the eye, at the back of which is the *crystalline lens.* The anterior chamber contains a watery fluid—the *aqueous humour.* Behind the crystalline lens is a much larger cavity, which contains a clear jelly-like substance—the *vitreous humour.*

These filled-up cavities maintain the eye in its globular form. It is by means of the lens that we are able to see objects at varying distances. The lens refracts or bends the rays of light passing through it so as to make them fall on the retina and produce a picture of the objects looked at.

The **conjunctiva** is a fine delicate membrane which covers the eyeball and lines the eyelids (Fig. 46).

The eye is capable of moving rapidly in every direction by means of small muscles connected with it above, below, and on either side; it is kept moist by a watery secretion which escapes from the *tear glands* placed in the inner corner of the eye, and we all know how well the eye is protected from dust, etc., by the quickly moving eyelids with its eyelashes, and how the eye-brows act as little drains to keep perspiration out of the eye.

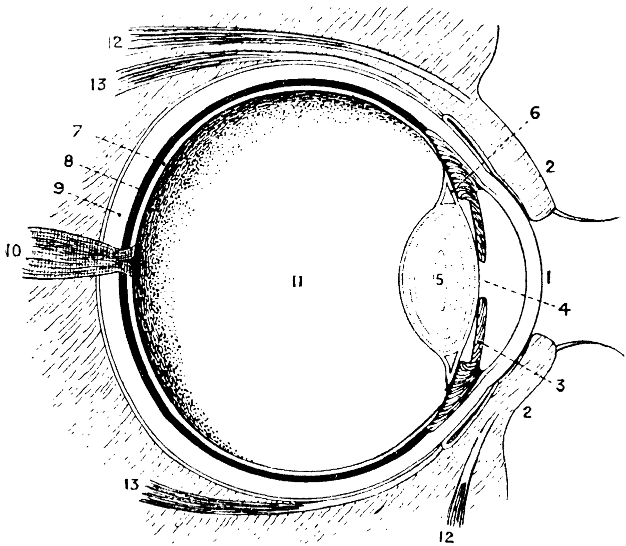


FIG. 46.—VERTICAL SECTION OF THE EYE.

1, Cornea; 2, eyelids; 3, iris; 4, pupil; 5, lens; 6, suspensory ligament of lens; 7, retina; 8, choroid; 9, sclerotic; 10, optic nerve; 11, cavity of eyeball; 12, orbicularis palpebrarum; 13, recti muscles.

Hygiene of the Eye. Good eyesight is most essential to success in life, and the education of young people whose sight is bad is much interfered with. It is through the eye that we are able to appreciate light and colour, and the size, form, motion and position of objects in their relation to one another. Some of the commonest causes of disease of the eye and defective sight are over-use and straining of the eye by reading in a bad light, reading books that are badly printed and printed in too small type and on glazed paper, foreign bodies getting into the eye, draughts of cold air, glare, and the want of proper food and fresh air and general bad health.

Blindness is often caused through disease, such as small-pox, and, frequently, by inflammatory diseases which have been badly treated or entirely neglected.

Any structure of the eye is liable to be affected with disease. Conjunctivitis is about the only one which lay people may at times treat successfully with a weak solution of *boracic lotion*, frequently applied, and perfect cleanliness. But even in such cases it is wise to get medical advice, as cases of conjunctivitis may not be so simple as they may appear to be.

Defective eyesight is obviously a condition which requires special care and attention. Two forms of it occur among young persons—viz., *hypermetropia* (Gr. *hyper*, beyond; *metron*, measure; *ōps*, eye) or long sight, and *myopia* (Gr. *myein*, to close; *ōps*, the eye) or short sight.

In the use of these terms some confusion has arisen.

A long-sighted person—that is, a person with hypermetropia—can clearly identify distant objects, but is unable to distinguish close objects—*e.g.*, print.

A short-sighted person, on the other hand, is unable to see distant objects, but, in most cases, can read print without trouble. Persons with extreme short sight may, however, be unable to read.

The hypermetropic or long-sighted eye is shorter than normal, so that the rays of light coming from an object are focussed behind the retina, and thus fail to produce a distinct image. They produce a blurred image instead.

The myopic or short-sighted eye is elongated or egg-shaped, with the result that the rays of light, coming from an object, fall in front of the retina and produce an indistinct image, and the person has to strain by getting closer to the object in his effort to form a sharply defined image. The short-sighted person may almost close the eyes completely to shut out peripheral rays in order to be able to focus the object. Hence the derivation of the term *myopia*.

Both these forms of defective eyesight produce nervous exhaustion through strain, and may cause squint. In both forms excessive nearwork should be avoided, and suitable spectacles worn to correct the defects.

Defective lighting is the main cause of bad sight in schools. The ill-effects in both long sight and short sight are more or less the same. After reading for a short time the eyes begin to ache, then the head aches, and the person cannot see clearly. If not attended to the eyes become watery and inflamed, and in the morning the eyelids are stuck together. Even sickness and vomiting may be caused by straining the eye too much. If reading is given up the eyes get better, but get bad again when study is recommenced. It is most important that the eyes of school children should be carefully watched, as they often suffer from defective eyesight which is overlooked. Suitable glasses will soon cure the evils of both long-sightedness and short-sightedness.

Note well that in a healthy eye no straining of the eye is required to see properly.

In order to save the eye, the following rules should be observed: Books should not be too large and heavy. The paper should be clean, white and smooth. The letters should be large, well-formed and well-printed. The spaces between the letters and between the words and lines should be relatively wide, and the line should not be too long. The light should be good and enter from the left side. The lessons should not be so long as to exhaust the power of attention. Reading while lying down is bad.

The Ear.

The ear or organ of hearing is subdivided into three portions—viz., the external, middle, and internal ear.

The external ear consists of the pinna or shell-like structure attached to the side of the head, and the auditory meatus or canal, the opening into which is situated at the bottom of a large hollow in the pinna, called the *concha* (Lat. *concha,* a shell).

The auditory meatus is about an inch in length and terminates at a structure called the *drum membrane*, or *membrana tympani* (Gr. *tympanon*, a kettle-drum). The outer third of the meatus is cartilaginous, and has on its surface near the opening small hairs attached to follicles or roots in the skin. There are also minute glands in the skin which secrete a sebaceous or oily substance, and others which secrete *cerumen*, familiarly known as the "wax of the ear." The hairs help to keep insects, dust, the germs of disease and other foreign bodies from getting into the meatus. The secretions keep the skin moist. The inner two-thirds of the meatus is of osseous or bony structure and covered with skin in which there are no hair follicles or glands. The meatus is tortuous in shape, and its bends serve to protect the drum-membrane, to some extent, from injury and cold. The drum-membrane is attached to the floor of the meatus in a slanting direction towards the middle ear, and has near its centre a small concave depression known as the *umbo.* The drum-membrane separates the external ear from the middle ear.

Sounds striking it are transformed into vibratory movements and conducted to the middle ear. The membrane is so highly sensitive, in a normal state, that the feeblest sounds are immediately responded to (Fig. 47).

The middle ear, tympanum, or **tympanic cavity** is only about half an inch in length and depth, and the sixth of an

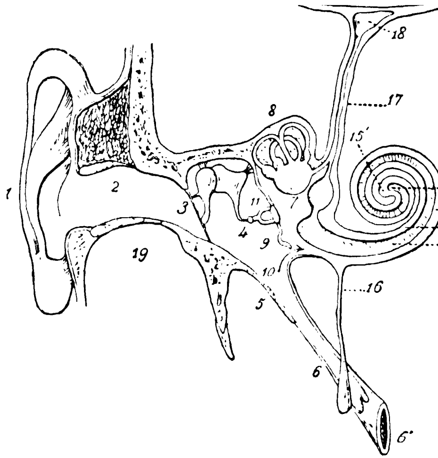


FIG. 47.—DIAGRAM OF THE HUMAN EAR AS A WHOLE. (AFTER DEBIERRE.)

1, Pinna or auricle; 2, external auditory meatus; 3, tympanic membrane; 4, stapes attached to fenestra ovalis (vestibuli); 5, bony portion of Eustachian tube; 6, cartilaginous portion; 6′, its internal orifice; 7, cavity of vestibule filled with perilymph; 8, semi-circular canals with utricle; 9, promontory; 10, fenestra rotunda (cochleæ) with arrow indicating tympanic orifice of cochlea; 11, tympanic cavity filled with air; 12, cochlear canal filled with endolymph, united to sacculus vestibuli by small canal; 13, scala vestibula; 14, scala tympani terminating in fenestra rotunda; 15, apex of cochlear canal, where the two scalæ unite at 15′; 16, cochlear aqueduct; 17, vestibular aqueduct; 18, endolymphatic sac; 19, parotid region.

inch in width at its ends, and even less than that in the middle. Although of such minute size the cavity contains the following structures:

(*a*) Three small bones—the *malleus* or hammer bone, the *incus* or anvil bone, and the *stapes* or stirrup bone. They are so called from their shape.

(*b*) Two small muscles—the tensor tympani and stapedius.

(*c*) Ligaments and other membranous structures which connect the bones and hold them in position.

(*d*) Nerve branches and bloodvessels.

There are also three openings in the cavity. One forms the entrance to the Eustachian tube which communicates with the pharynx at the back of the nose. Another, called the *fenestra ovalis* (Lat. *fenestra*, a window), which has a membranous covering over it, communicates with the internal ear. This opening is oval in shape. The third opening is also enclosed, and because it is round in shape it is called the *fenestra rotunda*. It also communicates with the internal ear, and is intimately associated with the cochlear portion of it (Fig. 47).

Description of the Structures in the Middle Ear.—The malleus has a head, neck, and handle, and two small projections. The head is rounded and articulates with the incus. The articulating surfaces of these two bones are provided with an arrangement of catch-teeth structures which dovetail and enable them to move together or separate as occasion may render necessary. They separate, for example, when air is forcibly driven into the middle ear when blowing the nose, or when, as is sometimes done, air is purposely blown into the Eustachian tube in certain affections of the ear accompanied with deafness. If the bones were not separable the traction on them and the stirrup bone, which are all connected together and with the covering over the fenestra ovalis, would cause serious damage to both the middle and internal ear. The handle of the malleus is attached to the drum-membrane and thus establishes contact with the outer ear.

The incus has a body with which the head of the malleus articulates, and one long and one short process.

The stapes or stirrup bone has a head, neck, two *crura* or legs, and a foot-plate. The legs join the head and the foot-plate together. The head articulates with a small knob at the end of the long process of the anvil bone. The foot-plate is attached to the membrane covering the fenestra ovalis. The purpose which the three bones serve is to convey the sound vibratory movements of the drum-membrane to the internal ear in which the receptive sensory nerve organs of hearing are located. Despite the complexity of the structure and arrangement of these three diminutive bones in such a small cavity, they are so securely fixed that they enjoy the greatest freedom of movement.

The Eustachian tube is about an inch and a half in length. It extends from its opening in the middle ear to its opening in the pharynx. It is cartilaginous in structure, near the middle ear, for about an inch of its length. The rest of its length is of osseous structure. Air passes through it from the pharynx into the middle ear, and in normal circumstances the air pressure on both sides of the drum-membrane is equal. In some diseases of the pharynx, such as adenoids, the entrance of air into the tube is obstructed, or the tube itself may become obstructed by catarrhal or other inflammatory ailments. The air pressure in the middle ear is thus lessened, and, owing to the unequal pressure on the two sides of the drum-membrane, hearing is impaired. Adenoids are frequently the cause of deafness in children. The same effect may be produced by the accumulation of wax in the meatus of the external ear or by putting oil, cotton-wool, or a finger into the meatus, and in many other ways.

The tensor tympani muscle, as its name implies, increases the tension of the tympanic or drum-membrane. This is induced when the muscle contracts.

The stapedius muscle, by contracting, pulls on the stirrup bone and the membrane covering the opening leading into the inner ear to which it is attached. The purpose of this muscle is not quite understood. The following views on the point have been expressed:

1. That when the muscle contracts it pulls on the stirrup bone and increases the tension of the membrane to which it is fixed and thus renders it less liable to be injured or ruptured by violent movements caused by loud explosive sounds (Müller).

2. That the muscle, by contracting, protects the ear from intense and disagreeable noises by lessening the responsiveness of the membrane.

3. That the contractions of the muscle adjust the membrane to the better reception of sound vibrations, and are used, therefore, in attentive listening (Mack).

4. That the muscles are kept constantly in play by sounds or sudden variations in the intensity of sounds, and that the effort experienced in listening intently to sounds is also due to the contraction of the muscles (Hensen).

The internal ear or labyrinth consists of tortuous cavities in the petrous portion of the temporal bone, which is of dense and hard structure (Gr. *petra*, a rock). It is subdivided into an *osseous* and a *membranous* labyrinth, the latter being within the former and constituting a replica or counterpart of it.

The osseous labyrinth contains a clear fluid called *perilymph.* The membranous labyrinth contains *endolymph.* These fluids have no communication with each other directly, and each has its own special function to perform.

The osseous labyrinth is composed of three bony structures —viz., the vestibule, semicircular canals, and cochlea. They are lined with a thin fibrous covering called periosteum

(Gr. *peri*, around; *osteon*, a bone), which adheres closely to the bones and gives them a smooth surface.

The membranous labyrinth forms a replica of all three bones.

The vestibule (Fig. 47) is an oval-shaped cavity. Its greatest measurement is about one-fifth of an inch and its smallest is only about one-eighth of an inch. The vestibule is so called because it forms the approach or entrance to the cochlea and is situated between the cochlea and the semicircular canals. It is separated from the tympanum or middle ear by a bony partition in which are the two openings—fenestra ovalis and fenestra rotunda—already mentioned. The inner wall, at its upper part, has a small hollow with several perforations or openings through which fine branches of the *vestibular nerve*—a branch of the auditory nerve—pass to a dilated oval structure, situated above the hollow, known as the *saccule.* Other fine branches are distributed to a more largely dilated structure called the *utricle*, which is situated close to the saccule but separated from it by a short and narrow canal. The vestibular nerve also gives off branches which supply the membranous semicircular canals which open into the utricle. These canals, the utricle and the saccule, contain endolymph and form a channel which is continuous with one in the cochlea, which will be described further on.

The semicircular canals are three in number and about one-third of an inch in diameter, except at the ends of three of their five openings into the utricle, which are dilated. The dilated portions are called ampullæ because of their shape (Lat. *ampulla*, a flask). One of the canals is placed horizontally. The other two are vertical. The ampullæ contain specialised sense organs provided with hair cells in which the fine fibres from the vestibular nerve end. The hairs attached to the cells project into the canals. It may conveniently be stated in this connection that the utricle and saccule contain somewhat similar sensory hair cells, among which are found small crystals of carbonate of calcium known as *otoliths*, or ear-stones (Gr. *ōtos*, ear; *lithos*, stone). There are no otoliths in the ampullary sense organs. It has been thought the otoliths act as a mechanical stimulant to the ciliary nerve endings in the utricle and saccule.

The functions of the membranous semicircular canals, the utricle and vestibule, are intimately associated with the maintenance of the body in the erect position, and for this reason the semicircular canals and the vestibule are sometimes spoken of as the *static labyrinth*. "The semicircular canals are believed to play an important part in the regulation or co-ordination of the movements of equilibrium and locomotion. The generally accepted view is that this is due to the effect of variations in the pressure of the *endolymph* in the canals on the hair cells of the sense organs in the ampullæ. And because the utricle and saccule in the vestibule have direct communication with the semicircular canals, it is believed that they give information regarding the position of the head when at rest and when making *non-rotary* movements, and in this way supplement the functions of the semicircular canals on the supposition that they act especially in movements of rotation" (Howell).

It is known that injuries to the semicircular canals produce rotatory movements of the head and eyes, and that in certain affections of the canals vertigo or giddiness, with a tendency to fall or rotate the head, may be a prominent feature. In some instances surrounding objects appear to sufferers as though they were revolving round them.

"Perception or ideas of space and direction are based on semicircular canal sensations and partly on muscle sense and visual and eye sensations" (Howell).

The cochlea (Gr. *kochlias*, a snail) is so called from its resemblance to a snail's shell. It is conical in shape and measures about one-sixth of an inch from base to apex. It is about one-third of an inch in breadth at the base, but gradually gets less to its termination at the apex which forms the dome or roof of the cochlea. The inner concavity of the dome is called the *cupola* (Lat. *cupa*, a cup).

The cochlea consists of the following structures:

1. *A modiolus* or central pillar, thick at the base and tapering at the apex. It has a main central passage and numerous other passages running through it, all of which communicate and through which fine branches of the cochlear nerve, one of the branches of the auditory nerve, pass on their way to the end-organ of hearing (organ of Corti), which will be described presently.

2. *A lamina* or thin plate of bone attached to the pillar, in its entire length, and coiling round it two and a half times from base to apex, forming what is called the *spiral cavity* and the outer wall of the cochlea at the same time.

3. *A second lamina* of bone projecting from the modiolus into the spiral cavity for a short distance only. This is called the *lamina spiralis ossea* or bony spiral lamina, to the free end of which are attached two membranous structures —viz., the *basilar membrane* and the *vestibular membrane*. These two membranes diverge from each other from their point of attachment to the bony spiral lamina to the outer wall of the cochlea, to which they are also attached. A triangular space is thus formed and runs in spiral form along the outer wall of the cochlea. Because the space is entirely membranous in structure it is called at times the *membranous cochlea*. It is also sometimes called the *cochlear duct* or *canal*. And because it lies between two other passages in the cochlea, which remain to be described, it is at times called the *scala media*. The membranous cochlea, it should

be noted, contains *endolymph*. It should be noted also that it ends blindly at the apex of the cochlea, and has no communication with the two other passages in the cochlea. At its lower end or base the duct communicates, through a small canal, with the endolymph in the saccule, utricle, and membranous semicircular canals, which have already been described (see 12, Fig. 47).

We will now proceed to consider the two other passages in the cochlea referred to above.

By the union of the bony spiral lamina, which projects from the central pillar a short distance into the spiral cavity, and the basilar membrane, the spiral cavity is divided into an upper and a lower complete passage. Each of these passages, so to speak, forms a spiral staircase, the Latin word for which is *scala*. The upper passage is called the *scala vestibuli* because it communicates with the vestibule of the inner ear (see 13, Fig. 47). The lower passage is called the *scala tympani* because it is connected with the tympanum or middle ear (see 10 and 14, Fig. 47).

Both of these passages contain *perilymph* and communicate with each other at the apex of the cochlea, the point of communication being called the *helicotrema* (Gr. *helix*, spiral; *trema*, a hole). The perilymph in these passages, it should be noted, is continuous with the perilymph throughout the rest of the *osseous labyrinth*.

4. *Organ of Corti* (Fig. 48). This is the essential organ of hearing. It is situated on the basilar membrane and extends throughout the whole length of the cochlea. Its structure consists of an inner and outer row of firm cellular structures called the *rods of Corti*, which lean against each other and form, with the basilar membrane as its base, what is known as the *tunnel of Corti*. "The arrangement of the rods has been likened to the keyboard of the pianoforte" (Gray). The inner row contains about 6,000 rods and the

outer about 4,000. On the inner side of the inner rods is a row of what are known as *inner hair cells*, each surmounted with a brush of fine, stiff, hair-like processes. On the outer side of the outer rod there are three or four successive rows of cells, of similar structure but longer, called *outer hair cells*. "The inner hair cells are about 3,500 in number, and the outer about 12,000. The middle layer of the basilar membrane consists of fibres, running radially, which, though united to one another, are sufficiently independent to be regarded as separate strings" (Howell). The whole structure,

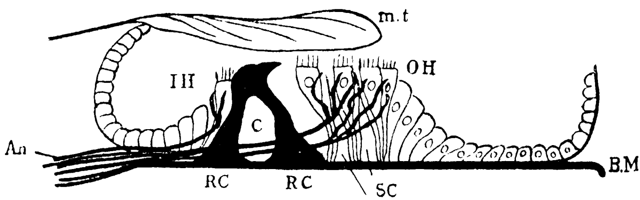


FIG. 48.—SECTION THROUGH THE END-ORGAN OF THE AUDITORY NERVE IN THE COCHLEA (ORGAN OF CORTI).

B.M., Basilar membrane; *C.*, canal of Corti; *R.C.*, rods of Corti; *I.H.* and *O.H.*, inner and outer hair-cells; *S.C.*, sustentacular cells; *An*, auditory nerve; *m.t.*, membrana tectoria.

(*From Starling's "Elements of Human Physiology."*)

according to Howell, is estimated to contain about 24,000 strings varying gradually in length from the base to the apex of the cochlea, where they are longest, and resembling in general arrangement the strings of a piano. The basilar membrane is regarded as the resonating apparatus of Corti's organ.

5. The cochlear aqueduct (see 10 and 16, Fig. 47) opens from the scala tympani near the fenestra rotunda, and communicates with the *subarachnoid space*, situated between two of the coverings of the brain, which is filled with cerebral fluid.

The physiological basis of the sense of hearing is discussed under the heading "The Nervous System" (p. 236).

Hygiene of the Ear. We have seen how delicately the ear is constructed. It is for this reason easily injured. Diseases of the ear are extremely common, and when not properly treated are apt to cause defective hearing and even deafness. To be deaf is perhaps almost as great an affliction as to be blind. Deaf people have great difficulty in getting employment of any kind. The causes of deafness are colds in the head, cold air, exposure to wet, damp feet, chills after exercise, obstructed nostrils, and enlarged tonsils and wax in the ear. Deaf people often become dull and stupid-looking. Children who suffer from deafness have a delicate look, keep their mouth open, their jaws are badly formed and their teeth are all jammed together.

Colds in the head and bad throats often lead to inflammation of the middle ear. Bad teeth often cause severe pains in the ear. The drum-membrane of the ear has often been ruptured by loud noises, blows on the ear, and by diving into water. If it is ruptured, foreign matter is apt to get into the middle ear and set up inflammation and abscess. The use of pins or other instruments for removing wax from the ear is a dangerous practice, and should be avoided, and on no account should the ears be subjected to blows of any kind. Diseases of the ear should be attended to without delay. (See also observations on "foreign bodies in the ear," p. 128.)

The Nose.

THE nose, or organ of smell, has two openings—the *nares* or nostrils—and two cavities or nasal passages which communicate, in a straight direction, with the back of the throat through two openings called the posterior nares. A thin plate of bone called the *vomer* forms a septum or partition between the nostrils. The roof of the mouth forms the floor of the nasal passages, and the *ethmoid* bone, which is one of the bones of the base of the skull, forms the roof.

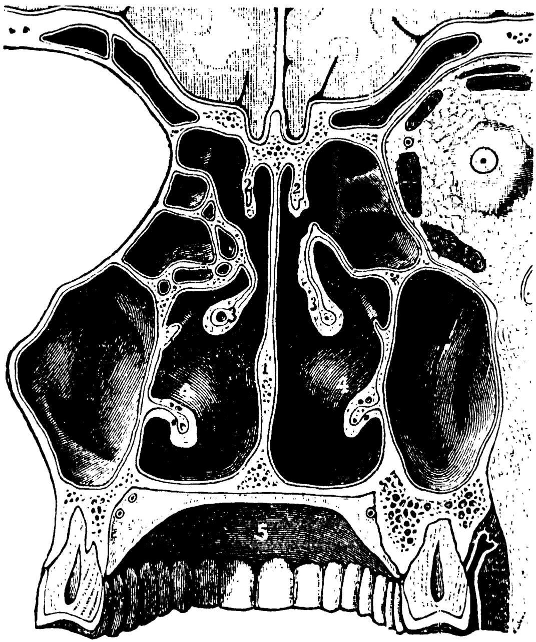


FIG. 49.—FRONTAL SECTION OF NASAL FOSSÆ, SEEN FROM BEHIND (THE SECTION PASSES THROUGH THE BACK MOLARS). (AFTER LUCIANI.)

1, Nasal septum; 2, upper; 3, middle; 4, lower turbinals; 5, vault of palate.

"Ethmoid" means sieve-like. The bone has numerous minute openings through which fine branches of the *olfactory* nerve or nerve of smell pass to the nerve end-organ in the upper part of the nose. The sense of smell is described more fully elsewhere (see p. 258). Each nasal passage contains three thin, irregularly shaped bones attached to the outer wall at its upper part. They project inwards and overhang the lower part of the passages. Because of their spiral shape they are called *turbinated* bones (Lat. *turbo, turbinis*, a whirl) (Fig. 49).

The nasal passages, at the back of the nose, open into

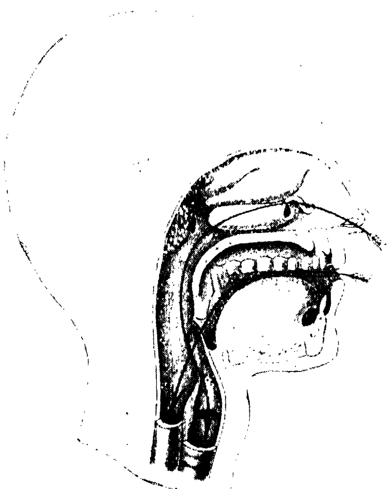


FIG. 50.—THE UPPER PARTS OF THE AIR PATH AND THE FOOD PATH. An adenoid growth is shown in the hinder part of the nasal chamber.

the pharynx. This part of the respiratory tract is called the *naso-pharynx*. It is in this situation that adenoids form and cause nasal obstruction and mouth-breathing. The Eustachian tube, described in the discussion of the ear, opens into the naso-pharynx (Fig. 50).

Hygiene of the Nose. The air, as it passes through the nose on its way to the lung, is heated by the blood contained in the rich supply of bloodvessels in the lower part of the nasal passages, which is the real breathing part of the nose, the upper portion being mainly concerned with the smell-sense.

Dust and other fine substances and the germs of disease are prevented, by the moist lining membrane of the nose and the tufts of hair-like structures in the nasal passages, from passing through the nose. The air passing to the lungs is thus filtered and purified. The importance of keeping the nasal passages clean, by simple disinfecting nasal douches, at all times, but more especially during the prevalence of epidemic infectious diseases, will thus be apparent. So sensitive is the lining membrane of the nasal passages that the slightest irritation produces violent sneezing. In this way dust and other foreign substances are forced out. Picking the nose is an objectionable and dangerous habit, which is very common among both children and adults. Septic diseases of the nose are often caused in this way through injury to the lining of the nose by dirty finger-nails. Such a practice should be avoided, and its dangers should be pointed out to children.

Blowing the Nose. The correct way to blow the nose is to blow one nasal passage at a time by closing the other with a finger. The closure of both nostrils increases the normal pressure of the air in the middle ear, and this, during violent blowing of the nose, may injure the minute structures in both the middle and inner ear. Blowing the nose in the manner described, and at the same time keeping the mouth closed, may help to remove small foreign bodies in the nasal passages.

TREATMENT OF MINOR AILMENTS AND ACCIDENTS

Minor Ailments.

Ringworm of the Body (Fig. 51). This disease is known under various Indian and English names. Moore gives the following: "Dad, dadru, majee's dad, denaii, dhobi's itch, washerman's itch, Malabar itch, and Burmese ringworm." The disease is caused by a vegetable parasite.

Treatment.—Moore recommends Goa powder mixed with lime juice or vinegar to form a paste, which should be well rubbed into the part at night for several nights in succession. The diseased part is thus bleached white, while the surrounding healthy skin assumes a deep, brownish-red colour, and becomes very tender. The redness and tenderness soon disappear when the treatment is stopped. When this powder is used old underclothing should be worn, as the drug stains clothing badly. Iodine is also useful, and may be applied with a feather daily till the skin becomes

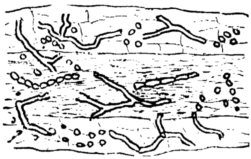


FIG. 51.—RINGWORM FUNGUS IN HAIR.

very tender or until blisters form. Strong carbolic acid solution of 10 grains to the ounce of water applied with a brush may also be tried. A very good remedy is whisky or country liquor. This may be rubbed into the diseased parts with a piece of rag until the skin almost begins to bleed. This is sufficient at times to cure the disease, The application of Goa powder afterwards, however, will make a cure more certain. Mercurial ointment has also been tried. Goa powder or medicines derived from it are, however, best of all.

Itch (Fig. 52). This is a disease which is to be found chiefly between the fingers and toes. It may also, however, attack the hips, wrists, and other parts of the body. It is caused by a small insect which burrows under the skin, where it lays its eggs, and where the young insects are hatched. Like ringworm, it causes intense itching. The disease is spread from one part of the skin to another by this means, and it is also conveyed from person to person by direct contact, as in shaking hands. The little tunnels under the skin, and the spot where the eggs are deposited, can be seen with the naked eye. In bad cases of the disease painful sores may form, and the whole of the toes and fingers may become one mass of scabs.

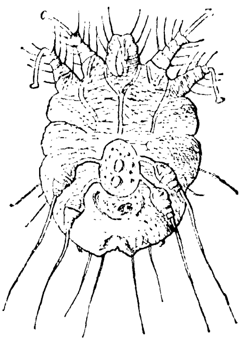


FIG. 52.—THE ITCH INSECT.

Treatment.—The best remedy is sulphur, which kills the insect and thus cures the disease. It should be applied at night to the parts affected; or, if the disease has spread extensively, it may be necessary to apply the sulphur to every part of the skin from the neck to the toes. A hot bath should be taken before doing so. One ounce of sulphur in powder mixed with 4 ounces of ghee makes a good ointment for the treatment of itch. It should be applied every night for three or four nights. No clothing which has been worn by the sufferer should be again used after the disease is cured until it has been thoroughly boiled.

Lice (Fig. 53) are too well known to need description. They are found chiefly in the head, but also in other parts of the body. They cause great irritation, and often severe inflammation of the affected parts. The animals themselves are easily killed, but their eggs, which stick to the hair, are very difficult to destroy.

Treatment.—Mercury ointment and carbolic acid are the best remedies. These may be obtained at a chemist's shop or charitable dispensary. Cyllin in a solution of ½ ounce to a gallon of water is said to prove most efficacious

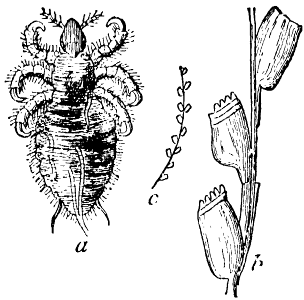


FIG. 53.
a, The head louse; *b*, nits on hair (magnified); *c*, same (nat. size).

in getting rid of lice. After washing the head thoroughly with soap and water, half a pint or so of this solution is well rubbed into the hair and scalp. The use of combs helps to get rid of the insects and their eggs. Cleanliness is the best means of prevention.

Round Worms (Fig. 54). Round worms, which closely resemble earthworms in appearance, are very common among those who are careless in their habits and indifferent as to what they eat or drink. They may be a foot in length, and often exist in very large numbers in the human system. They inhabit, chiefly, the small intestine. They are sometimes vomited or may escape in the discharges from the bowels. They are supposed to get into the system in drinking water. The disease has been known to prevail in India in almost epidemic form, Europeans and Indians alike suffering.

Treatment.—Round worms may be got rid of by clearing out the bowels as carefully as possible with a dose of castor

FIG. 54.—THE ROUND WORM.

oil and taking 4 or 5 grains of santonin powder early in the morning before taking any food. Children, of course, do not require such big doses of santonin.

Thread Worms (Fig. 55). Thread worms are small white worms which occupy the lower part of the bowel where they cause intense itching. They may exist in thousands. Children are the most common sufferers.

FIG. 55.—THE THREAD WORM.

Treatment.—A teaspoonful of common salt in a quarter of a pint of tepid water injected into the bowel is a useful and simple remedy. The bowel should be made to empty itself before using the injection.

Tape Worms (Fig. 56). Tape worm is not a very common ailment in India. It is caused by eating diseased and under-cooked meat such as pork.

Treatment.—The proper treatment for tape worms is to first thoroughly empty the bowel with castor oil and then take a dose of the extract of male fern on an empty stomach. Those who suffer from worms of any kind should consult a doctor, or, if poor, go to a charitable dispensary for advice and treatment.

Fainting. Fainting is due to weakness and sudden failure of the action of the heart. The patient becomes pale, a cold sweat breaks out on the face, the pulse becomes weak and fast, and vomiting may take place. The attack

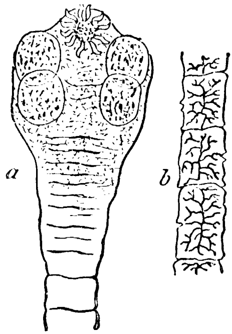


FIG. 56.—THE TAPE WORM.
a, Its head (magnified); *b*, joints (natural size).

does not last long. Sudden severe pain, such as is caused by a severe sprain, often causes fainting.

Treatment.—Pure fresh air is the best remedy. The patient's feet should be raised, and, if the fainting takes place while the person is sitting, the head should be bent forward between the knees. The dress worn at the time should be loosened, cold water may be applied to the face, smelling salts to the nose, and a little brandy, sal volatile, or other stimulant may be given.

Epilepsy, although at times serious, is an ailment in which first aid can at least be given, and may therefore justifiably be included in the category of ailments now being considered.

Suddenly, without warning at times, persons who suffer from this disease give a shriek and fall to the ground. It has for this reason been called "falling sickness." They froth at the mouth, and if the tongue is bitten, as it often is during attacks, the froth may be stained with blood. The face turns blue. The muscles of the body are at first rigid or stiff, and then become convulsed. The patient is unconscious, and knows nothing about what is going on around. Breathing is noisy. Children, when getting their teeth, or suffering from worms, often get fits of this kind called convulsions, which resemble epilepsy.

Treatment.—The clothing of the patient should be loosened, especially about the neck, so as to make the breathing easier. A piece of cork or wood should be put between the teeth to protect the tongue. The patient should be put on his back. It does no good to throw cold water on the face or give anything to drink. The attack will soon pass off if the patient is kept quiet and allowed plenty of fresh air. When children get fits of the kind referred to above a hot mustard bath and application of cold to the head is the best treatment.

Diarrhœa. Diarrhœa is looseness of the bowel. The most common causes of diarrhœa are bad food, tainted fish and meat, unripe or overripe fruit, uncooked or badly cooked vegetables, polluted water, impure air, and chills. Malaria often causes diarrhœa, and is one of the chief symptoms in cholera and enteric fever.

Treatment.—This depends on the cause. If it is caused by eating bad food, the patient may be made to vomit and a dose of castor oil given with benefit. In food poisoning a saline purgative, such as Epsom salts, should be given.

This quickly gets rid of some of the poison, if not all. If it is due to any other cause, such as a chill, opium or chlorodyne may prove useful remedies. Laudanum is the best form in which to give opium. It should be given with great care, and more especially in the case of infants. It is sometimes better to give no food for some hours, and to restrict the patient to sips of cold water if there should be vomiting. On signs of recovery the diet should consist of milk, rice, arrowroot, or bread and milk, given in small quantities often. The patient should be kept lying down. The entire body, but especially the belly, should be kept warm. A flannel bandage or kummerbund is useful for this purpose. When cholera is prevalent, diarrhœa should be attended to at once.

Minor Accidents.

Foreign Bodies in the Eye. Foreign bodies in the eye, such as flies, dust, particles of charcoal and so forth, can be best removed with the corner of a handkerchief, or clean lukewarm water may be allowed to flow into the eye. A drop of sweet oil is useful when anything burns the eye. The eye is a very delicate and sensitive organ, and, with the exception of simple cases such as those mentioned above, all cases should be treated by a doctor who has made it an object of special and careful study.

Foreign Bodies in the Ear and Nose. Children often put small objects, such as slate pencil, peas, beads and the stones of fruit into their ears and nostrils, where they sometimes remain for years. Peas have been known to sprout in a child's nose. Insects may find their way into the ear and give rise to much alarm. Rough treatment might push the foreign body further into the ear or nose, or severe bleeding from the nose might take place. The ear is still more delicate, and attempts to remove foreign bodies might injure the drum-membrane of the ear or set up severe inflammation. Careful syringing with lukewarm water is the best way to remove foreign bodies from the ear. The syringe should be pointed slightly upwards towards the top of the patient's head, and the outer ear pulled backwards and downwards to open up the canal. A drop or two of any kind of sweet oil poured into the ear will prevent insects moving about in the ear and they can be syringed out of it. Foreign bodies are sometimes easily removed from the nose. It is always safest and wisest, however, to get a doctor to remove them.

Foreign Bodies in the Throat. Foreign bodies in the throat of a child may be removed by holding the patient up by the heels and tapping the back sharply. The inside of the throat may be tickled to induce vomiting, and in this way the foreign body may be dislodged and got rid of.

Sometimes the foreign body, such as a fish bone, can be seen and easily removed with the fingers. Even when not seen the foreign body may be within the reach of the fingers, and in this way can sometimes be removed.

In cases where the life of the patient is endangered no time should be lost in sending for medical or surgical aid.

Burns and Scalds. Burns are caused by dry heat, such as a hot iron. Scalds are caused by moist heat, such as steam or boiling water. Injuries of this kind are very dangerous, more especially in the case of old persons and children. The larger and deeper the injury the greater the danger. Death from shock often follows severe burns and scalds. The patients sometimes die from diseases of internal organs following such injuries.

Treatment.—First remove the object that may be causing the burn or scald, or remove the patient. If the clothes are on fire the patient should be made to lie down, and covered with a blanket or other thick covering, to put out the *flames. Water is also useful, and in the case of oil flames, sand.*

The burn or scald should be immediately covered up with cotton-wool, or a thick layer of rags dipped in carron oil to keep out the air. Carron oil is made of equal parts of linseed oil and lime water. If no linseed oil is at hand, olive oil may be used instead. The wool or rags will stick to the burned or scalded part unless kept well soaked with the oil. Oil is also useful in helping to remove any of the clothing that may be sticking to the part. After the first two days or so, carbolic oil will be found useful in treating the affected part. If the patient suffers from faintness, stimulants should be given and the feet kept warm.

Bruises are accompanied by swelling, blueness of the injured part, and pain. The blueness is caused by the rupture of some of the small bloodvessels, and the escape of blood therefrom into the surrounding parts.

Treatment.—Rest and the application of cold at first, and warmth afterwards, is the proper treatment. The part should be raised.

Sprains. The joints are the seat of injury in sprains. They are caused by the sudden twisting and tearing or rupture of the ligaments which support the joints. Swelling takes place all round the joint.

Treatment.—Rest, pressure with a firm bandage, and heat are the best form of treatment at first. If the swelling and pain continue to increase, the pressure should be removed. When the pain and swelling begin to pass away oil or some liniment should be applied, and the part well rubbed with the hand. Gentle movement of the joint is good at this stage, for if the joint is kept at rest too long it will become stiff.

Stings. The stings of wasps and other insects can best be treated by applying a strong solution of ammonia to the part. This stops the itching caused by formic acid, which is introduced into the skin through the sting. Soap is sometimes used. It should be applied to the part freely. Glycerine and oil are also useful. If the sting is left in the skin, it should be removed. The stings of some of these small animals, such as wasps, if numerous, may be dangerous to the life of the patient. If the symptoms are severe, it may be necessary to give the patient stimulants.

Dog Bites. These may be trivial in nature or serious. In ordinary cases the wound should be thoroughly cleaned, freely treated with iodine, or by applying some caustic. If there should be the slightest suspicion that the dog that has inflicted the wound is suffering from rabies (hydrophobia), the injuries should be cauterised with a hot wire and arrangements made to proceed as soon as possible to a Pasteur Institute for anti-rabic treatment.

The above observations apply to bites of any rabid animals.

Snake Bites. Some snake bites are harmless. Others are deadly poisonous. If there is any doubt on the point the best thing to do is to treat the bite as a poisonous one. A piece of string should be tied firmly above the seat of the bite, and other pieces at short distances one above the other. The ligatures should not be kept on too long, or, as was said when dealing with bleeding, the part will die. If there is no wound about the lips or inside the mouth, the wound may be sucked. The mouth and lips should afterwards be well washed and disinfected. Bleeding from the part which is bitten should be encouraged. Wounds may be made with a small knife to cause free bleeding and permanganate of potassium powder should be well rubbed into the wound. The bitten part may be, and sometimes is, cut out. Fingers even have been amputated. The wound may be burnt with a hot iron, or some strong acid such as nitric or carbolic acid may be applied. Ammonia in the form of sal volatile should be given freely as a stimulant. Brandy is also good in cases of this kind. The use of what is called anti-venom serum has been attended with good results in many cases of snake bite. In snake bites, as in other serious cases, a doctor should be called in to treat the patient.

THE TEMPERATURE OF THE BODY AND ITS REGULATION

THE normal temperature of the body is about 98·4 degrees Fahrenheit, and in a state of health is the same and remains constant irrespective of climatic or other conditions. Heat is being constantly produced in the body by the oxidation of foodstuffs. Muscular activity is its chief source, the liver being second in importance. All the organs of the body, however, in performing their various functions, produce heat. If provision were not made for getting rid of some of the excess heat produced at times, the temperature of the body would not be able to be maintained at its normal level.

"A nerve centre for the regulation of temperature is said to exist in a part of the brain called the *corpus striatum*, and the rise of temperature which occurs during fevers is attributed to the stimulation of the centre by the toxic products of the infectious process" (Roberts).

Regulation of the temperature is affected by loss of heat by (*a*) radiation, (*b*) conduction, (*c*) evaporation of sweat from the skin and watery vapour from the lungs, (*d*) the discharges from the body, (*e*) cold, and (*f*) by heat indirectly.

Radiation is the passage of heat from the body through the air to its surroundings. If a person sits too long in a cold room the hands and feet get cold, and shivering occurs.

This indicates that the loss of heat by radiation is too great.

Conduction is the transmission of heat by a conductor. Some articles get hot more quickly than others. That is to say, they are better conductors of heat than articles which take a longer time to get hot. Iron, for example, gets hot more quickly than wood and is therefore a better conductor of heat than wood. Cotton conducts heat readily, and for this reason clothing made of cotton material is made use of in hot countries to keep the body cool. Fur, wool and silk, on the other hand, are non-conductors of heat, and clothing made of such materials are worn in cold countries to keep the body warm. They are often worn when they should not be, and their wearers get uncomfortably warm and feel fatigued in consequence.

Evaporation. During hard work or exercise involving great muscular exertion the bloodvessels of the skin become dilated, more blood passes through them, and the circulation is more rapid and less heat is radiated. The skin in consequence becomes hotter. The sweat glands are stimulated to greater activity, and sweat is exuded through the pores of the skin in large amount. By the evaporation of the sweat loss of heat takes place. If this did not happen the temperature of the body would rise. Sudden cooling of the skin after hard work or exercise is dangerous. The blood in the heated skin may be driven inwardly and cause congestion of the lungs or other organs. And as air in motion causes rapid evaporation of sweat sitting in a draught when the skin is hot and perspiring freely should be avoided.

Heat. Sponging the body with hot water is sometimes used to reduce temperature in cases of illness. The application of warmth to the skin dilates the bloodvessels in the same way as exercise does. Loss of heat by radiation follows, and the temperature may be reduced a degree or more and make the patient feel better.

Cold, even in the form of ice packs, may be used, when the temperature of the body rises dangerously high, with the object of effecting loss of heat as quickly as possible. The danger of continued high temperature is failure of the heart owing to paralysis of the nerve centre which regulates its action.

EXERCISE, RECREATION, REST AND SLEEP

EXERCISE is essential to the maintenance of the body in an active and healthy state. Besides increasing the size and strength of the muscles, it promotes the activity of the functions of all the bodily organs. The action of the heart is quickened, more blood passes through the lungs than at ordinary times, and more air and, consequently, more oxygen are inhaled, and more carbonic acid gas and other impurities from the blood are exhaled. More blood also circulates through the skin, as is indicated by the profuse perspiration which takes place during exercise, and waste products in large amount escape in the sweat. Besides purifying the blood, well-regulated exercise increases the muscular tone of the heart, improves the appetite, promotes digestion, and prevents constipation. The mental faculties, moreover, are strengthened by the improved quality of the blood supplied to the brain.

Forms of Exercise. The forms of exercise are numerous. We should select whichever form suits us best, whether it be riding, gymnastics, bicycling, walking, cricket, tennis, football, hockey, golf, rowing, the use of dumb-bells, or wrestling.

The forms of exercise taken should vary so that all the muscles of the body may be kept in good condition.

The painful feeling in muscles which are brought into action after prolonged rest and inactivity is due to wasting and weakness of the muscular tissue owing to disuse. Exercise, such as rowing, brings the abdominal muscles into action and increases their strength. They are thus enabled to support the internal organs and render greater help in the emptying of the bowel. *Deep-breathing exercises* develop the muscles of the chest and help to keep the spine straight. *Swimming* involves the use of most of the muscles of the body and quickens breathing and the action of the heart. *Lawn tennis* not only causes quickness and accuracy of movement but improves judgment, and has thus a good mental effect as well as a physical one. *Football, cricket* and *hockey* are considered to be the best forms of exercise for children. The most convenient form of exercise, however, and the one which most people perhaps prefer, is *walking*. Than a quick walk, no form of exercise is more health-giving. In ordinary breathing 480 cubic inches of air are taken into the lungs every minute. During walking at the rate of four miles per hour, 2,400 cubic inches are inhaled per minute, and at the rate of six miles per hour the amount of air inhaled is 3,360 cubic inches per minute. When walking the head should be kept erect, the shoulders well back, the abdominal muscles retracted, and the hips allowed freedom of movement. And the habit of breathing deeply while walking should be cultivated.

It is supposed that a walk of nine miles daily is sufficient for a man whose duties during the day are of a sedentary nature (Parkes). *Gymnastics* and other forms of exercise which involve intricate and skilled muscular movements can only be learned by instruction and experience.

Rules as to Exercise. Exercise should be taken daily, and preferably in the open air, or, during wet weather, in an open shed with a roof over it. Simple forms of exercise which call the muscles of the chest and abdomen into action can be taken indoors with the windows open. Exercise should never be excessive. Gasping for breath and sighing are due to the engorgement of the lungs owing to excessive exercise, and indicate that rest is required. Tight clothing of any kind should not be worn while taking exercise as it interferes with the free movements of the chest and abdomen. Alcoholic drinks during exercise are contra-indicated. Water may be taken, however, in small quantities at short intervals, but never in large amount when exercise is finished. Small pieces of ice, when sucked, or the juice of a lemon are refreshing and safe. Fatty food is of great benefit to those who take much exercise.

Dr. John Campbell, of the New Health Society, London, who is an authority on the subject, has stated that in his experience there is nothing better than honey as a heart and muscle stimulant, and a source of energy in training for sports and athletics, and that there is no better food for muscular fatigue. He advises its use as follows:

Training.—2 ounces daily spread over the day's diet.

Sprint.—½ to 1 ounce twenty minutes before the start. The same routine for the quarter and half mile.

Rowing.—1 to 2 ounces thirty minutes before the start.

Football.—1 to 2 ounces thirty minutes before the start, and honey and lemon at intervals.

Boxing.—1 to 2 ounces thirty minutes before start. If muscular exhaustion shows, a tablespoonful at such intervals as may be deemed expedient.

Long-Distance Cycling.—Honey whenever nutriment is taken and on the road. Protein is required in a digestible form as well in long-distance events.

Walking.—Honey at regular intervals on the road.

Dr. Campbell says that he has seen remarkable results in boxing and racing over and over again while acting as scientific adviser to a famous football and athletic association, and feels certain that honey is the one food that can be taken with certainty of results. He adds: "Sometimes honey disagrees—though this is very rare—then malt extract or brown cane sugar may be substituted." The above observations have been culled from Health Notes, by Sir W. Arbuthnot Lane, Bart., President of the New Health Society, which appeared in a recent London daily paper (the *Daily Mail*).

Recreation. Recreation and exercise are usually considered to mean the same thing, and it is difficult to draw a distinguishing line between them. Gardening, *e.g.*, is described in a leaflet issued by the New Health Society as a most healthful pursuit, since digging, weeding, etc., involve much abdominal movement. It is a restful recreation for brain-workers. In this sense recreation would imply muscular exertion after mental work, and rest from exertion of that kind after hard muscular effort. In whatever sense the term may be used, the object of recreation is to keep the body and the mind in a healthy state. Just as long-continued and excessive muscular endeavour may cause physical ailments, serious mental breakdowns may be induced by prolonged mental strain and anxiety, and in both instances a complete rest is necessary to enable the tired-out cells of the muscles in the one case and those of the brain in the other to regain their normal strength. The forms of recreation are innumerable, and include hobbies of all kinds. Some people are keen on fishing and shooting; others take to amateur photography, painting and sketching, or interest themselves in the cultivation of flowers. Others are fond of music and musical recitals. Others derive pleasure from a stroll in a public park or garden or along a river embankment. Others prefer going to a theatre or picture show. Innocent amusements of this kind, which divert the thoughts from the cares and anxieties of life, are useful forms of recreation and a pleasant way of spending one's leisure hours.

Rest and Sleep. Rest of body and mind is as much needed as exercise for the maintenance of good health. It is during rest that the repair and the renewal of our tissues take place. Rest is obtained chiefly during the hours of sleep. Sleep has for this reason been called "Nature's sweet restorer." Sleep is most sound and refreshing in rooms which are quiet, dark, well ventilated, and neither too hot nor too cold. Great heat prevents sleep, and prolonged sleeplessness brings on ill-health. It is for this reason that punkahs, electric fans, and other artificial means of producing a feeling of coolness in the air are used in India during hot weather. Hard beds are more healthy to sleep on than soft beds. It is a mistake to lie upon floors. They may be damp, or foul air from the underlying ground may be inhaled. Fever, dysentery, chills, and rheumatism may be caused in this way. There is, moreover, great danger of being bitten by snakes or other poisonous animals. The use of raised beds is strongly recommended. In order to enjoy a good night's rest it is important that our bedding should be clean. The clothing which we wear at night should be made of some light woollen material. Linen sheets should be used, and the under covering should be made of the same material. In the morning bedclothes and bedding should be well aired and exposed to the sun, and as much air admitted to our bedrooms as possible. During sleep our heads should not be covered. This leads to rebreathing the foul air exhaled from the lungs. For this reason two persons should not sleep in the same bed. Separate beds should be used. Animals should not be allowed to sleep in bedrooms as they deprive the air of some of its oxygen and give off impurities from their lungs, and thus the air becomes more vitiated than it otherwise would be.

Lamps, candles and charcoal fires also, as we know, vitiate the air, and should not be kept burning in bedrooms if it is possible to do without them. Cooking should always be done in cook-houses, and never in sleeping-rooms. Sleeping-rooms should contain as little furniture as possible, as furniture takes up air space. Mosquito curtains are extremely useful as a protection against mosquitoes, whose bites disturb sleep and convey the parasites of malarial fever. We should not retire to rest on empty stomachs, because even during sleep the heart, lungs, and other organs continue to work, and require to be nourished. A light meal not only supplies the energy to enable our organs to perform their duties during the hours of sleep, but also assists in inducing sleep. We should not retire to rest immediately after eating a heavy meal. The heart and stomach are both situated on the left side of the body, and close to each other, although separated by the diaphragm or midriff. A full stomach interferes with the free action of the heart; a person should not therefore go to sleep lying on the left side. It is better to lie on the right side. Palpitation of the heart, which is a common complaint, is often caused by pressure of the stomach on the heart. This happens when the stomach is distended with gas arising from indigestion. In cases of sleeplessness it is best not to struggle to go to sleep. Sleep often comes when least expected, and to struggle to go to sleep often makes the sleepless feeling much worse. The use of drugs to induce sleep should be strictly avoided except under medical advice.

The Amount of Sleep Required. "Infants require 16 hours of sleep every 24 hours, children of two years of age require 14 hours.

Children	four years	of age	require	12	hours.
,,	eight years	,,	,,	11	,,
,,	twelve years	,,	,,	10	,,

"At sixteen years of age 9 hours are needed. Women need 8 and men 7 to 8 hours of sleep. Old people require more" (Reynolds).

PART II

PUBLIC HEALTH

INTRODUCTION

Public health or public hygiene—as distinguished from personal hygiene which relates to individuals separately, and the part each one plays in the maintenance of one's own health and in the prevention of disease—is concerned with the health of communities or the public in general, and the conditions which cause or spread diseases and the measures adopted for their prevention. But as progress in public health depends largely on individual effort both branches of hygiene must necessarily be considered together.

Personal Hygiene teaches us how to live, where to live, what food to eat and what to avoid, what water is safe to drink and what is dangerous and unfit for use. It also teaches us how to construct our houses, and the dangers of living in dirty and overcrowded houses and localities. It enables us to select the kind and quality of clothing we should wear, and the kind and amount of exercise best suited for us. It teaches us that rest is required for both body and mind, the value of sleep, the evils of the use of alcohol, tobacco, opium, cocaine, and many other debilitating drugs. Personal hygiene, in short, teaches us what to do in order to prevent disease and keep our bodies in an active and healthy state.

Public Hygiene deals with the construction of houses, the making and cleaning of roads, drains, sewers, latrines, stables, and cattle-sheds, and the disposal of all kinds of refuse in towns and villages. It also deals with the supply of water and the prevention of the pollution of water and air, and the adulteration of food supplies. Public health has also to do with the notification of infectious diseases, the measures needed to prevent them from spreading, and the registration of births and deaths.

The high death-rate in India is due chiefly to preventable diseases, no less than seventy-eight deaths per hundred being due to such ailments as cholera, small-pox, plague, malaria, dysentery, and other bowel affections.

The total annual death-rate throughout the whole of British India, which has a population of 250,000,000, is estimated to be about 30 per 1,000, as compared with 12 per 1,000 in Great Britain; and the total number of deaths yearly about 7,000,000. Owing to the excessively high death-rate and inefficiency among the labouring and other classes through illness due to, for the most part, preventable disease, Mr. G. Bransby Williams, Chief Engineer, Public Health Department, Bengal, has calculated that the deaths from preventable disease in India represent in monetary value a yearly loss of 75 crores of rupees, and sickness a loss of 135 crores, or a total of over 200 crores of rupees or £140,000,000. This represents a loss of 8 rupees per head of the population yearly. Mr. Williams has pointed out that—so far as Bengal, excluding Calcutta, is concerned—only about 2 rupees per head were spent on public health during the year 1922, and that the amount set apart by district boards for expenditure on medical relief, vaccination, and sanitation was only one-third of an anna per head. Mr. Williams has ascribed most of the poverty existing in India to the high death-rate and sick-rate from preventable disease, which he considers could be, to a large extent, reduced but for the lack of interest in sanitary reform on the part alike both of electors and their representatives on municipal and other councils. Mr. Williams further considers that it is the duty of such councils to give greater financial support themselves to public health schemes, instead of depending on private individuals to take the initiative in their introduction, and at the same time pay the cost involved in carrying them out. The spread of disease is to a large extent due to ignorance, and the general community must be protected somehow or other. Hence it is that in all civilised countries *sanitary laws* have been passed to prevent irresponsible individuals from doing acts calculated to injuriously affect the health of their neighbours, and that sanitary inspectors are appointed to see that the laws are strictly observed.

If such laws were not passed our food-stuffs would be adulterated to a much greater extent than they are at present; articles of food unfit for use would be sold in our bazaars; the water which we drink would be polluted with human and animal refuse; the air would be poisoned with foul gases; houses would be badly built and overcrowded; and streets would be narrow, dirty, and dark owing to the absence of sunlight, which is so essential to health. There would be no open spaces left for taking exercise and breathing pure air; refuse would be allowed to accumulate everywhere; drains and latrines would not be kept clean or in a good state of repair; dead bodies and the carcases of animals would not be properly disposed of, and the practice of throwing them into rivers would become common; nothing would be done to prevent the outbreak of epidemic diseases or check their spread; people suffering from small-pox, cholera, plague, and other infectious diseases would travel about in palkees, hackney and railway carriages, and other public conveyances; nobody would try to prevent this; nothing would be done to cleanse and disinfect the conveyances afterwards, and other people using them would thus be liable to catch the disease. In short, nuisances of every kind would be committed.

RESPONSIBILITY OF THE INDIVIDUAL

When we imagine the terrible consequences which would result if no sanitary laws existed, it is not difficult to understand how important and necessary it is that people should be punished for disobeying them. The object of sanitary inspections is to ascertain how far, if at all, sanitary defects exist, and to enable the health authorities to take the necessary steps for their removal or mitigation. It is the duty of every citizen to assist the health authorities in their efforts to bring about an improved state of the health of communities. They should, for example, get their children vaccinated, and thus help to prevent attacks of small-pox; or inoculated when plague is prevalent. When cases of disease of this nature break out it is their duty to report the occurrence, so that proper steps may be taken by the authorities to keep them from spreading. It is also the duty of citizens to obey the law themselves, and to assist in trying to prevent other people from evading it, and thereby bringing about the sanitary evils mentioned above.

DISPOSAL OF REFUSE

Solid refuse, such as particles, ashes, and sweepings of floors, compounds, and courtyards, should be put into dust-bins with proper covers, and kept there till the refuse carts or village sweepers come round to remove them. Paper, straw, leaves and other refuse are sometimes used for filling up tanks. The refuse of stables and cattle-sheds, however, should never be used for this purpose. Mineral matter, such as building refuse, is best. Where possible refuse should be burned. In some large towns special furnaces, called incinerators, have been constructed for burning house and street refuse. In villages refuse may be burned in any hollow at a safe distance from houses. Refuse, when so disposed of, is no longer dangerous to health, because the germs of disease, which grow and multiply rapidly in it, are destroyed by burning. Solid refuse from stables and cattle-sheds should not be collected in heaps near dwelling houses. Such refuse is good for the growth of crops and should be taken to the fields.

The streets of some large cities in India, from which hundreds of tons of refuse are removed daily, always look dirty and neglected owing to the objectionable practice of throwing out refuse at all hours of the day and night. This, and the practice of allowing it to accumulate around dwellings, are fraught with the greatest danger to health. Epidemic diseases are always most severe in dirty places and amongst dirty people, no matter whether they live in palaces or humble huts in a bustee.

Liquid refuse, excluding sewage, consists chiefly of ordinary household refuse water such as that with which pots and pans have been cleaned or floors washed and of bath water. In cities and towns with a drainage system and a constant water supply, where there are no properly constructed drains and cesspools have to be used, the cesspools should be well made and kept in a good state of repair. They should be emptied regularly to keep them from overflowing and their contents soaking into the ground, and thus finding their way into wells from which the domestic water supply is got. Wells are often contaminated in this way by the germs of cholera and enteric fever and other diseases. Cesspools should not be built in the plinths of houses, and the use of any which exist should be forbidden, or, better still, they should be got rid of altogether by filling them up with suitable building material. A little over thirty years ago there was hardly a house in the city of Jagganath (Puri) in the plinth of which there was not a cesspool, the contents of which either soaked into the foundation of the house or overflowed into the streets. Such drains as existed were of the most primitive type and defective in every possible way. The occupants of the houses did not take kindly at first to receiving notices to fill up the cesspools, but were amenable to reason in the end. A proper drainage system was introduced later, and it is understood that most, if not all, of the cesspools have now been filled up and that the sea breeze from the Bay of Bengal is not so highly polluted as it was by the foul gases which escaped from them formerly.

Sewage may be either solid or liquid, or a mixture of both. It consists mainly of the discharges from the human body and the liquid material from stables and cattle-sheds.

Drainage. The object of drainage is to draw off water and prevent flooding during an excessive fall of rain, and to keep land from becoming water-logged, and thereby rendered unsuitable for the growth of crops. Drainage also helps to keep the foundations of houses dry and the houses healthy to live in. In most cities and towns large underground drains called *sewers* are constructed. They serve the purpose of carrying off sewage and rain water at the same time. This is called the "*wet carriage system or the wet method*" of the disposal of sewage. The sewers may be built of bricks or iron, or earthenware pipes may be used. They are usually round or oval. Sewers often empty themselves into rivers, and sometimes directly into the sea. The sewage of Calcutta runs into a river near the salt-water lake which is situated several miles away from the town. If possible the use of outlets of this kind should be avoided. In order to facilitate the flow of sewage, and for the purpose of flushing and cleansing the sewers, an unfiltered water supply is provided. If an abundant water supply were not provided, the contents of the sewers would stagnate, decompose and give off evil-smelling gases. Sewer gas is believed to be the cause of many fatal diseases, and, when constantly breathed, undermines the health. Sore throats and diarrhœa caused, it is believed, by sewer gas are not uncommon, and the general belief is that diphtheria outbreaks may be accounted for in this way. Direct infection, however, is the most plausible explanation in most cases.

The sewage from houses finds its way into the sewers

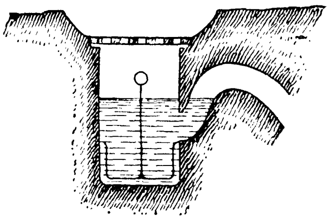


FIG. 57.—GULLY TRAP.

through small house pipes, which lead from the water closet or latrine situated inside the house. These house pipes should, therefore, be well made and of the best material, and have a good flow. In order to help the flow of sewage through the house pipes into the sewers, all water closets are provided with large iron tanks situated near the roof. The water is allowed to flow out of the tank into the water in the closet pan, which receives the discharges from the body, by pulling a handle or by some other simple means. The water washes out the contents of the pan, keeps it clean, and helps to flush the house pipes which convey the discharges to the street sewers. At least 2 gallons of water are required each time the water closet is used. In order to prevent the escape of gas from the sewers into the house pipes, and from the house pipes into houses, traps are provided. The traps are merely bends in the house pipe or sewers containing water which helps to keep the gas from passing through. This layer of water is known as a *water seal*. It is usual also to have a ventilating pipe, attached to house pipes, on the *outside* of the walls of houses and extending well above the roof, to allow of the escape of

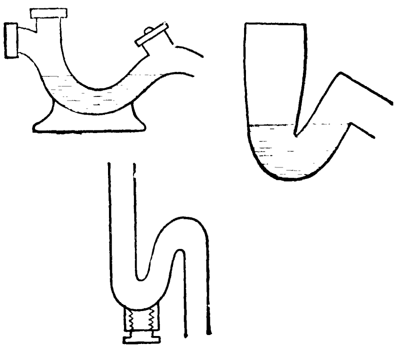


FIG. 58.—VARIOUS FORMS OF SYPHON TRAP.

any gas that may by chance find its way back from the sewers. In the same way the sewers should be ventilated by pipes placed at short distances from each other along the entire length of the sewers. The best traps are those known as the syphon and gully traps (Figs. 57 and 58). When the water-carriage system for the disposal of sewage is adopted, the sewers, drains, pipes, gully pits and everything connected with the system must be made of the best material, carefully constructed, provided with the best form of trap, and well ventilated. There must also be a liberal supply of water for flushing and cleansing purposes.

Dry System of Removal of Sewage. In some villages and towns, baskets coated with clay, wooden buckets well tarred, and sometimes iron carts are used for the removal of the solid contents of latrines. All latrines should be provided with suitable receptacles. This helps to keep them clean, makes the sweeper's duties easier and less

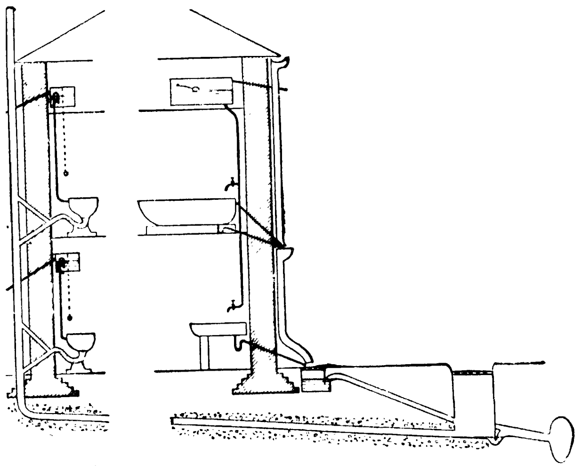


FIG. 59.—HOUSE WITH GOOD SANITARY ARRANGEMENTS.

disagreeable, and saves time. Earthenware vessels are generally used for this purpose. They should be kept thoroughly clean and well tarred. Broken vessels should never be used. The night-soil may be mixed or covered with ashes or dry earth or the sweepings of the house. The use of chemical substances to mask smell will not be needed if proper attention is paid to cleanliness. The liquid portion of the sewage of villages in India very often escapes into the ground. This should be prevented as much as possible. Both liquids and solids should be disposed of in trenching grounds in the manner described later on.

Precipitation of Sewage. The solid and liquid portions of sewage are sometimes separated by screening and by the addition of chemical substances such as lime, sulphate of alumina, and proto-sulphate of iron. This is called the *precipitation of sewage.* The solid portion is made into cakes, which are sold as manure or burned. The liquid portion may be filtered by allowing it to run through cinders with the object of purifying it. It should not be allowed to flow into rivers or other water channels, the water of which is used for drinking purposes.

Filtration of Sewage. Sewage is sometimes allowed to flow on to land without any attempt to separate the solid and liquid portions as described above. Porous dry land is best suited for the purpose. The land should be well drained. This method is adapted for districts in which the rainfall is scanty. Sewage farms are so called because sewage is sometimes used in this way for cultivation on a very large scale.

Septic Tanks. Another method of purifying sewage is what is known as the *septic tank system.* The sewage flows into settling tanks and then into large filters containing coke, breeze or cinders. The effluent is purified by passing over a weir with a series of large traps. It is thus well aerated and then passes into the filters. Hard-burnt pugged jhama bricks broken into cubes of suitable size, $\frac{1}{2}$ inch in the upper layer and $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in the lower layers, are best. The filling of the tanks, resting, discharging and aerating are done automatically. The liquid after filtration is clear and free from smell, and remains thus for months even when kept in bottles. In this method air is excluded by (*a*) covering the tank, (*b*) the inlet for the sewage and outlet are below the level of the surface of the sewage. There is a constant flow from one year's end to the other, and this may continue for four years even. The destruction of the solid matter and the purification of the dissolved matter is effected by bacteria which grow best when air is shut out (*anærobic*). The conditions under which the bacteria flourish best are (1) an abundant food supply; (2) darkness; (3) equable temperature; (4) absence of atmospheric oxygen; (5) a steady current to wash away the products of decomposition (Latham). Nitrates of sodium and calcium are the final products, and their presence in the effluent indicate that the tanks are working well. The nitrates should be more than 0·5 per 100,000. The effluent of the tanks should not be allowed to flow into rivers near the source of a public water supply. It might be disposed of by running it over land during dry weather, but on the whole this method of disposal is not to be recommended. Filtration of the effluent through sand has been suggested when the effluent is allowed to run into rivers; it should be carried in pipes to the middle of the river.

It was found by a committee appointed by the Government of Bengal to inquire into the matter that an addition of 5 grains of chlorinated lime for each gallon of effluent rendered the fluid virtually sterile, and hence much purer than Hooghly water itself, and that it contained less living organisms than the Calcutta drinking water. The cost, moreover, is very low—Rs. 10 or Rs. 15 per month for a septic tank installation for 200 persons.

This is a most excellent method of disposing of night-soil, and if it could be adopted on a large scale would be the safest and best of all systems for the disposal of human refuse. This method ought to be tried in small village communities.

Latrines. In villages with no drainage system or constant water supply latrines must necessarily be provided. Latrines should be well constructed and sweepers employed to remove their contents to trenching grounds at a safe distance. There are many different kinds of latrines, but one of the best and most suitable and convenient for small towns and villages is that known as "Donaldson's latrine," which is made of iron and is cheap. It is so constructed that the solid and liquid waste discharges are kept separate.

Trenching. This is a well-known method of disposing of sewage by burying it in the ground. The trenches should be large and shallow. Trenches 1 foot deep and 3 feet broad should be used, and not more than 3 inches of night-soil put into them. The night-soil should then be spread out, and, afterwards, covered with the earth removed in digging the trench. The earth and the night-soil combine with each other and in a few weeks no smell remains. Deep trenches are very objectionable and should not be used.

The Cultivation of Trenching Grounds. Trenching grounds are more or less dangerous to health. The dangers are, however, greatly lessened by cultivation. Unfortunately, the majority of Indians object to the use of anything grown under such conditions. Where this objection has been overcome and trenching grounds have been brought under cultivation abundant crops of cabbages, cauliflower, mustard, Indian corn and other grains are obtained and a rich reward is reaped, not only in money, but in health. The value of the waste products of human beings and animals for agricultural purposes is now recognised. The inhabitants of villages know that crops are always most abundant in fields which are used as latrines, and when such fields are put up to auction or leased out they fetch a better price than fields which are not so used. It should be understood, however, that the practice of using fields as latrines is exceedingly dangerous, because, as has been pointed out, the discharges from the bowels often contain the germs of some of the most fatal forms of disease.

Concluding Remarks on Refuse Disposal. No kind of refuse is more dangerous to health than the waste matters from the bodies of human beings. Terrible outbreaks of cholera and enteric fever have often been traced to the pollution of the water supply with the discharges from the bowels of patients suffering from these diseases.

It is most important, therefore, that the greatest care and attention should be given to their speedy removal and disposal. The health of towns and villages will depend largely upon whether or not this rule is followed.

WATER SUPPLY

The Composition of Water. Water is composed of two gases, namely hydrogen and oxygen. These two gases are not mechanically mixed in forming water as are the nitrogen and oxygen of which air is composed. They combine chemically to form water in the same way as carbonic acid combines with the lime in lime water to form a chalky compound which is neither the one nor the other, but a new and solid substance composed of both. Water is for this reason known as a *chemical compound*. When made slightly acid, water can be split up into hydrogen and oxygen by the use of electricity; and, on the other hand, the two gases may be made to combine to form water.

Water may exist in the form of either a gas, a liquid, or a solid. Steam, mist, clouds, dew, rain, snow, hailstones and ice are all forms of water.

Sources of Water Supply: *Springs.* Water is sometimes obtained from great depths in the ground through springs. Hollow tubes are sometimes sunk in the ground to great depths in order to obtain a supply of water, the water in such cases being raised by pumping. These are known as *tube wells.* Water obtained from this source is the best and safest for drinking purposes. Springs and tube wells should, however, be carefully protected against pollution.

Deep Wells. Wells over 50 feet in depth are sometimes, though not quite correctly, described as deep wells. It is more correct to regard as deep wells only such wells as are

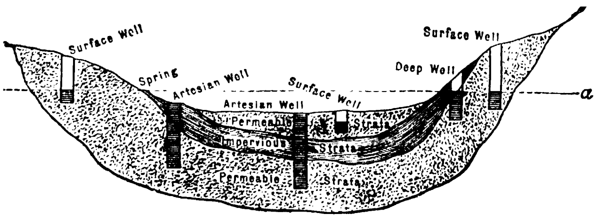


FIG. 60.—SOURCES OF WATER SUPPLY.

sunk through the surface soil and through an underlying *impervious stratum* into a deeper water-bearing one (Willoughby). Deep wells in some cases do not exceed 20 feet in depth. Water from this source is, as a rule, also good and safe to use.

Artesian Wells (Fig. 60) are made by boring, and extend to a great depth at times through various impermeable strata before water is reached. The water sometimes escapes from them like the water from a fountain, owing to the great pressure to which it is subjected.

Surface Wells. Wells which are less than 50 feet in depth, when not of the character above described as deep wells, are sometimes called surface wells. Surface wells are sometimes mere hollows in the ground. They obtain their water supply from the surface soil, and are, therefore, very easily polluted by dirty water and other filthy liquids, and should not be used. These wells may be comparatively deep, and yet be surface wells in the true sense of the term.

Tanks. The water of tanks is often used for drinking and other domestic purposes. Unless specially set apart for human use and carefully watched, which is not easy, water from tanks is exceedingly unsafe to use, because they are as a rule very badly polluted owing to the dirty habits of the people who use them and by animals.

Hills and Lakes. Water from hills and lakes situated far away from human dwellings, in places where the land is not cultivated or used for grazing cattle, and where there is little or no decaying animal or vegetable refuse, is good and wholesome. Many large towns obtain their water supply from such sources. Bombay and Madras, for example, obtain their water supply from distant hills. Loch Katrine, a lake situated at a distance of over 30 miles from Glasgow, a town as large in size and almost as large in population as Calcutta, is the principal source of the water supply of that great city.

Rain Water. Rain water collected and stored in large cisterns underground is sometimes the only source of the water supply. In large manufacturing and dirty towns rain water is rendered unsafe for use by the gases and other impurities contained in the air. In country districts where the air is pure rain water may be safely used, and is much softer and better fitted for general use than water obtained from most other sources.

Sea Water. It now and again happens that the supply of drinking water, carried in the large iron tanks with which all steamers and ships are fitted, is exhausted before the place of destination is reached. In those circumstances the crew and passengers have to fall back upon the use of sea water which is freed from its salt and other impurities, which make it unfit for use, by boiling it in specially constructed boilers and collecting the steam in separate chambers or condensers, where it forms water on cooling. This process is known as *distillation*, and the water thus obtained is called *distilled water*.

Rivers. Many large cities obtain their entire water supply from rivers. London, for example, is supplied chiefly from the River Thames and Calcutta from the Hooghly River. Many lakhs of rupees are spent yearly in the collection and purification of water obtained from this source. The water before use is purified by passing it through filtering beds made of stone, bricks, or other material of different sizes, and sand of coarse and fine quality, which must be thoroughly cleaned before being used. After being thus purified it is conveyed in large underground pipes or mains and distributed throughout the city by means of smaller branch pipes made of galvanised or wrought iron or lead. These pipes should be so carefully constructed that foul gases or liquids and other impure matter may not be able to find their way into the water supply through cracks and other defects. Severe outbreaks of disease have often been caused in this way. Water sometimes acts on lead and dissolves it. One-sixtieth part of a grain of lead in a gallon of water will cause colicky pains in the belly and other symptoms of lead poisoning.

Water which has been purified is often conveyed into the houses of those who can afford to pay for it. The poor have it at their doors, and a liberal supply can be drawn from the stand pipes by merely turning a tap or handle, or in some cases by pressing a knob. Dirty tanks and wells are no longer required in such cities, and the few that are not filled up are, nowadays, used chiefly for supplying water for washing floors and as a precaution against fire. People who use properly filtered water only live cleaner and healthier lives than those who, either of their own choice or because there is no other supply available, continue to use the water of tanks and wells. Since the introduction of a filtered water supply into Calcutta and elsewhere in India the deaths from cholera and other water-borne diseases have been very considerably reduced in number. The comparative freedom from such diseases is enjoyed in all towns with a good supply of filtered water.

The Use of Water. Water is required for the sustenance and growth of all animals and plants. Without water life could not exist. Three-fourths of the weight of our bodies consist of water, part of which is got from the food we eat. Some vegetables, such as turnips and potatoes, consist almost entirely of water. The greater portion, however, is taken into our systems in drinking water, tea, and other liquids.

Quantity of Water Required. In European houses between 20 and 25 gallons of water are required daily per individual for drinking, cooking, washing, cooking utensils, washing clothes, bathing and other household purposes. Besides this, in large commercial towns a supply is needed for carrying on trade, keeping sewers and drains clean, for watering streets, etc. About 30 gallons are considered sufficient for all purposes. In towns in India a smaller supply has been found sufficient.

Effects of the Scarcity of Water. Without water the crops would wither and die, food would become scarce and dear, and famine, sickness, and death would ensue. Wells and tanks are sometimes the only source of water supply for the crops when the rains fail. The water drawn from these sources is allowed to flow into the fields or gardens through shallow surface drains or channels, and in this way the crops are kept alive. This operation is called *irrigation* and may be seen on a small scale near almost any Indian village at certain seasons of the year.

Irrigation on a much more extensive scale, however, is carried on by the Government in those parts of the country in which the rainfall is scanty or where the rains often fail altogether. Many thousands of miles of canals have been made for this purpose. In the year 1898 no less than 46,000,000 acres, or nearly 72,000 square miles of land, which would otherwise have remained dry and barren jungle, were by means of irrigation with water obtained from tanks, wells, and canals, yielding rich harvests of grain and other produce for human use. Moreover, 4,000,000 more acres, chiefly in the Punjab and Sindh, were at that time about to be brought under cultivation in the same way. In the years 1900-1901, up to March 29th, the Government of India had spent in all 46½ crores of rupees or thirty-one million pounds sterling upon state irrigation, and had dug nearly 50 000 miles of canals and distributaries.* It will thus be seen that water is of the greatest value to the growth of the crops. Water is of no less value, however, for the growth and health of our bodies. Without it our kidneys and other organs could not perform their natural functions; our skin would cease to act, and become dirty and diseased. We should be unable to wash our clothes, keep our houses clean, or cook our food. Drains would become stagnant and the air would be poisoned with foul gases. Sickness would break out and we should all soon die.

Pollution of Wells. The well may be a shallow one. It may be dug in a loose and porous or soft and sandy soil, through which impure liquids easily percolate. There may be no masonry walls, or the walls, if any exist, may be broken and out of repair generally. The mouth of the well may be below the level of the surface of the ground.

* Irrigation has made great and rapid strides since then, but the writer was unable to get exact details when the present book was being composed.

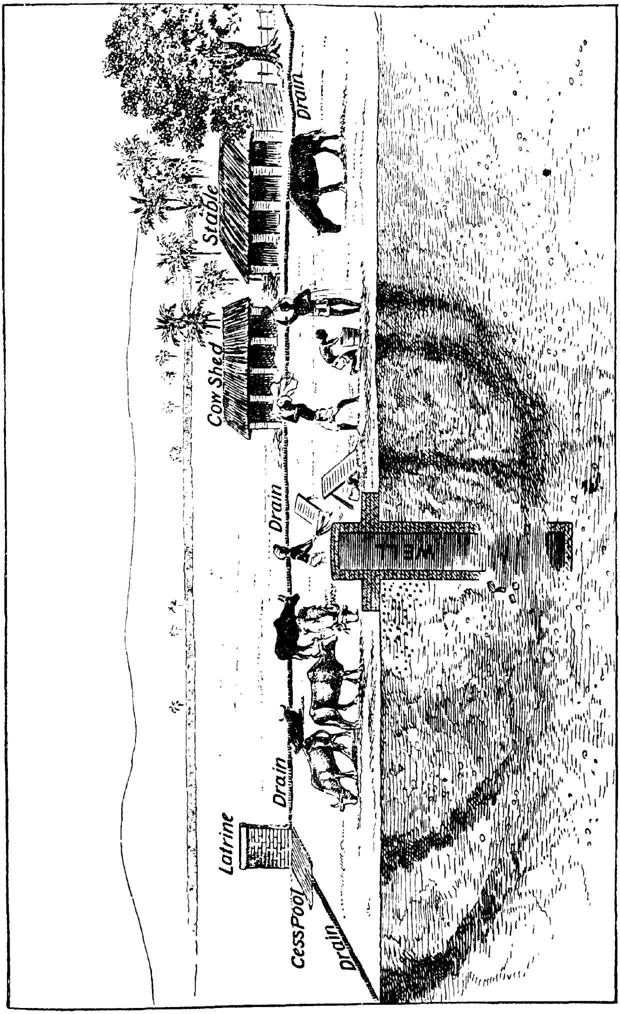


Fig. 61.—Showing how the Water in Wells is Sometimes Polluted in India.

It may be situated near a dirty drain, or a badly constructed and unclean latrine, cesspool, stable or cattle-shed. Buffaloes, cows and other animals may be tied up too close to it. The washings of the streets, latrines, and foul contents of drains, and the discharges of animals can thus easily find their way into wells such as those which have been described above. There are other ways, however, in which wells are often polluted. If the well is not covered, straw, leaves and dust may be blown into it. The water may be defiled by birds which often build their nests in wells. It is a common practice in India, too, for people to wash their dirty clothes and bathe themselves while standing over wells, and dirty vessels and dirty ropes are often used for the purpose of drawing water. Moreover, it often happens that wells are not cleaned out for years at a time. Mud, broken pots, pieces of rope and other refuse in consequence collect at the bottom, and sooner or later stop the spring from which the water flows. No fresh water can get into the well, and that which it already contains soon becomes unfit for use. These, then, are some of the ways, all of which the writer has seen, in which the water supply of wells may be polluted and rendered unsafe for human use.

Pollution of Tanks. Tanks are, as a rule, more polluted than wells. Ignorant and dirty people often build their latrines near them, or the margins of the tanks may be used instead of latrines, with obvious results when a shower of rain falls. The liquid refuse from latrines, cattle-sheds and similar places, and the foul contents of drains are often allowed to flow into tanks. Dhobies not infrequently ply their trade in them, and they are in many cases resorted to by thousands of people daily for bathing purposes. Further, beggars and others with all kinds of loathsome diseases are often to be seen using the water of tanks for washing their sores and the rags with which they are dressed.

Pollution of Rivers. Besides being polluted in the same way as tanks, rivers are still further defiled by the highly objectionable and dangerous custom of throwing the bodies or the ashes of dead persons and the carcases of animals into them. The liquid refuse of factories and mills is often disposed of by allowing it to run into rivers, while the whole of the sewage of large towns is often got rid of in this way. Rivers are also polluted by refuse being thrown into them from steamers and ships, and by the dirty and careless habits of boatmen. The night-soil of villages is often collected and thrown into rivers. *The result of all this sinning against the laws of health is the frequent outbreak of epidemic diseases of the most virulent kind.*

Impurities in Water (Fig. 62). When water is allowed to stand in a glass tube particles of sand, mud or other solid bodies which it may contain will sink to the bottom. The eye may be able to tell what these particles are. The most dangerous impurities in water, however, such as the germs of cholera and enteric fever, are so very small that they can be seen only under certain conditions, and often with great difficulty, with the help of a microscope. The eggs of worms are often found in water, and those who drink it become infected with the disease in consequence.

How to Prevent the Pollution of Water. If wells are used they should be as deep as possible. The walls should be made of thick stone, bricks, or other similar hard material. The walls should be set in cement, and should extend 2 or 3 feet above the level of the ground, forming a parapet. There should be no cracks in the walls. When the walls begin to sink, or otherwise get out of order, they should be repaired at once. The ground round the well should be paved with stone slabs or bricks on edge, set in cement, and the pavement should have a slope, 3 or 4 feet in width, to allow the spill water to run off. A small drain should be constructed round this pavement to catch the spill water, which should run into a branch drain from

FIG. 62.—MICROSCOPIC VIEW OF SOME DROPS OF WATER.
The objects depicted represent various forms of animal and vegetable life and decaying organic matter.

the main drain surrounding the pavement, and thus be conveyed to a safe distance from the well. This will prevent it soaking into the ground and getting back into the well.

The mouth of the well should be covered, leaving an opening large enough to admit a bucket. A small trap door with hinges should be provided with which to cover the opening after drawing water from the well. This will help to keep out birds, dust, leaves, straw, and other impurities. An iron bucket with a chain running over a pulley should be attached to each well, and the use of this bucket only for drawing water should be insisted upon. This will prevent the use of dirty vessels and ropes. The use of *pumps* would be better still (Fig. 63). When it is possible to have repairs executed without great delay, if they get out of order, pumps are the best means of keeping wells clean, and should be used in every town and village where there is no filtered water supply. Bathing and washing of clothes and cooking vessels near wells should be prohibited. Wells should be periodically cleaned out. Lastly, but not least, every town and village should be kept thoroughly clean. No kind of offensive matter should be allowed to remain either in the streets, around human dwellings, or elsewhere, because sooner or later it will get dried up by the sun, converted into dust, blown about in the air, and ultimately find its way into the water supply. When tanks are the chief or only source of supply of drinking water to a community they should be reserved for that purpose only. They should be as deep as possible, so that the water may be kept cool, and every precaution taken to keep them from being polluted.

How to Purify Water. It has been already observed that water from springs, deep wells, certain hilly districts and lakes, rain water, pipe water supplied by municipalities are, as a rule, reliable and safe to use for all domestic purposes. If there is any doubt, however, as to the purity of water, steps should be taken to purify it. There are several ways in which water may be purified.

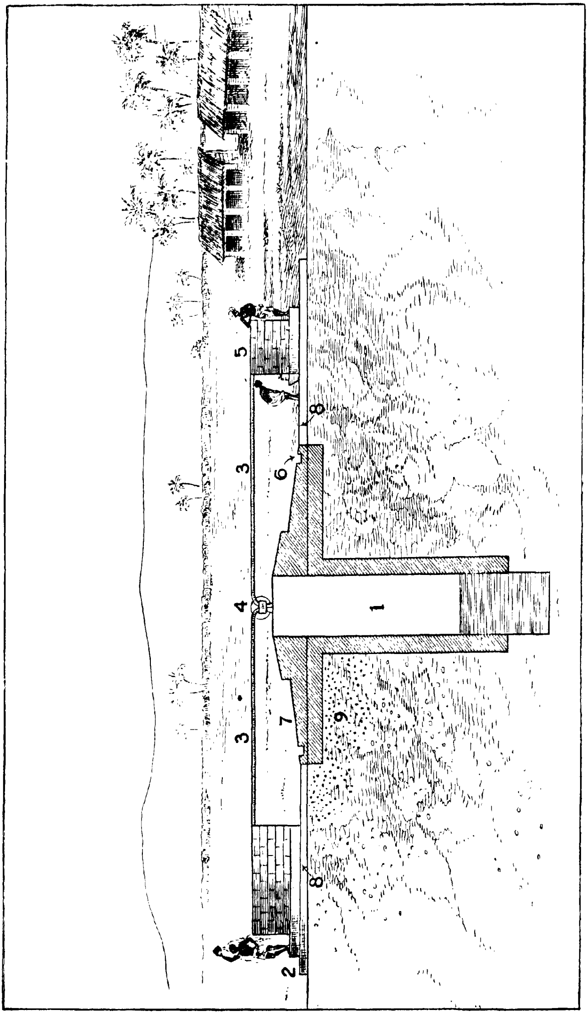


FIG. 63.—SHOWING HOW THE POLLUTION OF THE WATER OF WELLS MAY BE PREVENTED.

1. Well with masonry walls. 2. Bathing platform at a safe distance. 3. Water pipe. 4. Pump. 5. Drinking water in cistern with cover and tap. 6. Drain for waste water. 7. Masonry pavement around well.

Distillation. This was described when dealing with sea water under the heading "Sources of Water Supply."

Boiling. Boiling for ten minutes will destroy almost every known form of disease germs which water may contain. Repeated boilings will make the most impure water perfectly safe to drink. When water has been boiled it must not be allowed to stand unused too long, and must be protected against the entrance of dust and other impurities. This can best be done by keeping it in stoppered bottles. Water which has been boiled is not so palatable as unboiled water. It is, however, safe, which is much better. In order to make water which has been boiled more palatable it is often recommended that it should be well shaken, so as to mix it with the air. This, however, renders the water liable to pollution by disease germs, and should therefore be avoided.

The Use of Chemical Substances. *Alum* clears muddy water by carrying the mud and other suspended matters to the bottom of the vessel containing the water. Alum is even believed to be able to kill or prevent the growth of germs. Six grains of alum to a gallon of water are sufficient. *Permanganate of potassium* is, however, the best of all chemical substances. Its use is considered by some people to be the best means of cleansing the water of wells which are believed to be infected with cholera germs. Mr. Hankin, who has given the question a great deal of attention, in his pamphlet on the cause and prevention of cholera, gives the following directions for the treatment of wells with this substance:

"Care should be taken to explain to the villagers that permanganate is a salt-like substance in whose preparation only mineral substances are employed, and therefore its use ought not to be objected to by the strictest Hindu.

"The villagers should be warned against the danger of drinking any water except that from treated wells. It should also be explained that the permanganate is not a medicine for patients, but merely a means of cleansing water.

"Put 2 ounces of permanganate in the solid state into a dol or bucket that has been filled with water from the well about to be treated. Stir it up and pour the red solution thus produced into the well, leaving the portion of permanganate that is not yet dissolved at the bottom of the dol. Lower the dol into the well, draw it up, pour back the water as before. Repeat the process till all the permanganate has been dissolved. After half an hour draw up some of the water and examine it. If a red colour is still present enough has been added. If the red colour has disappeared, then more permanganate should be added to the water in the well. In all cases enough permanganate should be added to produce a faint red colour lasting twenty-four hours.

"If the water in the well is bad, more permanganate will be necessary. In such a case it will be found that the strong red colour at first produced slowly changes to brown, and then fades away. This is because permanganate and dirt destroy one another. Therefore, more permanganate must be added in order to produce a lasting colour. If the water in the well is clean a smaller quantity of permanganate will be found to be sufficient. From 1 to 8 ounces of solid permanganate will be found to be sufficient for ordinary wells. If possible, the permanganate should be added at night in order to leave the wells undisturbed as long as possible. The water will be fit to drink on the following morning. If at this time the water has the red colour it will have a slightly unpleasant taste, but it is perfectly harmless. If the inhabitants do not like the taste, they should be instructed to pump out the water until the colour vanishes. Always care should be taken to treat with permanganate all the wells in the place, not only those used for drinking, but also those used for washing purposes. The village police may be employed to show the operator the positions of the different wells. After, but not before, these wells have been found and treated, search should be made for a well near the police station that the police will have forgotten to show. This well or any other suitable wells should be treated with a double quantity of permanganate. Bhihisties may then be employed to pump out its water until the colour has nearly vanished. The inhabitants should be advised only to use this well until the following morning, when the water of the other wells will be fit to drink. The well thus selected for immediate use may afterwards be further treated with permanganate.

"Usually water is stored in the houses in ghurrahs for washing and other purposes. This should be poured away, and, if possible, the inhabitants should be persuaded to wash their *lotas* and other vessels with water containing permanganate. Unless this be done, isolated cases of cholera are likely to occur even four or five days after the treatment of the wells." Calcium hypochlorite, 2 pounds per 1,000 cubic feet of water, is recommended for the purification of tanks, etc. That is about 33 per cent. available chlorine.

Filtration. The purification of water by means of filtration is safe only in the hands of persons who possess an intelligent knowledge of the construction of filters, how they act, how they should be used, and how they may be kept in safe working order. The great majority of people know nothing about them, and hence the use of filters for domestic purposes is often fraught with the greatest risk to health. The writer had occasion some years ago to inquire into an outbreak of enteric fever, on a steamer in the port of Calcutta, which was shown by a skilled bacteriologist to be due to the use of water from a small domestic filter which was highly polluted. No less than eighteen persons were attacked with the disease. Charcoal and sand are used in that well-known simple and cheap

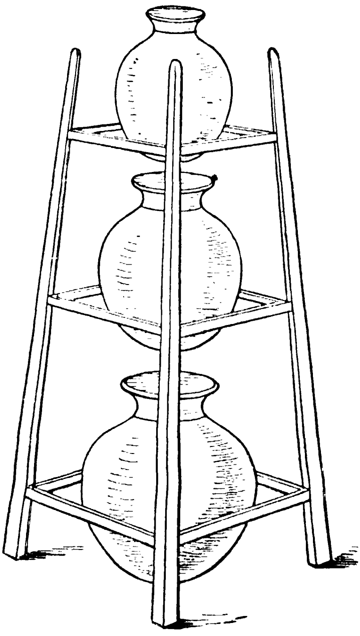


FIG. 64.—AN INDIAN FILTER.

Indian filter, which consists of three earthenware vessels (ghurrahs), arranged one above the other in a wooden frame.

The purification of water by filtration, through sand, depends upon the presence of numerous small living vegetable bodies which form a slime upon the surface. Sooner or later the slime becomes so compact as to prevent the water passing through. When this happens, some of it has to be scraped off. When new sand is used the water which passes through it is not safe to use until this layer of slime has formed. Twenty-four to forty-eight hours are generally sufficient for this purpose. Thorough cleansing of the sand before use, however, will make it fairly safe even before the slime has formed. In Germany the filtered water is not served out from a newly made filter-bed, but returned to the settling tanks until a fresh growth has formed, and the bacteria are reduced to 50 per cubic centimetre (Willoughby). Koch suggested that the water of wells may be purified by half filling the wells with sand and then using a pump. This converts the well into a sand filter.

The use of the ordinary cheap domestic filters, now described, and those most generally to be found in households, should be abandoned. It would be far better to get rid of solid particles of matter, and then merely boil the water. If, however, *domestic filters* are used at all, the Pasteur-Chamberland or the Berkefeld filter should be preferred. The filtering material in each of those filters consists of hollow cylinders or candles closed at one end, and which have at the other end fine earthenware or metal caps, through which the filtered water passes. The candles of the Pasteur-Chamberland filter are made of porcelain, a very fine form of earthenware, and asbestos, which is a mineral fibrous substance. The candles of the Berkefeld filter, on the other hand, are made up of compressed and baked earth, consisting chiefly of the hard flinty skeletons of infinitesimally small organisms called diatoms. They have been described by the Berkefeld Filter Company as being hardly larger than the bacteria which they are meant to catch. The Berkefeld filters give a flow of water through the candles five to ten times as rapid as the Pasteur-Chamberland, the reason assigned being that the candles are porous to the highest degree. The Berkefeld Filter Company observe that in this large supply of perfectly pure water, together with its absolute certainty of retaining on its surface all disease germs, rests the great practical value of the Berkefeld filter to the public.

The main objections which have been stated against the use of the Berkefeld filter are, that the candles are easily broken and their replacement is expensive, and that they require to be boiled every day or two to be made quite safe for use. On the other hand, it is stated that the Pasteur-Chamberland filter is difficult to break, and may last, with care, for months at a time. It is also easy to clean. Drs. Sims Woodhead and Wood, in their report upon filters published in the *British Medical Journal* of December, 1894, stated that "the Pasteur filter does prevent the communication of water-borne diseases, as is claimed by the vendors. Almost all other filters may materially increase the risk of acquiring infectious disease, and are to be looked upon as an unmitigated evil."

The *Lancet* observed that the purifying efficiency of the Pasteur-Chamberland tube is also attested by practical experience, and that the use of the Pasteur filter is a real preventive of water-borne disease. On the whole, the bulk of the evidence regarding the respective merits of the two forms of filter above described is in favour of the Pasteur-Chamberland. These filters may be made of earthenware, stoneware, or enamelled iron, and may be either plain or decorated. They are made in many different forms, of different sizes, and to serve various purposes. They may be so small as to be easily carried in the pocket, or large enough to supply water to an entire village or town. They may be attached to municipal water service pipes, or used for sterilising liquids of all kinds, including even beef-tea. Great care should be taken to avoid the use of broken candles.

How to Clean the Candles. They may be rubbed with a piece of clean rough cloth or with a brush. They should then be boiled for an hour, or they may be passed through the flame of a spirit lamp or baked in front of a hot fire. Great care should be taken in replacing the candles after cleaning them, otherwise they will allow the water to pass through unfiltered.

A Few Special Observations on the Impurity of Water. If on placing a drop of water from a well under a microscope fragments of cotton or portions of the human body are found, the only conclusion to be drawn is that the well is being polluted by household impurities, the water is unfit for use, and that the well should be abandoned at once. When many people or several members of a family. living in the same village, street, or house, are attacked with cholera at or about the same time, the well, tank, or other source of water supply is most likely to be the cause of the outbreak. In such cases the water on inspection may be clear, taste well, appear to be pure and wholesome, and be well liked by those who drink it. It should be noted, however, that water of this kind may be very badly polluted with disease germs, and therefore most dangerous to health if used.

How we can tell when Water is Polluted. The best test is the health of those who drink it. If there is no sickness in the form of cholera, diarrhœa, and so forth, the water may be regarded as safe and fit for use. If, however, sickness of this kind breaks out the water supply should immediately receive attention. In large cities, the water is examined weekly to ascertain the degree of purity or impurity of the supply. Wherever possible this should be done, as *prevention of disease is better than cure.*

The examination of water may be divided into three parts, namely: (1) *Physical*, (2) *chemical*, and (3) *bacteriological*.

Physical Examination of Water. In this examination the colour, clearness, sediment, smell, lustre and taste have to be noted. Good water has always a bluish colour. Greyish water may be good also. Greenish waters are not necessarily bad. *Yellow and brown waters are always unsafe to use.* Water should be clear and free from deposit. It may, however, as has been already stated, contain sand or other mineral matter, which gives it a yellow colour, and yet be perfectly safe. Good drinking water should be free from smell. Smell can be easily detected by heating the water and inhaling the steam that rises from it. Pure water should be neither bitter, sweet, salt, nor sour. It should be practically tasteless.

Chemical Examination of Water. This examination enables us to ascertain, amongst other things, the extent to which any given sample of water is polluted with organic matter of human, animal, and vegetable origin, and the degree of softness or hardness of water. A chemical examination can be made and the results understood only by persons who have acquired a thorough knowledge of chemistry after long and diligent study. The results of a chemical examination may show the water to be apparently of good quality, and yet it may contain the germs of the most fatal forms of epidemic disease.

Bacteriological Examination of Water. The presence of the most dangerous impurities in water, namely, germs, can sometimes be brought into view only by the use of *staining reagents*. Mr. Hankin thus describes the method of counting the number of *germs* or *microbes* in water: " The method of counting them depends on the fact that microbes whose presence in water we have to deal with can only grow in meat jelly. A small quantity of water to be tested is added and mixed with some melted meat jelly. The jelly is allowed to cool. Twenty-four hours later the jelly, which previously had been perfectly transparent, will be seen to contain numerous *white or yellow spots*. The reason for this change is as follows: When the jelly became solid each microbe was fixed at one point or other in the jelly, presumably separate from its neighbours. Each microbe began to grow and reproduce. Each parent microbe and the daughter microbes necessarily remain together, as they cannot move through the jelly. They thus form a small colony, which as time goes on becomes so large as to be visible to the naked eye. Generally these colonies are as large as small pinheads, and are as visible in the jelly as the small spots mentioned above. By counting the colonies we obviously arrive at the number of microbes present in the water added. If the bulk of this water is known, we can calculate how many microbes were present." This is called a bacteriological examination, and can be performed only by an expert in such matters.

FOOD SUPPLY

Food may be of either animal or vegetable origin with mineral matter added, as, for example, salt.

Animal Food consists chiefly of milk and its derivatives, such as butter, cheese and ghee; eggs, fish and flesh, such as beef and mutton; and the flesh of poultry, such as chickens, turkeys and geese, or of game, such as pigeons and teal. The fat of animals is largely used as food and for cooking purposes.

Vegetable Foods have been divided into six classes: 1st. *Farinaceous foods* or *cereals*, such as rice, wheat, barley, maize and millet. 2nd. *Pulses*, such as dal, peas and beans.

3rd. *Roots* and *tubers*, such as potatoes, beetroot, carrots, turnips, tapioca, arrowroot, and ground nuts. 4th. *Green vegetables*, such as spinach (sag), asparagus, brinjals, cauliflower and cabbages. 5th. *Fruits*, such as oranges, grapes, mangoes, lemons, guavas, papiyas and plantains. 6th. *Fungi*, a class of food to which mushrooms belong.

Food poisoning is often caused through eating unwholesome articles of diet, and a reference to some of these is necessary from the point of view of public health.

Meat of all kinds, in a state of decomposition, when consumed, causes severe internal pain, sickness, vomiting and diarrhœa resembling cholera. This form of food poisoning was formerly considered to be due to products of putrefaction called *ptomaines* (Gr. *ptoma*, a corpse), and the complaint is still generally spoken of as *ptomaine poisoning*. From careful investigations which have been made it may now be definitely stated that all such cases are due to *toxins* produced by bacteria contained in meat when it is eaten, and the term *botulism* is now applied to all of them no matter what the kind of meat may be.

Botulism (Lat. *botulus*, sausage) was formerly common in Germany, where sausages are largely consumed, and the disease has sometimes been spoken of as sausage poisoning for that reason. And since pork sausages are so much in demand it is not surprising that botulism should be so common after eating them, since the flesh of swine in a state of decomposition is the most often poisonous of all kinds of meat.

Owing to several cases of botulism having occurred four or more years ago at Loch Maree in Scotland, among visitors, of whom three at least died after eating meat paste preserved in "glass jars," considerable alarm was created throughout the country.

Botulism is a serious form of disease. "The death-rate is stated to be 30 or 40 per cent., and among those who survive recovery may be very slow " (Monro).

Shell-fish such as oysters and crabs are well known to cause not only severe stomach and intestinal disorders and an intensely itching eruption on the skin known as nettle-rash, but when obtained from sources polluted by sewage are a frequent cause of enteric fever.

Fruit in an overripe or decayed state or unripe is also a common cause of disturbance of the kind.

Milk enters largely into the diet of children and older persons alike both in health and sickness. Although most valuable as a food, milk, by virtue of the fact that the germs of disease grow, perhaps, more rapidly in it than in any other kind of food, is responsible, at times, for severe outbreaks of epidemic diseases such as cholera, enteric and scarlet fever. It is often, also, the cause of consumption of the bowel and other forms of tubercular disease. Finally, it should be noted that food may contain chemical poisons which cause symptoms to appear very soon after the poisons enter the stomach. The symptoms of food poisoning, on the other hand, may not appear for some considerable time after the food has been eaten.

How to Prevent Disease being conveyed through Milk. The milk of healthy cows only should be used. Water should never be added except when necessary in the case of infants and sick persons. Milk vessels should not be washed with dirty water. Boiling water only should be used for this purpose. Cases of epidemic disease occurring near dairies or places in which milk is sold should be immediately removed to some safe place for treatment. Cows should not be milked by people with dirty hands. Milk should always be boiled before it is used. Milk, as in the case of water, should not be kept standing too long after it has been boiled. It should be covered to keep out dust in which the germs of disease are, as we know, often carried, and also to keep out flies which may infect it.

The danger of the contamination of milk and all foodstuffs by flies should in particular be guarded against.

"Dr. Howard has estimated that, in a climate such as Washington, U.S.A., twelve generations of flies are born in a single summer, and calculates that in a single summer the descendants from a single fly might number 1,096,182,249,310,720,000,000,000,000" (O'Shea and Kellogg). *These appalling figures should, at least, convince public health bodies and the general public of the great necessity of waging war against flies in the interest of the general health of communities.* And it is the duty of health departments to issue instructions as to how this can best be done in order to achieve success.

Signs of Good Meat. The flesh and fat should be fresh, firm, tender, of reddish colour and healthy looking. Wholesome meat should not contain too much blood. The fat should be bloodless. Meat should be of the same quality throughout its entire substance. Softening, offensive smell, and greenish discoloration indicate that meat is bad and unfit for human use, and this applies particularly to fish.

Preservation of Foods. Food is sometimes preserved by freezing, or by currents of cold air, as in the case of the carcases of cattle and sheep. Cold storage is being more and more resorted to daily for the preservation of foodstuffs and their conveyance from one country to another many thousand miles apart. Food may also be preserved in ice. Alcohol, vinegar and other substances are often used for the purpose. Beef for the use of sailors is often preserved in brine. Drying is sometimes resorted to, as in the case of fish, vegetables and fruit. Foods of almost every description, such as milk, fish, fruit, and jams are also sometimes preserved in tins or bottles hermetically sealed after all the air has been expelled by heat. If gas escapes when a tin is opened the contents are bad, and bulging of the ends of the tins takes place owing to the pressure of the gas inside.

Great heat is required to destroy some disease germs, and as tins can be subjected to higher temperatures than glass jars, they are considered safest to use, apart from the risk of the food which they contain absorbing, though perhaps in small quantity, lead, tin or copper or other substances used in their manufacture. The bulging of their ends, when food is bad, also counts in favour of tins.

Adulteration of Food. Water may be added to milk or the cream may be removed and flour or other similar starchy food added to give the milk a thick appearance, or sugar or salt may be added. Plantains and meat fat and other substances are often added to butter, ground maize to flour, and sand to sugar. Ghee is often adulterated with ground-nut, cocoanut, or poppy oil. Arrowroot may be mixed with cocoa and chocolate, or the starch granules of potatoes, rice, sago, or tapioca may be used. Alum is often added to bread to give it a white appearance. Tea leaves are sometimes mixed with other kinds of leaves or with tea leaves which have already been used. These are a few examples of the manner in which food supplies may be adulterated. Of all forms of adulteration, that of milk with polluted water is one of the most dangerous.

INFECTIOUS DISEASES AND THEIR CAUSATION, PREVENTION, AND ARREST

Some infectious diseases are due to parasites introduced into the blood by the bites of insects; others are caused by worms or their eggs which get into the digestive canal in food or drink, or by eating with infected hands. But by far the largest proportion of them are due to minute living bodies known indiscriminately as bacteria, bacilli, microbes, micro-organisms, or germs. The use of the terms microbes and micro-organisms (Gr. *mikros*, small; *bios*, life) was originally accepted, as a compromise, when views differed as to whether single-celled organisms, when first discovered, were of the nature of plants or animals. Bacteria and bacilli, although in some respects different, belong to the same group of organisms. Both terms are regarded as implying the same meaning, and either is now used according to choice.

Bacteria. Until about one hundred years ago bacteria were not known to exist. The history of their discovery is interesting. It is a familiar fact that when water or other liquid, containing any kind of organic matter of plant or animal origin, is allowed to stagnate it becomes cloudy, and a scum of the nature of a fungus or mould forms on its surface. This scum, on being examined by the microscope when it was first used, was found to be swarming with single-celled living structures of different kinds, to which the term *protozoa* was applied (Gr. *protos*, first; *zōon*, animal). In the year 1835 the use of an improved and more highly magnifying microscope revealed the existence, in the scum, of organisms so minute in size as to have eluded previous detection. Because of their shape they were called bacteria (Lat. *bacterium*, a rod).

Distribution of Bacteria. Bacteria * are now known to exist in air, water, and soil, in food and drink, in *diseased* tissues of the body, in the contents of the alimentary canal, and even in sulphur springs and minerals. In short, they are found everywhere throughout the universe, and many hundreds of bacteria, all of which differ from each other, have already been discovered, and the list is constantly being added to.

* *See Bacteria: "The Illustrated Chambers's Encyclopædia."*

The Activities of Bacteria. By their action bacteria can produce pigments. The red scum which appears on the surface of stagnant pools, and which can be seen on the surface of the ocean and on sea-shores at times, is due to pigmentation. *Red-snow, red water-spouts,* and showers of what was superstitiously regarded as *blood-rain*, are all due to the activities of bacteria. Bacteria can produce light in the form of phosphorescence in dead fish. By the heat which they evolve in their action they may set up spontaneous combustion in hayricks and hop-granaries. They can cause the formation of marsh gas in stagnant pools, and, by an oxidising process, they help in the formation of iron-ore found in boggy soil, and of manganese and the pale yellow clay, known as ochre, which is used for making colour washes for the walls of houses. It is due, moreover, to the action of bacteria that butter becomes rancid, that milk turns sour and curdles, and wine ferments, that cheese becomes mouldy, and that toxins are produced in decomposing meat and offensive odours given off. On the other hand, there are some innocuous bacteria which, by their action, impart an agreeable flavour to certain classes of food-stuffs and improve their taste. But the most important purpose served by bacteria in nature is that, by their action, they bring about the decomposition of all dead and decaying animal and vegetable matter and change it into substances which provide food for plants. To quote from a contribution on the subject of germs, written by a biologist, which appeared in a recent London periodical, "were it not for the activities of these germs of putrefaction the earth would be encumbered with the dead bodies of its past generations, and there would be no room for the living."

Bacteria Associated with Infectious Diseases. Bacteria present marked differences in size and shape. In shape they may be round, oval, rod-like, etc., and some of them may be branched. The rounded forms may be so arranged as to resemble strings of beads. They may be straight, curved, or spiral, and some of them may be so twisted as to look like cork-screws. Bacteria, as a rule, multiply by division and ubdivision, and with great rapidity. Each bacterium divides into two; the two divide into four: the four into eight, and so on, until several millions of them may be present in a single drop of the liquid material in which they breed. It is said that under favourable conditions of temperature, etc., one bacterium may produce as many as 17,000,000 bacteria in twenty-four hours, and they are so minute in size that. according to Hankin, if sixty cholera germs were put in a row they would form a line the length of which would be equal to the thickness of a hair. It has also been calculated that if it were possible to string them together 25,000 would measure only ½ inch in length.

A temperature about that of blood heat is the most favourable to the growth of bacteria. They may be destroyed by great heat or great cold, and, in some instances, by exposure to sunlight. Cholera germs are killed in an hour by a temperature of 55° C., and more rapidly at higher temperatures. They have been found alive after being exposed for several hours to a temperature of −10° C. They are killed if kept in ice a few days. A 1 per cent. solution of lime kills them in an hour, and they are rapidly killed by drying (Muir and Ritchie). Some bacteria, however, produce spores or seeds which are not destroyed even when frozen or subjected to very high temperatures. And the spores, under favourable conditions, may at any time become active. When examined by a microscope bacteria may be seen to be kept in a constant state of motion by fine delicate thread-like structures or lashes, called flagellæ (Lat. *flagellum*, a whip). Some of them may be seen to clump together and form *colonies*.

Some bacteria can exist only in the free oxygen of the air, and are, for this reason, called *aerobic* bacteria; others cannot survive in free oxygen, and are, therefore, called *anaerobic* bacteria. They manufacture their own supply of oxygen from the material in which they live. The bacteria found in the scum on the surface of stagnant liquids and pools are aerobic. Those found beneath the surface are anaerobic.

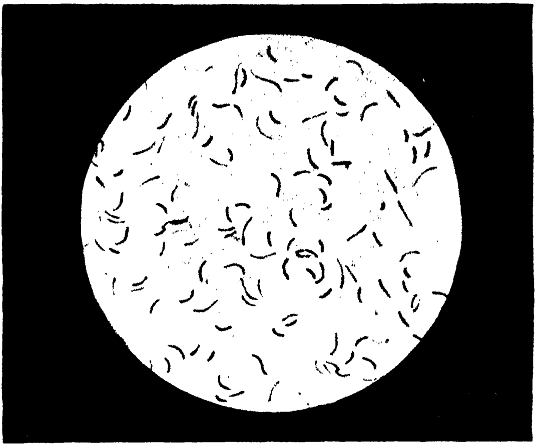


FIG. 65.—BACTERIA OF CHOLERA (× 1,500).

It is due to the action of anaerobic bacteria that the sewage, collected in septic tanks, is decomposed and ultimately purified and rendered innocuous.

Modes of Transmission of Infectious Diseases. These are:

(*a*) By contagion—*e.g.*, small-pox, anthrax, or wool-sorter's disease, diphtheria, syphilis, scabies or itch, and ringworm.

(*b*) Through the air—*e.g.*, small-pox, influenza, and tuberculosis.

(*c*) Through water—*e.g.*, enteric fever, cholera, and dysentery.

(*d*) Through food—*e.g.*, enteric fever, cholera, tuberculosis, scarlet fever, and diphtheria. Diphtheria may be spread by milk, and tuberculosis may be caused by eating portions of the infected carcases of cows, while tapeworm may be caused by eating infected pork.

(*e*) Through clothing—*e.g.*, small-pox, plague, cholera, measles, scarlet fever, and numerous other diseases of the kind common among children.

(*f*) Through the bites of insects, such as mosquitoes, fleas, bugs, and lice—*e.g.*, malaria, plague, yellow fever, typhus fever, and sleeping sickness. Kala-azar or dum-dum fever is also believed to be transmitted in this way.

(*g*) Through infected soil and stable manure—*e.g.*, tetanus. The bacillus of tetanus is *anaerobic*, and grows chiefly in soil and stable refuse. It is also, however, found in the intestinal contents of many herbivorous animals. Lacerated and punctured wounds, or even abrasions of the skin, are frequently followed by tetanus. If not properly sterilised, catgut ligatures which are made out of the intestine of sheep may be infected with the bacterium of tetanus, and so also may horse-hair ligatures.

(*i*) Through *flies*, which feed on filth and carry about bacteria on their legs, wings, and mouths. They are now recognised to be very largely, if not the chief, means of the spread of enteric fever and the summer diarrhœa of children through the infected discharges from the bodies of the sick. It is a well-known fact, too, that flies are mainly responsible for the continuous prevalence of serious affections of the eye in some hot countries. No less than 6,600,000 bacteria have been found in the body of a single fly by bacteriological examination (O'Shea and Kellogg). The female flies, about seven days after mating, lay their eggs in clusters, and, in a day or so, a *larva* (maggot) about $\frac{1}{3}$ inch in length is formed in each egg. It becomes a *pupa* in about two weeks and an *imago* or fully formed insect in about two weeks longer.

(*j*) Through *carriers*. Some individuals may be infected with bacteria or parasites, such as worms, and yet not appear to suffer in health in consequence. They may, however, convey the disease to others who are in good health and free from infection. Hence they are called "carriers." It is known that diphtheria, cholera, enteric fever, amœbic dysentery, and epidemic infantile paralysis may be conveyed by such carriers. Children who have been in contact with a case of diphtheria may carry about the bacteria in their air-passages, and yet not suffer from the disease themselves. They may, however, infect other children who are more susceptible to the infection, and epidemics of diphtheria in schools are often caused in this way, or one member of a family who is a carrier may convey the disease to other members. A parasitic disease with a big name, *ankylostomiasis*, but caused by small worms, often appears in the form of epidemics, and the disease is sometimes spoken of as "epidemic anæmia." Carriers are largely responsible for the spread of this disease, which is discussed more fully later on.

Conditions which Favour the Spread of Infectious Diseases. Infectious diseases spread most rapidly in badly lighted, badly ventilated, and overcrowded houses, and among people who are careless and unclean in their habits, where houses are too closely built together, as in bustees and slum areas of cities and towns where filth is allowed to accumulate, and where the water supply is polluted. In brief, infectious diseases prevail, mostly, among those classes of the community living under conditions in which the most elementary rules of personal and public hygiene are most flagrantly violated.

Specific Infectious Diseases. Some infectious diseases have been definitely proved to be *always* associated with, and caused by, distinctly different kinds of bacteria, and that each of these bacteria can cause one kind of disease only and no other. They are, for this reason, called *specific bacteria or organisms*, and the diseases of which they are the cause are known as *specific infectious diseases.* The following are examples—viz., anthrax, which was the first specific bacterium discovered: tuberculosis, cholera, plague, enteric fever, diphtheria, and tetanus. Altogether about twenty specific infectious diseases are known.

There are many other diseases of which bacteria, believed to be the cause of them, have been found; but they have not yet been proved to be the specific cause. And, besides these, there are numerous others which are, undoubtedly, infectious, but in which no bacteria, suspected to be the cause of them, have yet been detected. There is every reason, however, to assume, from their symptoms, the course they run, and their general behaviour, that even these diseases may be due to bacteria of such minute size as to be beyond the power of any microscope of the present-day type to detect.

Koch's Postulates. Before any bacterium can be stated to be the specific organism causing any form of infectious disease, the following conditions must be fulfilled—viz.:

1. The organism must be demonstrated in the blood or tissues.

2. It must be able to be cultivated in pure form.

3. The cultures must be able to produce the disease in healthy or susceptible animals.

4. The organisms must be found in the circulation or tissues of such inoculated animals.

Immunity from Infectious Diseases. It is a well-known fact that some persons are more liable to be attacked with certain diseases than their neighbours. On the other hand, some people are proof against certain diseases, and are said, therefore, to enjoy what is called an immunity to these diseases.

Natural or Innate Immunity is immunity which is inborn in some persons.

Acquired Immunity is conferred on others through having suffered from such diseases as small-pox and enteric fever. This form of immunity is not due to the disease itself, but to the effect of the products of the bacteria left in the system after recovery. Acquired immunity may be continuous throughout life. Attacks of some infectious diseases, such as diphtheria, pneumonia, erysipelas, and the "common cold in the head," do not confer immunity from the recurrence of future attacks.

Induced Immunity is that which is conferred by vaccination, as in the case of small-pox, or by inoculation in plague, cholera, enteric fever, hydrophobia, and other diseases.

Cause and Prevention of Cholera. Cholera is caused through the germs of the disease getting into the digestive system through contaminated water, milk, and other foodstuffs. Attendants on the sick should thoroughly wash and disinfect their hands before eating or drinking, otherwise they run the great risk of being attacked with the disease themselves. The vomited matter and the discharges from the bowels of the sick should be destroyed by burning, when possible, or mixed with a disinfectant at once, and carried to some distant spot where they can be safely buried deep in the ground. They should not, however, be so disposed of near any source of water supply. One of the most effective disinfectants is quicklime. It is rapid in its action, and it is cheap.

Anti-cholera Inoculation is a form of preventive treatment which has met with considerable success where it has been tried, and during outbreaks of the disease it is advisable to be inoculated. The operation is a simple one. A hollow needle, containing a small quantity of a carefully prepared fluid serum, is passed through the skin above the hip, and the serum is thus introduced into the system. The person inoculated may have a little fever and slight headache afterwards, but gets well in a few hours.

Cause and Prevention of Small-pox. Small-pox may be caused by contagion, or conveyed through the air or in clothing. If it were possible to avoid, in every possible way, exposure to infection, there would be no risk of catching the disease, but when small-pox is prevalent, there is great risk of doing so, owing to its highly infectious nature. The only reliable preventives are vaccination and revaccination. *Vaccination, we must understand, does not always protect against small-pox, nor, indeed, does one attack of small-pox protect against a second attack.* Every person should carefully remember these two facts. *If, however, vaccination has been successfully performed, the chances are that for a number of years, at any rate, the vaccinated person is (in the great majority of instances) proof against small-pox.* Vaccination should be performed in the early months of infancy, preferably between the ages of two and six months. If performed for the first time in grown-up persons, it may, in *rare* instances however, render active some ailment latent in the person vaccinated. This risk is trivial compared with the grave risk of small-pox being contracted by unvaccinated persons, and the consequences which follow small-pox are of much more serious moment. Even one insertion in vaccination affords a degree of protection, although the immunity may not last so long as when two or more insertions are made, and revaccination may be deemed advisable after a shorter interval. In England, under the orders of the Ministry of Health issued in August, 1929, public vaccinators are required to comply with the following rule:

"In all ordinary cases of vaccination or revaccination, the public vaccinator should vaccinate in one insertion preferably by a single linear incision or scratch not more than $\frac{1}{4}$ inch long merely through the epidermis. This incision should be made in the long axis of the limb. The lymph may be applied to the cleansed skin and the incision made through it, or the lymph may be applied to the incision immediately after the latter has been made. The lymph may be gently rubbed into the scratch with the side of the needle or lancet. In cases in which the public vaccinator or the vaccinee (or the parent or other person having custody of a child vaccinee) desires to obtain additional protection at one operation (*i.e.*, where the maximum protection against smallpox is desired, or where the circumstances make it especially desirable to avoid risk of failure), the public vaccinator may, if he considers it necessary, increase the number of such insertions. The number of insertions should not exceed four, and they should be placed so as to avoid coalescence of the resulting vesicles. The aim of the public vaccinator should be to produce successful vaccination with the minimum of injury to the tissues. In no circumstances should the vaccinated area be cross-scarified or cross-hatched.

"Opportunity should be taken by the public vaccinator to recommend that, in view of single-insertion vaccination, revaccination is advisable at an earlier period than if more insertions had been made than one."

Cause and Prevention of Malarial Fever. This disease is rampant throughout India, and the death-rate from it is very great. Moreover, much of the ill-health, poverty, and distress in rural villages, particularly, is due to malaria. It is now known that the disease is caused by a small animal parasite introduced into the blood of patients bitten by a special kind of mosquito called *anopheles* (Gr. *anōphēles*. hurtful or harmful). It is the female mosquito that conveys the parasite. Mosquitoes breed, chiefly, in districts and areas where the soil is waterlogged owing to the absence of proper drainage, or where there is none at all, and in streams and ditches which are obstructed in their flow. They also breed in tanks and wells and any hollow or receptacle in which water is allowed to stagnate. This explains the greater prevalence of malaria in rural districts and suburban areas than in cities and towns provided with a proper drainage system and constant water supply.

"In 1870 malaria was so bad in the Meerut Cantonment that it was nearly abandoned. A system of drainage was introduced at a cost of Rs. 1,50,000. Malaria is now practically non-existent; 900 lives are said to be saved yearly, and sickness has been greatly lessened, to say nothing about the consequent economic gain. All this is due to the abolition of pools of water" (Lukis).

But far greater and more successful results have been achieved throughout the world since Ross's brilliant discovery, about thirty years ago, that anopheles are the source of infection. The writer takes this opportunity of stating that he frequently sat beside Sir Ronald Ross in the primitive laboratory in which he carried out his researches in Calcutta, up to the time when his patient and unobtrusive efforts to solve the problem of the mode of the dissemination of malaria were rewarded with such well-deserved success. Ross's discovery has been of inestimable value to humanity. "Si monumentum requiris, circumspice," or as translated, "If you seek his monument, look around you."

Anopheles mosquitoes are, chiefly, found in villages where malaria is latent or indigenous among the inhabitants, and malarial parasites may be found in large numbers in the blood of children, apparently in good health, living in such villages. Wells are often their breeding-places, and the larvæ of mosquitoes can be seen in water drawn from them.

Many years ago, in Calcutta, when the attention of an old lady was directed to the presence of large numbers of young mosquitoes in a ghurrah of water she had just drawn from a well in the courtyard of her house, she cheerfully said, "They have no bones and can do you no harm." She did not realise the potential danger lurking in the larvæ left in the well on reaching their fully developed stage.

The following are some measures which have been recommended for the prevention of malaria:

Houses should be built on high sites, when possible, and the sites kept free from rank vegetation and undergrowth which interfere with the free perflation of the air and cause dampness. It is well known that malaria is most common at the foot of hills where there is the densest jungle and the soil is swampy. It is in such sheltered and damp places that the female anopheles breed most rapidly. O'Gorman strongly advocates the removal and burning of scrub jungle, twice yearly, for a radius of a mile around every malarial stricken centre of population, and since it is known that mosquitoes seldom fly a greater distance than a quarter of a mile, it is obvious that, if this suggestion were acted upon, much good would be effected. The removal of jungle, by burning or otherwise, has the further advantage of allowing the wind to blow freely and uninterruptedly. This handicaps the movements of mosquitoes, which seek protection from the wind by flying low.

With a view to the prevention of malaria in rural areas, E. H. Aitken, many years ago, in a report to the Government of Bombay, suggested that "when a new village is to be put up or an old one rebuilt, any site within a quarter of a mile of a hot season rice-field should be rejected absolutely."

Bentley has advocated the concentration, in healthier areas, of scattered village populations living among dirty tanks and in the midst of rank vegetation, and the carrying into effect of Sir Edward Buck's recommendation that river silt should be used for fertilising land and increasing cultivation. He also advocates subsoil drainage.

In the interest of the health of the inhabitants, it is of the utmost importance that villages should be provided with proper drainage, and that all hollows in and around them for a considerable distance should be filled up. Ditches choked with weeds and garbage of all kinds are a source of danger in that they form the chief breeding-places of mosquitoes. Every effort should be made, at whatever cost, to provide well-constructed and properly cemented surface drains which can be easily flushed and kept clean, and which allow water to flow through them freely. Where the use of cess-pools is unavoidable they, too, should be similarly constructed, and able to be readily cleaned out and kept clean. Further, all discarded tin-cans, broken earthenware pots, and other receptacles, in which water can collect, should be removed and disposed of at a safe distance from, and not allowed to be thrown about anywhere near houses. Even the hollows in trees should not be overlooked, as they form convenient places for mosquitoes to breed in. Water, moreover, should not be allowed to stand neglected too long in vessels inside dwelling houses, or in places in which animals are kept.

Tanks which cannot be drained should be kept as clean as possible, and their pollution guarded against. A thin layer of kerosene oil spread over the surface of the water in them effects the destruction of mosquitoes and their larvæ. Their destruction is facilitated greatly by keeping the tanks free from weeds.

Other measures advocated for the prevention of malaria are the prohibition of digging and excavating of earth or ponds, and the prevention of brick or tile making close to towns and villages (Birdwood).

When mosquitoes infest a house their destruction may be effected by burning sulphur or *pyrethrum*, which is a plant with a hot pungent root; or *naphtha*, which is distilled from *petroleum* and commonly called *tar-camphor*; or any of the derivatives of naphtha may be used. *Formalin*, which is one of them, is often used for disinfecting purposes, and is a good *insecticide*. While rooms are being fumigated no one should stay in them, as the fumes are irritating to the eyes and air passages. And the rooms should not be reoccupied until they have been well ventilated and the fumes got rid of.

Individuals may secure, in some degree, protection from the bites of infected mosquitoes by sleeping inside mosquito nets. Especially is this desirable in the night time when mosquitoes are most active. Even gauze windows and doors have been advocated as a means of escape.

Suitable clothing, puttees, and mosquito boots have been recommended for wear in malarious places by those who can afford to buy them, and those who cannot are to be pitied.

Protection may also be afforded by the isolation of persons suffering from an attack of malarial fever.

Finally, the more extensive use of quinine in malarious districts is strongly advised as the best means of preventing malarial attacks so far as medicinal treatment is concerned. The Italians have found that only 2 per cent. of those who take quinine have primary fever. This medicine can be bought at any Post Office in India, in 7-grain pice packets. An adult may take as much as 4 or 5 grains every four hours, or even larger doses at longer intervals, and young children 1 or 2 grains three times daily. There can be no doubt that of all remedies for malarial fever quinine has been proved to be the most valuable.

Ross gives 5 to 10 grains daily before breakfast.

Koch advised taking 15 grains on two successive days in each week.

Celli gives 4 grains every two or three days.

Liston gives 10 grains morning and evening once a week, or after specially fatiguing exertion.

Quinine destroys the sexual cycle of the parasites in the blood.

The following is the order in importance of the measures considered necessary for the control of malaria:

1. An attack against the malarial parasite itself in the human body by vigorous treatment.

2. An attack against adult mosquitoes by cutting away jungle and rank vegetation of all kinds, screening houses systematically, and killing the insects in dwellings.

3. Anti-larval measures.

Cause and Prevention of Influenza. Influenza is, perhaps, the most infectious of all diseases, and occurs in epidemic form at short or long intervals. The outbreak which occurred in 1918 was the worst that has ever been recorded, and the death-rate throughout the world the highest. No less than 5,000,000 deaths are reported to have occurred in India and Burmah alone. From 1892 the *Bacillus influenzæ* (Pfeiffer) had been, generally, believed to be the organism which causes the disease, although some doubt existed as to whether it was the *specific cause.* While this chapter was being penned, it was announced that Professor Falk, of the University of Chicago, U.S.A., with the help of eighteen co-workers had, after six years' intensive research, been able to isolate the germ which he had every reason to believe was the *specific organism* of the disease. Professor Falk, however, generously stated that, in his opinion, the organism was the identical streptococcus described in the year 1924 by two London doctors—Dr. David Thomson, bacteriologist, and Dr. Robert Thomson, physician, who are brothers. Owing to lack of facilities, however, the Thomson brothers could not carry their researches far enough to prove in terms of Koch's postulates (see p. 184) that the streptococcus which they had described and believed to be the cause of influenza was the specific organism. The main interest attached to the question, so far as the general public throughout the world are concerned, is that if the specific organism has been discovered it may be possible to produce an antitoxin or serum which, when introduced into the system, will induce immunity and prevent, in the future, such an appalling destruction of human lives as occurred during the epidemic referred to above. In the meantime such preventive measures as the isolation of the sick, strict cleanliness, and the disinfection and destruction of discharges from the nose and other respiratory passages, should be taken.

The following "hints and precautions," which were issued by Sir George Newman, Chief Medical Officer of the Ministry of Health, England, for the information of the public during the epidemic of 1918, may form a suitable conclusion to the observations on influenza:

Infection may be guarded against by—

1. Healthy and regular habits, and avoidance of fatigue, chill, alcoholic excess, crowded meetings and hot rooms and unnecessary travelling.

2. Good ventilation in work and sleeping rooms.

3. Warm clothing.

4. Gargling from a tumbler of hot water to which has been added enough permanganate of potash to give the liquid a pink colour.

In the event of an attack, the patient is advised with a view to a speedy return to convalescence and the avoidance of complications:

(*a*) At the first feeling of illness go home and go to bed, keep warm, and send for doctor.

(*b*) On convalescence avoid meeting-places and places of entertainment for at least one week after temperature has become normal.

(*c*) Recovery should be completely established before returning to work.

Cause and Prevention of Tuberculosis. This can, to a large extent, be effected by the removal of the causes which predispose to the disease. These are, among others, overcrowding, bad ventilation, insufficient and poor quality of food, exhaustion, wet and damp, bad drainage, and polluted

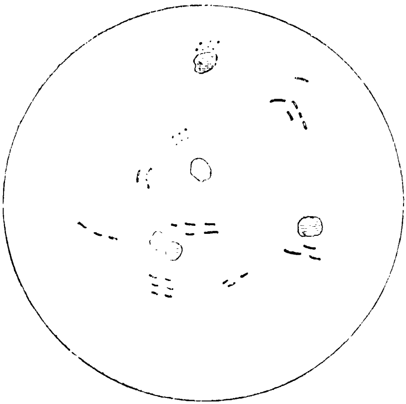


FIG. 66.—BACILLUS OF CONSUMPTION.

subsoil, alcoholic excess, and close confinement in badly-lighted rooms. An old Persian proverb says, "When the sun and air do not enter the physician enters often." While it is the duty of sanitary authorities to take action for the removal of many of these causes, individuals may do a great deal to protect themselves, in many ways, and more especially by being cleanly in their habits and observing the simple rules of health. Tuberculosis is, undoubtedly, spread chiefly by the filthy and dangerous habit of indiscriminate spitting. Spitting in public places has been made a punishable offence in France, Germany, Austria, and America. In America the penalties attached to it are very heavy.

In past times the habit of promiscuous spitting was so common in Great Britain that hardly a square inch of railway station platforms escaped being defiled. Now it is a rare occurrence to notice spitting in public places anywhere. The practice is, unfortunately, still prevalent to a large extent in India. It has been estimated that a cubic centimetre—that is, about 16 minims or drops—of tubercular sputum may contain 100,000,000 bacilli (see Fig. 66). These germs get into the air through coughing and speaking. The particles of sputum containing them may float in the air for fifteen minutes or an hour and a half. In a dry state they are carried about in dust, and get deposited on furniture or elsewhere, or they may be conveyed by house-flies. It is believed that the bacilli may remain virulent for two years in a dry state, and they are said to have resisted putrefaction when buried for two years. The dry sputum is largely responsible for the dissemination of tuberculosis; but soiled bed-linen, ordinary clothing, and handkerchiefs can also spread the disease. The following precautions should be taken in the case of patients suffering from tuberculosis:

1. Arrangements should be made to secure the freest possible ventilation and admit sunlight, and all furniture which is not absolutely necessary should be removed from the sick-room.

2. The patients should not be allowed to spit on floors. They should be provided with pieces of paper or rags, which should be burnt immediately after being used. In no case should they be permitted to use handkerchiefs. They should be instructed to cover their mouths during a fit of coughing. Suitable receptacles containing some liquid disinfectant may be used, and after being emptied they

should be cleansed with boiling water to which soda has been added.

3. The vomit and other discharges should also be disinfected and properly disposed of.

4. All dishes and feeding utensils should be kept separate *from those used by other members of the household, and after being used they should be at once plunged into boiling water.*

5. Soiled bedding and clothes should be put into a disinfecting solution before they are removed from the room to be washed.

6. Rooms should be kept clean and free from dust. Daily cleansing and disinfection of rooms is advisable, and the floors and furniture should have all spots of dirt and stains removed from them.

Rubbing with a damp cloth containing some disinfectant should take the place of dry sweeping and dusting, and the cloth should be put into some disinfectant after use.

Many kinds of reliable disinfectants can be purchased at any chemist's shop. When used they should always cover the sputum and other discharges.

Burning is the safest precaution to take in the case of soiled clothes and bedding, and all articles of the kind, of little value, should be so disposed of.

Other such infected articles should be boiled, and afterwards washed with soap and water. When this is done soaking in a disinfecting solution is not so necessary. It is always necessary, however, when the soiled articles cannot be boiled and washed at once. In such cases they should be soaked for twenty-four hours, or until they can be boiled and carefully washed.

7. Persons attending patients should be warned of the danger of infection, and instructed to carefully wash and thoroughly disinfect their hands before eating, and to spend as much time as possible in the open air, and not remain day

and night in the patient's room. They should, moreover, be told to keep at a safe distance when the patient has a fit of coughing (see Disinfection, pp. 208-213).

Health authorities in India, in conference, have recommended the following measures for the prevention of tuberculosis:

1. Sanatoria, which should be available at any time of the year.

2. Shelters at every dispensary, and that these shelters in the United Provinces should be protected on three sides from dust, wind, and heat.

3. Special wards in hospitals or hospitals entirely set apart for tuberculous patients to be used, mainly, for early cases of the disease.

4. Education of the masses in hygienic matters, generally, and instruction as to how to prevent the spread of tuberculosis.

5. The destruction of infected houses, and the construction of other houses to take their place. It was thought that less palatial colleges would serve their purpose, and that the money saved might well be devoted towards helping to carry this recommendation into effect. It was also thought that public and private effort might be relied upon to find any further funds that might be needed.

6. The use of tuberculin in selected cases to be used only by competent medical officers.

Cause and Prevention of Plague. Since plague, in epidemic form, broke out in Bombay over thirty years ago, many opinions have been expressed as to its mode of transmission. Dogs, cats, rats, mice, ants, flies, bugs, fleas, and lice have all been regarded with suspicion. So also have all kinds of food-stuffs, such as grain, ghee, oil, jaggery, milk, butter, curds, cocoanuts, and dates, infected by rats or other animals, and especially grain stored in places infested with rats. The belief that plague can be spread by direct contact through the skin or through the infected air of inhabited rooms, getting into the lungs of attendants on the sick, has also been held. And eating with unclean hands, and drinking out of vessels used by sufferers from plague, is believed to have been the cause in some cases. The sputum, vomited matter, and discharges of patients have also been regarded as causative agents. It is believed that immediately after, or even before, the death of plague-infected rats, the fleas on their bodies leave them and attack any warm-blooded animal within their reach, and that human beings are infected in this way.

At the beginning of the epidemic in India, Professor Haffkine visited some houses in Bombay in which there were 700 to 1,000 people living when cases of plague were occurring daily all over the ward. After studying the situation carefully, he made the following statement: "If an actually first case of plague is discovered in a big population, it is almost as easy to arrest its development as to put out a burning match; but it is hopeless to try to check it after the disease has spread," and concluded that other measures than the burning of sulphur in the streets were required. In view of the success of vaccination in preventing small-pox, Professor Haffkine set about trying to prepare a serum which he hoped would be successful in preventing persons inoculated with it from being attacked with plague. And his efforts were crowned with success. Authoritative medical opinion now is that inoculation offers the chief hope of combating the disease successfully, supplemented, of course, with the destruction of rats and other sanitary precautions.

Cause and Prevention of Enteric Fever. The germs of enteric fever are found chiefly in the discharges from the bowels of patients. They are also found in the urine during convalescence. It is known, too, that they may linger in the discharges of *carriers* of the disease for years after recovery from attacks. If allowed to lie in or about latrines, or elsewhere, the discharges get dried up and converted into dust, and in this form the germs may remain active for an indefinite length of time. The dust gets blown about by the wind and finds its way into tanks, wells, and houses, or it may be conveyed into houses on the bodies of flies. Water stored in houses and food supplies thus get contaminated. The chief precautions to take towards the prevention of enteric fever are personal cleanliness, clean surroundings, and the protection, in every possible way, of water, milk, and other food supplies. These precautions have been fully discussed in the chapters on water and food supply and the disposal of refuse, and need not, therefore, be repeated.

Inoculation with a *vaccine* has achieved considerable success in reducing the number of cases and deaths occurring among inoculated persons, as compared with those not inoculated. It is believed to be more effective when carried out some time before the person inoculated is exposed to the risk of being infected with the disease. Hence it is that non-immune persons leaving a country in which the disease is rare to go to one in which it is of common occurrence are advised to be inoculated before they proceed on their journey.

Cause and Prevention of Dysentery. There are two forms of dysentery—viz., *amœbic* and *bacillary*. The amœbic form is due to a parasite four times the size of a red blood corpuscle. The parasites are found in the bowel discharges, and have also been found in the walls of the bowel, in sputum, and in liver and lung abscesses. Amœbic dysentery prevails chiefly where large numbers of people live together and where there is insufficient ventilation.

Bacillary dysentery is caused by a small rod-like bacillus with rounded ends. It is believed to be the cause of epidemic dysentery in all parts of the world. It was discovered by Shiga in 1898 during an epidemic in Japan. The bacillus has been found associated with some forms of seasonal diarrhœa. The discharges from the bowel are the main cause of infection, and infected clothing, contaminated water, flies, and human "carriers" may spread the disease.

Among the measures which should be taken for the prevention of dysentery are the following:

1. The disinfection and destruction of the discharges from the bowel by burning if possible. Incineration is adopted in jails and other institutions.

Water should be boiled and vegetables well cooked.

3. Predisposing causes should be avoided, as, for example, changes of temperature which cause chills, overcrowding and bad ventilation, fatigue, and alcohol.

4. Thorough cleanliness in habits and otherwise, and the destruction of flies and their breeding-places. This is desirable at all times, but especially so during epidemics of the disease.

Inoculation is said to have been practised in Japan with much success as a preventive measure.

Emetine. The immediate use of this drug in cases of amœbic dysentery, as recommended by Sir Leonard Rogers who discovered its value and was the first person to use it, not only cures the disease but prevents the formation of abscess of the liver, which was formerly so common in India and other tropical countries after attacks of dysentery, but is of comparatively rare occurrence nowadays. Even in neglected cases where the formation of liver abscess has been suspected the use of emetine has resulted in complete recovery.

Cause and Prevention of Ankylostomiasis or Hook-worm Disease. The cause of the disease is a small nematode (Gr. *nema*, thread; *eidos*, form) which inhabits the upper part of the intestine and eats into its lining membrane. It is believed to live on blood obtained in this way through suckers. The female parasite is about $\frac{2}{5}$ inch in length, and the male rather less. The eggs of the parasites are found in the excreta from the bowels of infected persons, and as many as 4 million eggs may be found in each motion in bad cases of the disease. The eggs mature rapidly when the excreta are mixed with warm earth. When the larvæ escape they can live in water or mud for months. They become infective when they are only four or five days old.

Ankylostomiasis is also known as tropical anæmia, anæmia of miners, and sometimes as Egyptian *chlorosis* (Gr. *chloros*, pale green). The parasite is found almost everywhere, and affects mostly workers in mines and those employed in making tunnels and among brickmakers. Among this class of workers in Cornwall 95 per cent. have been found to suffer from the parasites, and in India 60 to 80 per cent. among this class of labourers. A Rockefeller Commission in one of their investigations found 97,632 sufferers among 165,866 persons examined. In 1915 Dr. Percy Rendall, the surgeon in charge of a steamer conveying 868 emigrants to Fiji, after careful investigation found that no less than 428 were affected with worms of one kind or another; 104 of them were infected with ankylostomiasis, 26 with thread-worm, 29 with tape-worm, 24 with round-worms, 2 with whip-worms, and 1 with what was considered to be a liver-fluke. These figures may be of interest, in this connection, as showing the great prevalence of parasites of the kind in the systems of certain classes of people.

It was formerly believed that drinking contaminated water, eating with soiled hands, and *earth-eating* were the chief sources of infection in ankylostomiasis. Loess, in 1898, however, showed that the infection could be introduced into the system through the skin. He described how the minute worms on escaping from the ova penetrated the

FIG. 67.

1. Ankylostoma duodenale (female). (× 14). 1*a*. Ankylostoma duodenale (female) natural size. 2. Ankylostoma duodenale (male). (× 14).

hair follicles, and in this way get into the veins and lymphatics, in which they are carried to the heart and lungs. He traced them from the air-passages of the lungs, into which they escape from the circulation, through the trachea and larynx, and thence through the gullet into the stomach and intestines. Although this may be considered a complicated method of infection, it has, nevertheless, been confirmed, and it is now believed that it is the chief mode of infection, and that infection by the mouth is comparatively rare. An irritation which is caused by the parasite when burrowing its way through the skin is known as "ground-itch." The feet, legs, arms and hands are mainly affected.

The preventive measures consist in the removal of conditions favourable to the hatching of the ova and the growth and development of the young worms. Proper sanitary conveniences should be provided, disinfectants freely used, and excreta carefully disposed of. Everything possible should be done to keep the surroundings from being defiled. The feet and legs should be protected by covering the legs and wearing boots and thick stockings. The legs, feet, arms, and hands should be kept perfectly clean, and more especially the hands, which should be thoroughly cleansed and disinfected before eating, and all patients should be isolated and receive treatment under medical supervision. Thymol has been found to be of the greatest value in the treatment of infected persons. Dr. Rendall, referred to above, in a communication on the subject, wrote thus: "Before I started this treatment with thymol, not one of the emigrants showed any of the classical symptoms of ankylostomiasis. Eucalyptus oil I found unreliable and inefficacious. Beta naphthol is very nauseous and, I think, dangerous. No patient to whom I administered thymol in full doses had a single symptom which in any way contra indicated its use. It was quickly and easily swallowed with a draught of water." And what is of great interest and worth recording, he further wrote: "There is no doubt in my mind that by ridding the intestines of entozoa (worm parasites) has in these emigrants prevented malarial attacks, and the use of thymol appears, on this voyage, to have made dysenteric diarrhœa, which in my experience is one of the most frequent diseases among Indian emigrants, as rare as cholera." Dr. Rendall's concluding observation was: "When I look at the four large septic teeth of the *Ankylostoma duodenale*, I cannot help thinking that the day is not far distant when people will cease to saddle all diseases on fleas and bed-bugs, but will pursue with unrelenting hate this *apache*, among entozoa, the *Ankylostoma duodenale*."

Lieutenant-Colonel Clayton Lane, I.M.S. (retd.), has recorded the fact of his having given, in the treatments and re-treatments of some 20,000 persons in Darjeeling, 50,000 doses of 60 grains of thymol without mortality or serious anxiety, and says: "It is the drug with the best record for safety." And in order to get the best effect from its use and avoid waste he advises the use of *powdered* thymol mixed intimately with an equal quantity of sugar of milk or bicarbonate of soda, so that the particles may be well separated, and thus prevented from forming masses and thereby losing their effect. Colonel Lane says that, as because thymol is soluble in alcohol and oil, their use should be interdicted during treatment, owing to the risk of absorption, and that the final purge, therefore, should not be oil ("Modern Technique in Treatment," *Lancet*, vol. iii., pp. 157-161).

Cause and Prevention of Kala-azar. This disease is known, also, as Leishmaniasis, Dum-Dum fever, Burdwan fever, and tropical cachexia (Gr. *kakos*, bad; *hexis*, condition). The causative agent is a parasite which was first discovered in 1900 by the late Sir William Leishman, whose views were confirmed by later investigations made by Donovan. The parasite has for this reason been termed the "Leishman-Donovan" body. The parasite is oval in shape, and varies in size from $\frac{1}{12}$ to $\frac{1}{8}$ inch. Most of the parasites are enclosed in cells. "Some of the cells are of large size. and may contain a hundred or more parasites" (Monro). The disease has a wide distribution. It is known to have existed, since 1869, to a large extent in Assam. It is also prevalent in many parts of India, Burma, Ceylon, China, the Malay Archipelago. North Africa, the Soudan, Syria, and Arabia. There are three forms of the disease—viz., Indian kala-azar, infantile kala-azar, and tropical sore. The parasites in the infantile form, which affects children mainly and prevails largely in places situated along the coast of the Mediterranean Sea, and the parasites in tropical sore differ in some minor respects from the Leishman-Donovan bodies, but are akin to them. They are known as the *Leishmania infantum* and *Leishmania tropica* respectively. *Indian kala-azar* is also called "black disease," because of the changes which take place in the skin of patients suffering from kala-azar. The symptoms which are manifested are fever, anæmia, enlarged spleen and liver, ulcers of the skin, and dropsical conditions. The disease may continue for several years, but in 80 per cent. of cases proves fatal.

Tropical sore is also known as Aleppo boil, Delhi boil, Bagdad sore, and Nile sore. This form of kala-azar is characterised by ulceration of the exposed parts of the skin and other lesions. Rogers and Patton are of opinion that the bed-bug is the means of transmission of the disease in India. Donovan is inclined to think that the plant-feeding bug is the transmitter. Quinine, when administered in the early stages of the disease, is attended with good results; but it is not curative. As, however, the generally accepted view is that bugs convey the disease, the best preventive measure is to take every possible precaution to avoid being bitten by these insects.

Cause and Prevention of Yellow Fever. This is a tropical disease which occurs chiefly in the West Indies, parts of

Mexico, and the West Coast of Africa. It prevails mostly in sea-port cities and towns, and follows the line of steamer traffic, and in this way has spread to European countries, in some of which it has assumed an epidemic form. No specific germ has yet been demonstrated to be the causative agent. But a species of mosquito—the *Stegomyia fasciata*—is known to be the transmitter of the germ whatever it may be. In 1902-1903 a United States Army Commission, after careful investigation, reported that "bacteriological examination of the blood during life, and of the organs and blood immediately after death, was negative." They at the same time were able to report that, "when the *Stegomyia fasciata* was allowed to suck the blood of a yellow fever patient, forty-one hours after the onset of the attack, the mosquito could, twenty-two days later, on biting a non-immune person, produce the disease in such person." Two other interesting points may be mentioned: (1) That the mosquito concerned does not, it is believed, bite except by night, and that, therefore, an infected locality may be visited with impunity in the daytime; and (2) that soiled articles do not transmit the disease, and that, therefore, if there are no mosquitoes about there is no risk attached to nursing yellow-fever patients. In view of the above observations, it will be apparent that the only hope of being able to prevent yellow fever lies in the extermination of the mosquitoes concerned in its dissemination (see Malaria).

ARREST OF INFECTIOUS DISEASES

The measures necessary for the prevention and arrest of infectious diseases to a large extent overlap. The preventive measures recommended in the different diseases discussed in the foregoing pages are precautions, many of which individuals can take themselves. There remain, however, for discussion other important measures which Public Health Authorities are, under legal enactments, required to take in most countries, with a view to the early arrest of outbreaks of infectious disease in the interests of the general community. They are as follow:

1. **Notification.** The London County Council have issued regulations under the Public Health (London) Act, 1891, and the Public Health Regulations of the Ministry of Health for the Compulsory Notification, to Medical Officers of Health, of any case of infectious disease occurring among school children. They have also in a summary indicated the period during which such children should be excluded from attending school, and issued orders for the exclusion of children living in infected houses, flats, and tenements. At present seventeen infectious diseases are notifiable under the London County Council Regulations, including small-pox, diphtheria, scarlet fever, typhoid fever, dysentery, malaria, erysipelas, and *all* forms of tuberculosis.

2. **Isolation.** This is the separation of infected from healthy persons. In every instance, where suitable accommodation is not available for isolation and proper treatment in private houses, patients should be removed to hospitals exclusively set apart for the reception of such cases. For the patient's own sake and in the interest of relatives, friends, and other people it is most desirable, in these circumstances, that hospitals should be made use of. It is, on rare occasions only, that any objection is raised to the removal of patients from their own homes by the poorer but educated classes in England and elsewhere, and even those who have heaps of accommodation in their own homes recognise the benefits which accrue from isolation and treatment in hospitals.

3. **Segregation.** It is considered advisable, at times, not only to isolate patients, but to prevent those who have been

in contact with them from associating with the general public until the risk of infection being conveyed by them is over. This is called segregation. In some instances persons who have travelled on steamers, for example, on board which infectious cases have occurred, are kept under observation, instead of being segregated, and required to present themselves to the Health Authorities, at regular intervals, for examination, or are visited at their places of residence so that they may be isolated at once in the event of their showing any signs of the disease themselves. They are kept under observation until the period of incubation has expired.

Disinfection has been defined as the destruction of the most stable known infective matter—that is to say, the disinfection of the germs of disease and their spores. The agents employed for effecting this object are known as *disinfectants*. Some chemical substances used merely restrain the growth of germs, and prevent fermentation and putrefaction, but do not destroy them. These agents are called *antiseptics*, of which borax and boracic acid, formerly much used for preserving food-stuffs, are examples. Other chemical substances merely mask or conceal smells. These are called *deodorants*. Examples of these are charcoal and camphor used in urinals, tar used for the walls and woodwork of latrines and receptacles for refuse, and chlorinated lime for latrines, drains, and cesspools. Regarding the use of disinfectants for sewers and drains, Dr. S. Rideal says: "The reagents are practically lost in the immense volume of water and fail to reach a proportion sufficient to destroy the bacteria, although they may partially remove the smell." Disinfecting powders sprinkled over gratings of house drains, he says, "are not only useless, but positively to be condemned, as it leads to a false idea of safety. . . . Chloride of lime," he says, "retains its power much longer than ordinary disinfecting powders; but even this is inefficient, has an unpleasant smell, and quickly corrodes gratings and pipes."

Such agents as permanganate of potassium, peroxide of hydrogen, formalin, and boracic lotion form useful gargles in septic conditions of the throat and for cleansing the mouth. And creosote, an oily distillate from wood-tar, is a useful antiseptic and deodorant in tubercular and other diseases of the lung when the breath is foul.

For disinfecting purposes on a large scale, fumigation with chemical substances and their use otherwise and heat are the agencies on which reliance is chiefly placed, and these may now be considered.

Fumigation. Fumigation with sulphur fumes, which was much in vogue some years ago for the disinfection of rooms, fell into disrepute because they were considered to be inefficient. Their efficacy, when associated with watery vapour, has now been clearly re-established. It is a cheap way of disinfection, although sulphur has the disadvantage of being injurious to articles of wearing apparel and other fabrics and to colours. For the disinfection of rooms Public Health Authorities, nowadays, chiefly use formalin, which is wood alcohol containing 40 per cent. of formaldehyde. The term aldehyde, it may be explained, is applied to a large class of compounds intermediate between alcohol and acids. Formaldehyde is also called formic aldehyde, because the acid (formic acid) contained in it was originally obtained from ants (Lat. *formica*, an ant). The prefix "al" in aldehyde is a contraction for alcohol, and "dehyde" a contraction for dehydrogenation.

It has been suggested that mixed vapours of sulphur dioxide and formaldehyde may have the advantage of not only destroying bacteria, but also of killing vermin, such as moths, fleas, and bugs.

Formalin tablets, each containing 15·432 troy grains of ormalin, are used extensively for the disinfection of rooms,

Fig. 68.

because they are convenient, and when used properly insure thorough disinfection. Twenty to twenty-five, when used in a suitable fumigator such as Lister's, or an "alformant" lamp, are sufficient to disinfect 1,000 cubic feet of room space, the time of exposure needed being three or four hours.

Before proceeding to disinfect a room the doors of all almirahs and cupboards should be opened and drawers emptied of their contents, and everything left lying loosely about the room. All openings in the room should be properly pasted over with some suitable paper. The walls, windows, doors, wood-work, and articles in the room should then be sprayed with water, and arrangements made to have the door leading from the room fastened as securely as possible to keep the vapour from escaping when the fumigator is put into action. And as formalin is very irritating to the eyes, nose, and throat, no one should enter the room, after disinfection, until it has been well ventilated and made safe to do so. It may be noted that a pint of formalin for each 1,000 cubic feet of room space, when evaporated in an open vessel over a bunsen or spirit lamp, serves the same purpose as the formalin tablets. Rooms are also, at times, disinfected by using sprayers, which are small hand-pumps, into which the disinfecting liquid is poured (Fig. 68). But no matter what means may be employed for the disinfection of rooms, the importance of sunlight, fresh air, and soap and water must not be overlooked.

Heat. This is the best disinfectant of all. The forms in which heat has been employed are by the direct use of the flame, by boiling, by the use of dry gas or vapour generated in a disinfecting chamber or stove, by steam vapour and steam, and by means of saturated steam confined under pressure in stoves. Hot air is objectionable, on the ground that the temperature necessary to destroy the germs of disease is so great that the articles to be disinfected would in most cases be destroyed. Dry heat, however, is useful for sterilising instruments in bacteriological laboratories. Leather and indiarubber goods are destroyed when exposed to great heat in any form. Prolonged boiling destroys almost all germs of infectious disease. For all practical purposes boiling is a safe and simple means of disinfection for ordinary household use. Boiling is also largely used for sterilising water and milk and instruments used for performing surgical operations. Moist heat such as boiling should be applied for three hours at a temperature of 100° C., or for twenty minutes at 115, to 120° C., or for fifteen minutes, three times, at intervals of twenty-four hours, at a temperature of 60° C. Sodium bicarbonate may be added to the water with advantage (Latham). The slowest method when adopted is used for converting spores into bacteria, which are more easily killed than spores. For the disinfection of bedding and clothing of patients, and the crew of a ship, or disinfection on a large scale, at any time, special arrangements are necessary, and these are made by the Health Departments concerned. Large steam disinfectors are provided, of which the "Equifex stove" is regarded as one of the best kind to use. The articles to be disinfected are put into a large wire cage, the door of the stove is shut and firmly fixed by means of screws. Steam under pressure, in order to get the greatest heat possible (a temperature far above boiling-point), is then admitted. After the expiration of half an hour, or less time even, the articles thus treated may be safely removed and used again. Every large city and town should be provided with some such appliance for public use.

Concluding Observations on Disinfection. The discharges from the bodies of the sick should be mixed with an equal quantity of a disinfecting solution and allowed to stand for half an hour, and then be burnt or buried. Solutions of carbolic acid, 1 in 5, mercuric chloride, 1 in 1,000, or other reliable disinfectant, of which there are many on the market, may be used. Dry earth, charcoal, chloride of lime, and carbolic acid powder are useful deodorants and cheap. As has been previously said, all articles of clothing, etc., of little value should be burned. Boiling, or at least soaking, infected clothing and bedding for twenty-four hours in a disinfecting solution, such as carbolic acid 5 parts to 100 of water, or bichloride of mercury 1 in 1,000, is an effective means of disinfecting such articles. After soaking they should be boiled and thoroughly washed with soap and water.

All rooms in which the sick are treated should be kept scrupulously clean and well ventilated. The room should contain as little furniture as possible. Clothes, mats, books, papers, etc., should be removed. Nothing should be taken out till disinfected, and this more especially applies to the discharges from the body. Nurses should always be dressed neatly and cleanly, and should be careful not to eat with infected hands. The spread of disease can also be checked to a large extent by personal cleanliness, avoiding overcrowding, by fresh air and light, and the lime-washing of houses inside and outside.

GARDENS, PLAYGROUNDS, AND OTHER OPEN SPACES

Judging from the closely built and badly ventilated houses, the narrow streets and the absence of open spaces in old cities and towns, the fact that fresh air and sunshine are as essential to health and life as food and water does not appear to have been recognised. And to make things worse some of the rooms in such houses have no means of proper ventilation, are dark and dismal, often overcrowded, and even used when food is being cooked. Although such conditions still exist everywhere, great improvements have been effected in many countries during recent years, and India has not been behind in that regard, as witness the great changes that have taken place in Calcutta, Bombay, Delhi, and other Indian cities and towns, and even in bustees situated within their boundaries. Old, dilapidated, and insanitary houses in slum areas have been demolished, and substantially built and sanitary houses constructed to take their place; streets have been widened and properly aligned. Adequate drainage and lighting and water supply have been introduced, and playgrounds, gardens, and other open spaces, which are aptly regarded as the lungs of densely populated cities and towns, have been provided where they were most needed. One of the most desirable, highly commendable, and appreciated innovations has been the reservation of well-laid-out parks, for the exclusive use of purdah-nashin and other Indian women and their women friends of other nationalities, to which they can resort for fresh air and recreation, and have such social entertainments as they think fit, without being disturbed by the madding crowd. Although improvement schemes of cities and towns involve a huge outlay, the benefits which accrue from them are inestimable and fully justify the cost.

Owing to high land-values, some of the most densely populated and insanitary areas of some cities, in which large improvement schemes have already been carried out, remain neglected. A typical example of the kind is *Bara Bazaar*, a rich trading centre in Calcutta, for the improvement of which the appeals of the general public, during the past thirty years or longer, have so far been in vain.

Gardens serve many useful purposes. They help to keep the air fresh, ventilate their surroundings, and admit sunshine. When used for the cultivation of flowers, they contribute largely to human pleasure and happiness, and provide a safe and healthy retreat from the dangers and noises of street traffic for all classes, and especially for aged persons and young children. Flowers, in their infinite variety of colour, kind, size, shape, and the arrangement of their leaves, afford a valuable means of cultivating the faculty of observation and discrimination on which mental development so much depends. Moreover, the cultivation of gardens, whether with vegetables or flowers, is an agreeable and healthy occupation, and owners of small gardens find it a convenient form of exercise and recreation.

The London County Council and other public bodies elsewhere in Great Britain and other countries have, during recent years, built many thousands of houses, on modern sanitary principles, for the working classes, in healthy areas where land is comparatively cheap, and as near as possible to their places of employment. Each house has its own plot of ground, in front and at the back, and the occupants of the houses vie with each other in cultivating and keeping them neat and tidy. The display of flowers in front of the houses not only adds to their own pleasure, but are a source of pleasure and admiration to passers-by. The houses have an upper and ground floor, and are attached to each other mostly in ranges of six, with open spaces between the ranges, while large open squares are distributed freely among the houses.

Playgrounds, though primarily intended for the purpose of enabling children and others to take exercise, are useful breathing spaces, and help to keep the air of the localities in which they are situated fresher than it would be otherwise. They are specially of benefit to children of the poorer classes living in overcrowded and slum areas in the centre of cities and towns, who cannot make use of the large public parks in the suburbs or in rural areas. Fresh air, play, and exercise are essential to the physical and mental growth and development of children, and games appeal to them more than gymnastic exercises. Hence their value, at schools, in places where there are no other open spaces. In selecting sites for playgrounds, and especially for school playgrounds, clayey soils should be avoided when possible. Such sites are damp, and if not properly drained are liable to become waterlogged or even flooded if on low ground. Diseases, such as rheumatism and tuberculosis, are common in places where the soil is damp, as are also mosquitoes, which, as is well known, convey the malarial parasite through their bites. High sites, with porous soils, should always, therefore, be preferred.

The subsoil water level should not be less than 15 feet below the surface of the ground. School playgrounds should be large enough to provide not less than 30 square feet for each scholar, and their relative position such as will insure the benefit of the prevailing winds. They should be level, properly drained, and kept in good repair, and free from hollows in which water may collect and stagnate, and form breeding-places for mosquitoes. They should, moreover, be enclosed by a wall or railing so constructed as to interfere as little as possible with the free perflation of the air. Gravel or gravel and sand are considered to be the best covering for playgrounds.

"A hard covering, such as asphalt or stone-flagging, has the disadvantage, as has been pointed out by a French authority, of restricting children in their movements and thus depriving them of full opportunities for the co-ordination of muscles and the more exact and perfect development of their physical powers. Jumping, which is likely to be indulged in by boys and girls as well, leads to more or less injury when the surface upon which the pupil jumps is hard and unyielding, as in the case of flagging or very hard asphalt" ("School Hygiene," by Professor Edward R. Shaw).

All playgrounds should be provided with sheds for shelter from rain and excessive heat of the sun, as occasion may necessitate. They are particularly needed at schools to enable the children to get some form of exercise when weather conditions are such as to prevent them using the playgrounds. Provision should be made for the extension of the playgrounds if it should become necessary.

The question of providing playing fields for boys and girls at elementary schools in England is, at present, receiving the attention of the Board of Education. It is suggested that to meet the requirements of schools in the centre of large towns, which ordinary means of transport cannot bring within reach of playing fields, class-rooms should be provided on the fields. In this way classes may spend a whole school-day at the fields, and receive instruction when not playing games. Experiments have been made by three education authorities. In one a pavilion, with two class-rooms to accommodate fifty boys and fifty girls, has been provided, containing also cloak-rooms, kitchen, radiator, and a store-room, at a cost of £1,900. This pavilion is used by six schools.

MODERN MOVEMENTS FOR THE EDUCATION OF SOCIETY IN THE LAWS OF HEALTH

THE most important of these movements are maternal and infant welfare work, the object of which is to try to reduce the high death-rate among mothers and infants at childbirth, or ailments occurring afterwards, the welfare of children until they begin their educational careers, and educational hygiene.

Maternal and Infantile Welfare. Professor Dame Louise McIlroy, in an address* delivered to the Glasgow and West

* *British Medical Journal*, February 15th, 1930.

of Scotland Branch of the British Medical Association on October 25th, 1929, said: "We can never be Utopian enough to hope to eliminate deaths from childbirth; but we can reduce them considerably. This is the faith of all those who are concerned with maternal welfare." She drew attention to the fact that in Scotland, in 1928, the maternal mortality was 7 per 1,000, and observed: "If over 27,000 lost their lives in England and Wales in the last ten years because of pregnancy or childbirth, we cannot but feel that some of these deaths were due to inadequate treatment of the patient"; and added: "It is not only the death-rate we are concerned with, but the enormous amount of ill-health among women which is due to unskilled aid during pregnancy and childbirth."

Professor McIlroy suggests that, because of more efficient registration, nowadays, the true facts about maternal mortality are better known, and may, to some extent, explain the small progress that seems to have been made during the past twenty years in trying to reduce it. In her address reference was made to Dr. Jellett, formerly in charge of the Rotunda Hospital, Dublin, as having written from New Zealand, where he is now in practice, that during the five years preceding 1898 the maternal death-rate at that hospital was 3·1 per 1,000 only, although the importance of asepsis was not understood then so well as it is now. Dr. Jellett ascribes the low mortality at that time to limited interference during childbirth, and still strongly advises as little intervention as possible and scrupulous regard to aseptic precautions to insure freedom from infection.

In a lecture on antenatal, natal, and post-natal problems* —that is, maternal welfare before, during, and after childbirth—Dr. W. H. F. Oxley gives statistics showing the

* *British Medical Journal*, February 15th, 1930.

maternal mortality in the East End Maternity Hospital, London, throughout its history. From 1884 to 1928 the number of in-patients was 22,383, and the number of deaths forty-seven, or 2·10 per 1,000. From 1890 to 1928 the number of out-patients attended was 27,184, and the number of deaths twenty, or 0·74 per 1,000. Thus, for the whole period, on district and hospital combined, the death-rate was 1·35 per 1,000.

During 1929, at the General Lying-in Hospital, which is situated in one of the poorest and most congested areas in London, there were 2,113 childbirths and no maternal deaths.

In a recent contribution to a monthly journal,* mainly devoted to the discussion of Indian affairs, on the Welfare of Indian Women and Children, Dr. Margaret I. Balfour C.B.E., gives the following figures showing the mortality, of mothers in Madras, Calcutta, and Bombay in the year 1926:

MATERNAL MORTALITY IN CHILDBIRTH.

Madras	15 per 1,000 live births.
Calcutta	38 ,, ,,
Bombay	13 ,, ,,

as compared with a maternal mortality of 3·9 per 1,000 for England and Wales in 1925.

The high maternal mortality in India is acknowledged to be due, chiefly, to early marriage, which the late Dr. Mohendra Lal Sircar regarded as the greatest evil in India. And at a public meeting he said, " From medical observation extending over thirty years he could say 25 per cent. of Hindu women died prematurely through early marriage, 25 per cent. more were invalided by the same cause, and the vast majority of the remainder suffered in health from it."

* *India*, vol. iii., No. 6, December, 1929.

More recently, in an address delivered at a Social Congress at Bombay, His Highness the Gaekwar of Baroda remarked: "It is not necessary for me to dwell upon all those familiar questions which cluster round the question of the status of women. I would merely point out that early marriage must increase death and disease among the mothers, swell infant mortality, and injure the physique of the race. It interferes also with the proper education of women."

Dr. Balfour, in her article, cites an interesting inquiry relating to maternal and infantile mortality in the towns and villages of Murshidabad, Bengal, extending over a period of five years (1917-1921). Regarding the results of the inquiry, she observes: "If it were taken as correct for the whole of the country, it would mean that India loses 100,000 mothers annually during childbirth, and that about 2 million babies die during the first year of life."

Besides early marriage, physical malformations and diseases, which may develop in expectant mothers, are to a considerable extent responsible for both maternal and infant deaths, either during childbirth, or, in the case of infants, in the early years of life, owing to their enfeebled condition when born. With a view to ascertaining to what extent diseases occurring in expectant mothers might be responsible for the high maternal death-rate in India, Dr. Balfour refers to an interesting inquiry begun four years ago in Bombay. "A questionnaire was sent to All-India Maternity Hospitals, and records were kept in the Bombay hospitals. It was found that the greatest single cause of mortality was an acute form of anæmia which attacked expectant mothers a few months before childbirth." To what extent infantile mortality may be influenced by disease occurring in expectant mothers is not known, but Dr. Balfour suggests that it also would form a suitable subject for inquiry.

Maternal and Child Welfare Centres. These are institutions which have been established, within recent years, for the purpose of giving medical aid to certain classes of women and children whose circumstances are such that they may be unable to get such aid otherwise. In England some of these centres are administered by Borough Councils. The funds necessary to defray the cost of their maintenance are derived from municipal rates and grants from the Ministry of Health. *Voluntary centres* have been established elsewhere. These are under the control of the Ministry of Health, from which grants-in-aid are received. Voluntary contributions are depended upon to make up any deficiency in the cost of their maintenance. Special medical officers attached to these centres advise mothers as to the feeding and clothing of infants, and other matters relating to their health and upbringing, and give advice to the mothers themselves when they are in a poor state of health. And supervision is exercised over the health of the children until the age when they go to school. Provision has also been made for the care of expectant mothers at these centres by the establishment of antenatal clinics, at which they can obtain expert medical advice and be kept under observation until childbirth. During their attendance the existence of physical defects, or the development of disease of any kind, can be detected early, and steps taken to prevent any untoward occurrence before or during childbirth. Advice is also given to expectant mothers as to the diet most suitable for them, the kind and amount of exercise they should take daily, and when they should rest. And stress is laid on the importance of fresh air and sunshine, well-ventilated rooms, cleanliness of their homes and surroundings, and personal cleanliness and regular habits. These antenatal clinics are much appreciated and becoming more and more popular daily. And authoritative opinion is to the effect that they have resulted in a remarkable reduction in maternal death-rate.

Professor Dame McIlroy regards them as being of the greatest value, and ascribes the comparatively low maternal mortality of 2·7 per 1,000 at the Royal Free Hospital, for the last eight years, to antenatal care.

Dr. Oxley gives the following figures, showing the maternal death-rate in the East End Maternity Hospital for the periods before antenatal work was begun and afterwards:

Period.	*Cases.*	*Deaths.*	*Rate per* 1,000.
1884–1913	19,584	37	1·9
1921–1928	17,525	12	0·68

And he adds: "The institution of full antenatal work with compulsory attendance has been followed by a drop in the already low mortality to a third of its former level."

Dr. Gilbert I. Strachan, of the Cardiff Royal Infirmary, in a paper* read before the South-West Wales Division of the British Medical Association on December 18th, 1929, began with a reference to antenatal work which, he said, "needed no stressing at this time of day when a large and constantly increasing experience has demonstrated not only to the medical profession, but also to the lay public, the enormous value of antenatal care in saving maternal and infantile lives."

Attendance during Childbirth. In former days any old woman was considered good enough to attend cases of childbirth. In Scotland the village midwife was known as the "howdie," a term which is thought to have been derived from "How d' ye ?" the midwife's first question. This class of midwife is now non-existent in any country where

* *British Medical Journal,* February 15th, 1930.

the dangers of unskilful aid and the importance of scrupulous cleanliness and care are recognised. In England duly qualified medical practitioners or highly trained and certificated maternity nurses only are allowed to take sole charge during childbirth, and in cases of difficulty or emergency, maternity nurses are required, under the rules of the Central Midwives Board, which is constituted to carry out the Provisions of the Midwives Acts, to call in the help of a doctor. When a doctor is in attendance uncertified women, known as " handy-women," may, if considered competent, because of experience in nursing and at childbirth, be employed to help in any way they can. But the propriety of employing such women depends upon whether or not the services of a certificated nurse are available, the ability of the persons concerned to pay for the services of such a nurse, and on the fulness of the responsibility of the doctor and the actual attention he himself gives during and after childbirth. It is illegal for such women to take sole charge of a case of childbirth under " cover " of a doctor, and any doctor allowing this to be done would be liable to have his name removed from the Medical Register.

Maternal and Child Welfare in India, based, more or less, on Western ideas, began about the year 1913. The following brief history of its introduction, culled from Dr. Balfour's article, is given here for the convenience of those who may be interested in the matter, but may be unable to refer to the periodical in which the article appears.

The first step taken was when Lady Willingdon opened Maternity Homes at Bombay, and organised a system of house-to-house visiting.

In 1914 two health visitors, with special qualifications, were appointed to organise the work in Delhi as a first-class centre, as a model for similar work in other parts of India. This proved a great success. In 1918, in order to provide trained workers, a training school, under the superintendence of the health visitors, was started at Delhi, and since then trained workers have been appointed to posts in different parts of India. The late Sir Pardey Lukis, then Director-General of the Indian Medical Service, was mainly instrumental in the institution of this scheme.

In 1926 the Lady Reading Health School was opened as a permanent training school, and about the same time the Ram Chandra Lohia Infant Welfare Centre for the welfare of mothers and babies in Delhi and the training of students was founded. At first everything went well, but owing to the lack of financial support later, the scheme for subsidising the work may be said to have practically proved a failure.

In 1920 a Maternity and Child Welfare Exhibition was organised at Delhi. Dr. Balfour, with regard to this exhibition, says: "Pains were taken to insure that this should be of an All-India character, and delegates were invited from all parts of the country; a conference of doctors, health visitors, and nurses was held—the first of its kind in India; and there is no doubt that the principle of prevention laid down there soon began to be better understood by workers throughout India."

In the same year Lady Chelmsford, through funds collected by her, announced the formation of the All-India League for Maternity and Child Welfare. Branches of the League were formed in the different provinces, and, Dr. Balfour says, "from that time onwards centres began to multiply."

In 1924 the late Lady Reading inaugurated the National Baby Week, regarding which Dr. Balfour says: "None of the schemes for child welfare has proved so popular as this," and considers the rapidly growing interest in child welfare and the growth of new centres as a direct consequence.

Even before the inauguration of Baby Week, Dr. Balfour states that the Red Cross had turned to child welfare as a suitable field for its peace-time activities, and had decided to devote some of its large funds to that purpose, and adds, "the Lady Chelmsford League and the Red Cross jointly organised the first Baby Week."

Dr. Balfour gives the following figures, showing the infant mortality in Madras, Calcutta, and Bombay during the year 1926:

Madras	279 per 1,000 live births.		
Calcutta	317	,,	,,
Bombay	419	,,	,,

compared with an infant mortality of 70 per 1,000 in England and Wales in 1925. And in referring to the high maternal and infant mortality in India, she directs attention to the fact that, except in the United Provinces, where a medical woman has been appointed by Government to supervise and organise it, maternal and child welfare work comes nominally under the Public Health Department. It may be concluded, however, from what follows, that the Public Health Departments in India are fully alive to their responsibility in the matter, although no doubt a special department to deal with maternal and child welfare work might achieve more satisfactory results.

In his report for 1928 Major C. M. Ganapathy, I.M.S., Director of Public Health for the Central Provinces and Berar, states that the infant death-rate in that district was over 238 per 1,000, and again higher than any other province, and adds that nearly one-third of the total mortality of the district was due to the deaths of infants under one year of age. It may be concluded, therefore, that the infant death-rate in Madras, Calcutta, and Bombay has considerably decreased since 1925. Major Ganapathy states in his report that, during the year 1928, fourteen new infant welfare centres were established, bringing the total of these institutions to thirty-five at the end of that year, and that the establishment of additional centres is contemplated. The following further observations in the report, relating to the efforts being made to make maternal and child welfare in the Central Provinces and Berar a success, may be regarded as of sufficient interest to justify their inclusion in this chapter.

A nursery school was opened in Nagpur to continue the care of children from infancy until the school-going ages and to maintain continuous health supervision. At some of the infant centres arrangements are in force for training native midwives, who are paid for attending the classes; they subsequently enter for examinations, on passing which they are registered and receive certificates. In the year under review eighty-eight midwives were being so trained, and it is hoped that the scheme will extend considerably. Antenatal clinics have been instituted in the centres wherever medical supervision can be obtained. In order to meet the demand for trained health visitors to take charge of these centres a well-equipped health school under medical control was opened in August, 1928. Health propaganda work was continued throughout the year, and baby weeks were organised in several towns. A large number of municipal committees gave financial and other support to women engaged in conducting labour cases and visiting houses where children had been born. Important factors in infant mortality are recognised as being ill-informed interference by untrained midwives and the lack of proper post-natal care; it is believed that the preventive measures being taken will soon make their influence felt.

The Organisation of Maternal and Child Welfare Work. Dame Janet Campbell, D.B.E., M.D., Senior Medical Officer for Maternal and Child Welfare to the British Ministry of Health, on the invitation of the Prime Minister of Australia, made an inquiry, in 1929, into the organisations for maternal and child welfare throughout that Commonwealth. In her report emphasis is laid on the excessive maternal mortality —nearly 6 per 1,000—though it is stated that the infantile death-rate is decreasing to a gratifying extent. The main recommendations made in the report, which might well be adopted in connection with schemes for maternal and child welfare elsewhere, are as follow:

1. The establishment of an appropriate division of the health department.

2. The subsidising, extension, and improvement of maternal, infant, and child hygiene work.

3. The encouragement and subsidising of relevant research.

Dr. Campbell adds, "Voluntary agencies must prepare themselves to surrender, for the greater good, some portion of their, perhaps, over-cherished independence."

The Education and Hygienic Welfare of School Children. Nowhere, perhaps, has more been done in this regard than in the huge and densely populated area under the jurisdiction of the London County Council, which is the central co-ordinating health authority, and exercises administrative control of the health and general welfare of school children. Special medical officers are employed to regularly inspect the children and see that they receive proper care and treatment when necessary. And during convalescence from illnesses, children are frequently sent, at the expense of the Council, to seaside places or holiday homes in the country to recuperate. The medical officers are also required to see that the health of the children is in no way affected, prejudicially, by the existence of sanitary defects in schools, such as insufficient space and consequent overcrowding, bad ventilation, bad lighting, inadequate heating during cold weather or by insanitary surroundings, want of exercise or play in the open-air or by excessive school work. Particular regard is paid to the physical condition of the children, on which their mental development so largely depends. If found to be suffering from defective eyesight or hearing, or diseases of the eye, ear, throat, nose, or skin, or from bodily deformities of any kind, they are sent to hospitals or clinics where they can obtain appropriate treatment. Children suffering from sore-throat or skin complaints suspected to be of an infectious nature are at once separated, and suitable measures taken for their own safety and the protection of other children in the school.

Similar arrangements as the above are made for the welfare of children attending schools in other cities and towns, and in the rural areas of counties. Observations under this heading would not be complete without reference being made to headmasters, headmistresses, and other members of the teaching staff of schools, who fully realise their responsibility, and do everything in their power to maintain, at a high level, the health of the children in their charge.

School-going Age and its Effect on the Health of Children. In England children begin to attend school at the age of five years. Regarding the effect which going to school for the first time has, Mr. Dumville in his book on "Child Mind" writes: "It is probable that the sudden change from the comparative freedom of home-life to the more restricted life, with respect to both thought and movement, which even the most modern schools involve, makes too great a demand on the child, so that he suffers both mentally and physically. The rate of mortality has been found to increase during the first school year." Mr. Dumville suggests that weakly children should be leniently dealt with and not forced to work like others, and generally that teaching conditions should be much less rigid than they usually are. Referring to the system of education developed by Madame Montessori, a great Italian educationist, Mr. Dumville gives a long quotation from an account of her schools in which each child is given "the maximum of freedom that is compatible with his not hurting or incommoding others; and as long as he is busily and suitably employed, he is not likely to hurt or incommode others, or to make himself a nuisance to the school as a whole." Another interesting quotation from "Child Mind" is the following:

"Mr. Winch has demonstrated, after careful investigation, that early entrance to school is not advantageous to intellectual progress. When children were tested at the age of seven to eight, it was found that those who had been at school since the age of three produced results which were no better than those of the children who did not commence school before five. Early entrance to school, then, is of no advantage even with respect to progress in the school subjects. With respect to general intellectual progress, it is probably harmful. For it tends, as we have seen, to produce retardation in bodily growth; and although the correspondence between physical excellence and intellectual ability cannot be demonstrated at all points and in every individual case, it has been found that on the average this correspondence is very marked. The brighter children, as a whole, are bigger than the duller ones. In early education, therefore, whatever else we do, we should make certain that the child leads a life of healthy bodily activity."

If early going to school serves no other useful purpose, it at least keeps children out of mischief at home and relieves the responsibility of their mothers during school hours. In many cases also it enables children to enjoy the benefit of school games, drill lessons, and breathing exercises, and of fresher air during school hour intervals than is possible in their own homes and their surroundings, and all this is to their good.

Education and Hygiene in India. Nearly thirty years ago a committee appointed by the United Provinces Government (India) submitted an interesting and exhaustive report on Educational Hygiene, with special reference to colleges, hostels, and schools throughout these Provinces.* Regarding the teaching of hygiene, the Committee observed:

"The provision of hygienic surroundings in schools is of the highest importance in the teaching of the elements of hygiene. It is of little use to teach dogmatically the advantages of clean and wholesome surroundings where such are not provided. The impressions of childhood are deep and lasting, and it is necessary therefore that they should be in all respects sound. Neatness, tidiness, cleanliness, freshness of atmosphere, punctuality, and orderliness in school, leave impressions on scholars which are likely to have lasting effects in their after-life. The hygienic conditions of the schools should, therefore, in all cases, be of a vastly higher standard than those to which the scholar is accustomed in his own home. Teachers also must show to their pupils that they practise what they preach, and that they themselves are tidy and clean in their person and clothing, punctual and orderly in their work, and of good moral character. They should in their own lives carry out the precepts of hygiene which they themselves have been taught."

The Committee in their report recommended the periodical examination of the sanitary condition of all Anglo-vernacular schools, colleges, and hostels, and suggested the appointment of medical officers for the health inspection of children, with special reference to eye diseases, infectious diseases, skin diseases, malaria, and tuberculosis, and the administration of quinine in malarious areas. With regard to school work the Committee summarised the causes which affected the health of scholars injuriously as follow: Unhygienic surroundings, unsystematic and irregular work throughout the session and serious overwork and cramming for a few months prior to the annual examinations, and the want of

* *United Provinces Gazette*, September 25th, 1913.

regulation of work during actual school hours, and undue length of hours of home work necessitated largely by ineffective tuition during school hours. With regard to mental fatigue induced through long spells of instruction, the Committee observed that in England authorities are agreed that the time during which children can fix their attention is very short. For example, a child of six can fix his attention for fifteen minutes, children from seven to ten for twenty minutes, from ten to twelve for twenty-five minutes, and from twelve to sixteen for thirty minutes. Based on these considerations the Committee recommended for general adoption the following scheme for the duration and the subdivisions of school hours for both boys and girls:

"I. *Preparatory sections A and B* should have a total of three hours' school work, divided into half-hour periods with five-minute intervals, and a half-hour play interval after the fourth period. This would mean a total of three hours and fifty minutes in school.

"II. *Lower primary sections I. and II.* should have a total of four hours, divided into half-hour periods, with five-minute intervals, and a half-hour play interval after the fourth period, making a total of five hours in school. If the school day be for any reason divided into morning and afternoon periods, the half-hour interval should be extended accordingly.

"III. *Upper primary sections III. and IV.* should have a total of four and a half hours' school. In these sections also, the Committee is strongly of opinion that the time should be divided as above into half-hour periods with five-minute intervals whenever possible, and that there should be at least half an hour play interval after the sixth period. This provides for a total time of five hours and thirty-five minutes in school.

"IV. *Middle and high schools* should have five working hours. In these the time should be divided into six periods of not more than fifty minutes, with five-minute intervals, and a forty-minute interval, preferably after the fourth period. This provides for a total time of six hours in schools."

The Committee suggested that the five-minute intervals should in all cases be utilised for the thorough ventilation of class-rooms by throwing open all doors and windows, and that headmasters should impress the necessity for this on their staffs, and that no one should be allowed to remain in the class-rooms during these intervals. The Committee were of opinion that by allowing five-minute intervals between the periods above prescribed, the scholars are enabled to have a brief but sufficient relaxation, mental and physical, and are thereby better fitted to put their minds to work during the actual working periods, and that the better the quality of work during actual working hours the less would be the necessity for home lessons.

The Committee further suggested regular and continuous physical training, and that half an hour each schoolday should be devoted to prescribed drill and exercises, in each class, in the open-air or, during wet weather, in rooms with the windows open, and in such clothing as would allow the greatest freedom of bodily movements. But, they added, "physical drill and exercises must not be regarded as taking the place of organised games, such as cricket, football, hockey, etc., but as auxiliaries to these." In the higher sections they recommended such physical exercises as those included in the Müller system, which do not impose undue strain.

There was no question concerning education and the teaching of hygiene in colleges and schools in the United Provinces which was not thoroughly discussed, and a careful perusal of the report by those interested in the subject would be well worth the time spent in doing so. It is on lines similar to those recommended by the Committee that modern movements in the education and hygienic welfare of students at colleges and school children are being conducted in England and elsewhere. And, no doubt, the progress made in India generally has been due, to a large extent, to their recommendations. The report has, at least, been of much value to the writer of the foregoing pages.

PART III

PSYCHOLOGY

THE term "psychology" is derived from two Greek words, *psyche*, soul; *logos*, reason. It has been defined as "the science of mind and mental operations and their analysis and classification." No subject, perhaps, has given rise to so much discussion and diversity of opinion as to whether psychology should be considered to be the science of the soul, mind, consciousness, or behaviour. Although much remains to be discovered before it can be regarded as an exact science, considerable knowledge has been acquired, by experiment and observation of facts established in this way, since the days of Plato, who located desire in the lower part of the body, anger in the heart, and reason in the brain. Even nowadays, persons who are of a spiteful disposition are said to be suffering from *spleen*. Referring to the present position of psychology in the realm of science, a critic in the London *Times* wrote: "In order to establish its claim to be one of the Natural Sciences, it must be able to differentiate its subject-matter. It must provide some hall-mark by which we may know the facts it deals with are as specifically mental and belong to a scheme of psychology, as physiological facts are specifically physiological and biological facts are specifically biological." The knowledge which has been acquired about physiological facts is much greater and more accurate than that about psychology. In many instances physiology and psychology are intimately associated. For example, the sight, smell, or thought, even, of savoury food produces a flow of saliva and gastric juice; while anger and fear retard the flow and interfere with the activities of the stomach during digestion. These are psychological or mental effects.

Food in the mouth or stomach induces secretion of the digestive juices. This is a physiological process of an organic nature as distinguished from a mental effect. The various forms of psychology include differential, applied, and general psychology.

Differential psychology treats of the differences in the habits, conduct, and mode of life of individuals, the effect of hereditary tendencies and traits of character, and the effect of environment.

Applied psychology deals mainly with education and mental hygiene.

General psychology includes such mental operations as the acquirement of knowledge through the senses, perception, instincts, habits, imagination, association of ideas, memory, reasoning, interest and attention, and the will.

Psychology, moreover, includes in its range of study abnormal as well as normal individuals.

However much there may be in it to criticise, psychology is, admittedly, of the highest value to the educationist, the social reformer, and medical practitioner. So far as medical practitioners are concerned, whether they are conscious of the fact or not, much of the good effect obtained in the treatment of patients, more especially those suffering from functional, nervous, or imaginary ailments, is the result mainly of the psychological effect of inspiring them with confidence and giving them assurance. Even in organic diseases the same beneficial effect is often obtained in this way.

It would be impossible to study psychology to any advantage without some knowledge of the nervous mechanism of the body, a description of which is therefore given in the following chapter, which may help towards a better understanding of what is said about various mental phenomena in later pages.

THE NERVOUS SYSTEM

THE nervous system consists of the brain, the spinal cord, and the nerves passing from them to different parts of the body.

The Brain is divided into the cerebrum, or great brain, and the cerebellum, or small brain.

The Cerebrum consists of two halves separated by a deep longitudinal fissure, called the right and left *cerebral hemispheres*. They are joined together at the bottom of the fissure, by a firm, dense nervous structure known as the *corpus callosum* (Lat. *corpus*, body; *callus*, hard skin), because of its consistency. This structure is the *great commissure*, or joint of the brain. It will be seen from the diagram (Fig. 69) that the surface of the cerebrum has numerous convolutions or folds all over it, with grooves lying between them.

The Cerebellum is situated beneath the cerebrum at the back of the skull. It also is divided into two halves by a fissure, and has a well-marked convoluted surface. It is attached above to the cerebrum by a band of nervous tissue, and below to a part of the brain called the *medulla* (Lat. *medulla*, marrow), from its appearance and consistency. The medulla is a continuation of the spinal cord into the skull cavity. The two halves of the cerebellum are united at the bottom of the fissure by a structure, composed of nerve fibres, known as the *pons* (Lat. a bridge) or *pons Varolii*.

Coverings of the Brain. These are three in number—viz., the dura mater, arachnoid membrane, and the pia mater.

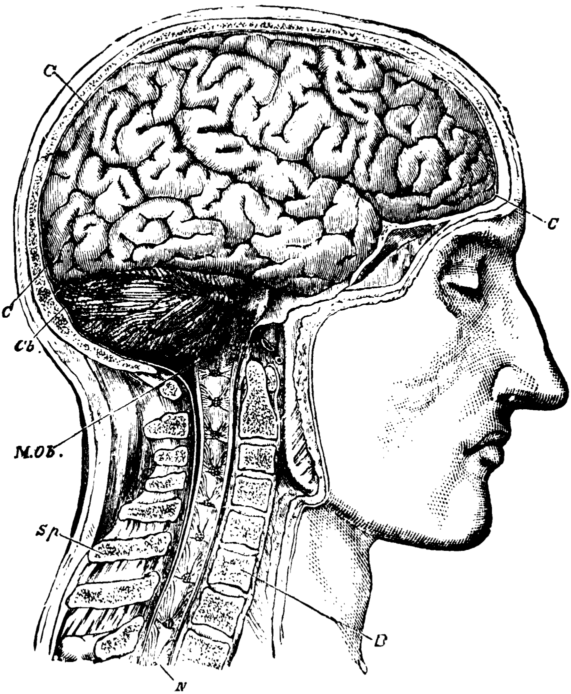


FIG. 69.—SIDE VIEW OF THE BRAIN AND UPPER PART OF THE SPINAL CORD.

C, The convoluted surface of the right cerebral hemisphere; *Cb*, cerebellum; *M.Ob*, medulla oblongata; *N*, spinal cord with spinal nerves; *B*, the bodies, and *Sp* the spines of the vertebræ.

The *dura mater* is a firm membranous structure consisting of two layers. The outer layer lines the inner surface of the skull. The inner layer supports the brain.

The *arachnoid membrane* (Gr. *arachne*, spider) is a thin, transparent, and non-vascular structure like a spider's web. Hence its name. It forms a covering over the convolutions of the brain, but does not dip into the fissures.

The *pia mater* is an extremely vascular membrane which covers the whole of the brain and dips into the convolutions and into the fissures. It also gives off coverings or sheaths to important structures inside the brain substance.

The collective name applied to the three coverings of the brain is *meninges* (Gr. *meninggos*, a membrane). Hence the term "meningitis" applied to inflammation of the coverings.

Cortex of the Brain (Lat. *cortex*, bark) is the outer grey layer of the brain substance. It is composed of five layers of nerve cells and nerve fibres, the supporting structure of which is called *neuroglia*, which has been described as "the peculiar ground substance in which are embedded the true nervous constituents of the brain and spinal cord" (Gray). The undermost layer of the cortex is closely connected with the white matter of the brain through which three sets of nerves pass. These are as follow:

1. *Afferent* or sensory nerves, which convey impulses to the cortex, and *efferent* or motor nerves, which convey impulses from the cortex to muscles and other parts of the body.

2. Nerves which link up different parts of the cortex, and form what is called the *Association System*. When nerves link up convolutions of the brain situated near each other, they form what are called *short association tracts*. When lobes of the brain are linked up, they form *long association tracts*. What are known as the *associated areas* of the brain will be referred to further on.

3. Other nerves form bands connecting portions of the two halves of the brain together, forming what is called the commissural system—*e.g.*, the pons Varolii previously mentioned.

Cranial Nerves are those which proceed from different parts of the brain and pass through openings in the skull to supply organs in different parts of the body. There are twelve pairs, some of which are the nerves of the special senses of touch, smell, sight, taste, and hearing. Others are for regulating the movements of the eyeball, tongue, etc. The *pneumogastric* nerve (Gr. *pneuma*, breath; *gaster*, the belly) is an important cranial nerve which contains both *sensory* and *motor* nerve fibres. It supplies both kinds to the organs of the voice and motor branches to the

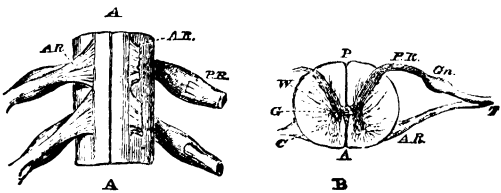


FIG. 70.—A, FRONT VIEW OF A PORTION OF THE SPINAL CORD. On the left side of the cord the anterior roots, *AR*, are cut to show the posterior roots, *PR*.

B, CROSS-SECTION OF THE CORD.

A, Anterior fissure; *P*, posterior fissure; *G*, central canal; *C*, grey matter; *W*, white matter; *AR*, anterior root; *PR*, posterior root; *Gn*, ganglion of posterior root; *T*, trunk of a spinal nerve.

pharynx, gullet, stomach, and heart. Because of its wide distribution, it is sometimes called the *vagus* nerve (Lat. *vagus*, wandering).

The Spinal Cord is continuous with the brain, and passes downwards, in the vertebral canal, to the lower part of the vertebral column. It is about 18 inches long and $\frac{1}{2}$ inch thick. It has a longitudinal fissure in front, and another behind. They almost divide the cord into two halves. The dark shaded portion, seen in the cross-section in the diagram, represents what is known as the *grey matter*, and the unshaded portion what is known as the *white matter* of the cord (Fig. 70).

The grey matter is so distributed in the two halves of the cord as to resemble the letter H. The front projecting portions of the grey matter are called the *anterior cornua* or *horns*, and those behind are called the *posterior horns*. The two halves are united in the middle by a narrow band which separates the two fissures. A small duct passes in the centre of the band throughout the entire length of the cord.

Coverings of the Spinal Cord. These are similar to those of the brain. The *dura mater* lines the inner surface of the spinal canal, to which it is loosely attached by a fine intervening membrane richly supplied with small blood-vessels. The *arachnoid membrane* is separated from the dura mater by a space containing fluid. This space, at its lower part, also contains the end portion of the spinal cord and long nerve roots given off from it. The cord and the nerves form what is called the *cauda equina* (Lat. *cauda*, tail; *equinus*, a horse). The *pia mater* is closely adherent to the spinal cord, and portions of it pass into the substance of the cord and form sheaths for some structures in it.

Between the pia mater and the arachnoid membrane is a large space containing *cerebro-spinal fluid*, the examination of which is of the greatest importance in certain diseases of the brain and spinal cord, such as cerebro-spinal meningitis.

Spinal Nerves. Thirty-one pairs of spinal nerves are given off from the spinal cord through openings on either side of the spinal column. Each nerve has an anterior and a posterior *root*. Each posterior root has a small swelling on it called a *ganglion* or nerve centre composed of a mass of *sensory* nerve fibres (see Fig. 70).

The anterior roots have no ganglia. They contain *motor* nerve fibres which have their origin in large motor nerve cells in the anterior horns of the grey matter of the spinal cord.

Structure of Nerves. Nerves are composed of bundles of filamentous fibres, the finest of which may not be more than $\frac{1}{4000}$ part of an inch in thickness. The *axon*, or central core, is surrounded in motor nerves throughout their entire length by two coverings. The inner covering consists of a fatty-like substance called *myelin* (Gr. *myelos*, marrow). This covering is called the *white sheath*, as distinguished from the outer covering called the *grey sheath*. "The white sheath probably serves to protect, nourish, and insulate the axon" (Roberts). Insulation, in this application, means that nerve currents passing through the axons to their nerve centres cannot be diverted from their course. It should be noted that it is the white sheath of the nerves which form the white matter of the brain and spinal cord. The grey matter, on the other hand, consists mainly of nerves and nerve cells which have *no white sheath*. This explains the difference in the amount of grey and white substance in the brain and spinal cord and in different parts of these structures.

The greater the number of nerves with white sheaths passing through any part of the brain or spinal cord, the greater will be the amount of white matter; and the greater the number without white sheaths, the greater will be the amount of grey matter.

In the foregoing pages, reference has been made to nerve cells, nerve centres, and ganglia in the description of the cortex of the brain and of the spinal cord and spinal nerves.

Before proceeding further, a definition of the terms may make what is contained in later chapters more easily understood.

Nerve cells are nucleated masses of protoplasm which enter into the formation of any part of the nervous system, and all nerves are composed of them.

Nerve centres are collections of nerve cells composed of grey nervous substance. They are sometimes spoken of

FIG. 71.—A NERVE CELL FROM THE CEREBELLUM. (LUCIANI.)

as *neurones.* But a neurone, as is explained below, consists not only of a nerve centre, but of nerve branches connected with them (Fig. 71).

A ganglion is an enlargement in the course of a nerve forming a special centre of nervous action or influence, and is composed of masses of grey nervous matter.

Neurones. A neurone consists of a nerve centre and all the nerve branches associated with it (Fig. 72).

Neurones may have one nerve branch only or two or more branches, and have been classified, for this reason,

FIG. 72.—DIFFERENT TYPES OF NERVE CELLS.

as unipolar, bipolar, and multipolar nerve centres respectively. The main nerve branch is called the *axon* or *axis-cylinder process*, which is the core or central portion of nerves. The branches from the axon are called *dendrons* or *dendrites* (Gr. *dendron*, a tree), because of their tree-like appearance. All the branches, of each individual neurone, are, directly

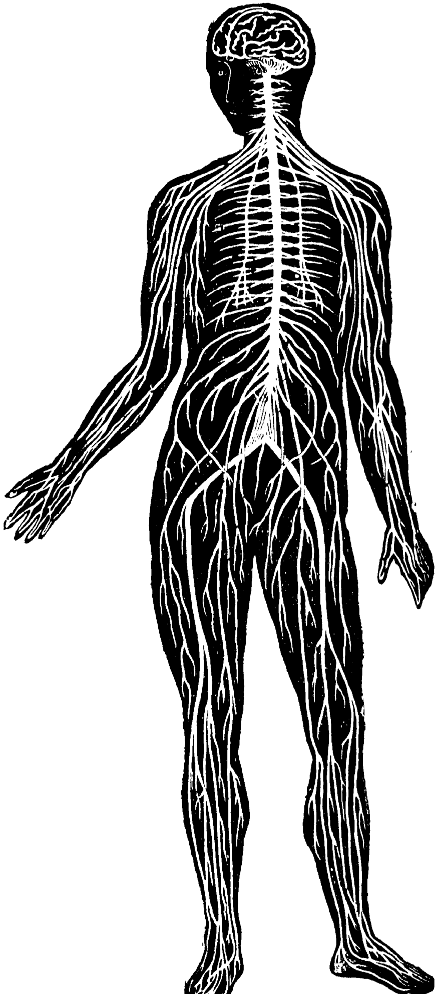


FIG. 73.—DIAGRAM OF THE NERVOUS SYSTEM, SHOWING THE BRAIN SPINAL CORD, AND NERVES.

or indirectly, connected with each other, as are, also, the nerve centres. The whole nervous system is composed of numberless neurones. "It is possible that their office is not merely to transmit the disturbance arriving at them, but to send it on with increased energy, acting like a battery relay in a telegraphic circuit" (Starling).

The axons of nerves may be very short or of great length; but no matter what their length may be, all of them are continuous from the nerve centres in which they originate to their termination, and give off branches in their course. The longest axon, in the body, is that of the *sciatic* nerve which has its origin in a plexus of nerves in the sacral bone region and passes through the pelvic cavity down the back of the leg to the great toe. (See Fig. 73, which is introduced here to give a general idea of the distribution of the nerves throughout the body.)

THE SYMPATHETIC NERVOUS SYSTEM

The Sympathetic Nervous System consists of two chains of ganglia, nerves and plexuses of nerves, situated one on either side of the spinal column and along which they travel, in a downward direction, through the neck, chest, and abdomen, in close relationship with the aorta. Each chain begins its course in a ganglion situated at the base of the skull and terminates in a ganglion in the coccyx. Other ganglia are located in the heart, lungs, kidney, and spleen. Plexuses of nerves and ganglia exist also in almost every part of the walls of the alimentary canal. Further, there are ganglia in the salivary glands, the internal ear, and in the orbital cavities. The ganglia of the sympathetic nervous system are considered to be, to some extent, independent of the central nervous system—that is, of the brain and spinal cord, with both of which, however, the sympathetic ganglia and their nerve branches are linked up. The sympathetic nerves have no white sheath. They are continuations of the sensory nerves, which pass from the spinal cord through the openings in the vertebræ nearest to which the sympathetic ganglia are situated. The chief functions of the sympathetic nervous system are to regulate the contraction and dilatation of the blood-vessels, the action of the stomach and other parts of the digestive canal, and to some extent other organs in the abdomen. It also regulates the action of the heart and the secretory glands, especially the salivary glands, and helps to maintain the heat of the body. The actions of the pupil of the eye, the urinary and genital organs, and the skin are also controlled by the sympathetic nervous system (Fig. 74).

The Sympathetic Ganglia and their Connection with the Cranial and Spinal Nerves. Sensory or *afferent nerves* (Lat. *ad*, to; *ferre,* to carry) transmit impulses from different parts of the body to ganglia in the spinal cord and brain. *Motor* or *efferent nerves* (Lat. *ex*, out; *ferre*, to carry) transmit impulses from ganglia in the brain and spinal cord mainly to involuntary muscles and secretory glands. The sensory nerves, in their course to the spinal cord and brain, pass through one or other of the ganglia in the sympathetic chain. The motor nerves, in their course from the brain and spinal cord, also travel, by way of the sympathetic ganglia, to their terminations. The sensory nerves induce impulses in the motor nerves, which in turn induce muscular action in the heart, digestive canal, etc., and glandular secretion. This is known as *reflex action*, which is considered more fully later. In concluding this chapter, it may be mentioned that some nerves are entirely sensory, while others are entirely motor. The majority of them, however, contain both sensory and motor nerve fibres.

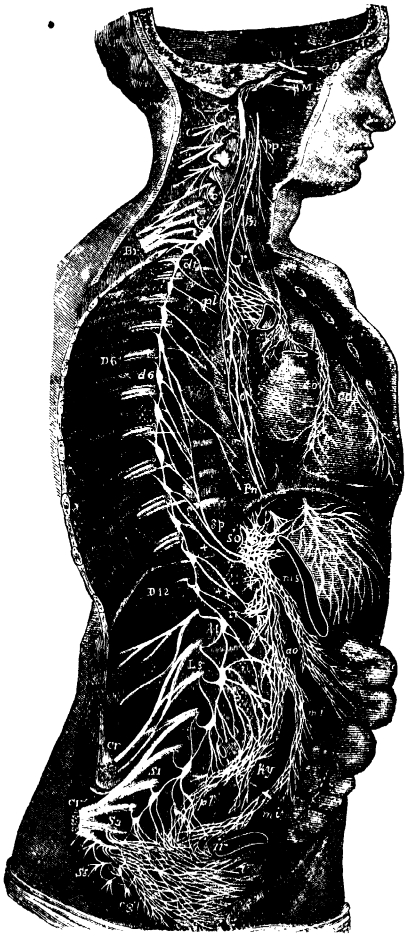


FIG. 74.—THE SYMPATHETIC NERVE CHAIN OF THE RIGHT SIDE, SHOWING BRANCHES GIVEN OFF TO VARIOUS INTERNAL ORGANS AND CONNECTIONS WITH THE SPINAL NERVES.

(From Furneaux's "Human Physiology." By permission of Messrs. Longmans, Green and Co., Ltd.)

Their functions are the adjustment or regulation of the activities of the various organs of the body and maintaining them a healthy state. They also influence growth and development.

STIMULUS AND RESPONSE

Stimulus and Response. *Stimulus* may be defined as an agent producing reaction in any irritable tissue or bodily organ, and *response* as the reflected action or movement caused by a stimulus. The length of time taken in making response to different kinds of stimuli can be measured by an instrument called a *chronoscope* (Gr. *chronos*, time; *skopein*, to look at). It has been demonstrated, in this way, that the response to sound or touch takes about three twenty-fifths of a second, and of light three-fourteenths of a second. The one-tenth of a second is regarded as the shortest possible time in which, under the most favourable conditions, response can be made to any stimulus. Response to an order such as "Ready! present! fire!" or the application of the brakes to a motor-car when a policeman regulating street traffic puts his hand up are examples of what are called "*simple reaction.*" Decision, or making up one's mind as to how to cross a road with the greatest chance of getting to the opposite side safely, is an example of what is termed "*choice reaction.*" Test experiments have been made, by selecting colours to be named, by the multiplication or addition of figures, mental arithmetic, and in other ways, to ascertain how long it takes to make a response. This is called "*association re-reaction.*"

In this reaction several seconds, or even minutes, may be occupied in responding, or no response at all may be made. All these are sensory reactions.

Reflex Actions are movements which take place in muscles independently of the will. For their production a sensory nerve, a nerve centre, and a motor nerve are necessary. This is known as a *reflex arc* (Fig. 75).

In the diagram below the stimulus is represented as proceeding from the skin through a sensory nerve to a nerve centre in the spinal cord, and thence to the brain, from which an impulse is conveyed through a motor nerve to special sensory nerve endings in a muscle. Other examples of reflex action are as follow:

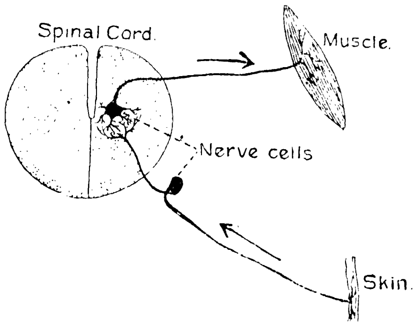


FIG. 75.—DIAGRAM OF A REFLEX ARC, SHOWING THE DIRECTION IN WHICH THE MESSAGE TRAVELS FROM THE SKIN TO THE SPINAL CORD, AND FROM THE SPINAL CORD TO THE MUSCLE.

1. If a speck of dust or other foreign substance gets into the eye, the eyelids immediately close and a flow of tears takes place. So rapid is this protective response that foreign bodies may not get further than the eyelids.

2. If a strong light be held in front of the eye, the pupil at once contracts to protect the inner delicate structures.

3. If one happens to tread, barefooted, on a piece of hot charcoal, or gets a needle into the foot, the leg is promptly flexed and the foot raised, and in this way serious injury

which might result from continued contact and pressure is prevented.

4. If a gentle tap be given to the tendinous structure which encloses the knee-cap, either above or below the knee-cap, so long as no restraint is applied, the leg is immediately jerked forward. The time occupied in making this response is said to be only about one thirty-third of a second and to be the quickest of all responses.

5. Coughing and sneezing are further examples.

The reflexes mentioned are known as the *lid reflex*, *pupil reflex*, *flexion reflex*, *patellar reflex*, and *protective reflexes*. Besides these, there are what are called *internal reflexes*. Their functions are to regulate involuntary muscular movements, such as those of the stomach and intestine, the dilatation and contraction of arteries through nerve influence on the muscular layers in their walls, and glandular secretion such as saliva, gastric and other intestinal juices. There are, also, what are called *inhibitory reflexes*, which check muscular movements. Breathing, for example, is checked, when one plunges into excessively cold water, through the respiratory muscles ceasing to act, or the heart may be reflexly inhibited in its action by a severe blow over the pit of the stomach. Sudden death, even, is not infrequently due to inhibitory reflex action. Internal reflexes are inborn and essential to existence. The habit of responding to stimuli may be acquired. We may respond to sounds, for example, without actually being aware of the fact, as when the mind is concentrated, say, on trying to solve a difficult mathematical problem, or when studying any subject that requires great mental effort to grasp the meaning of—as, for example, psychology.

Habit Responses are such as are acquired during life. To learn, *e.g.*, to play the violin or any other musical instrument requires long practice and continuous mental effort.

But in course of time playing becomes automatic, or, in other words, it involves no conscious effort. Habit responses are innumerable.

Effect of Damage to Reflex Arcs. Owing to the interdependence of nerve centres and sensory and motor nerves in a reflex arc, any break in its continuity involves loss of function. And as some reflex arcs have a long range, the loss of function may be very widely distributed. The effects produced by such occurrences are loss of the power of movement, loss of sensation, and inability of the bodily organs to perform their natural functions in a normal way. This is what is termed *paralysis*. Injuries and diseases of the brain and spinal cord affecting the important nerve ganglia situated in these organs are often the cause of complete or incomplete paralysis of movement and sensation and of bodily organs. The degree and extent of the paralysis depend upon the nature and severity of the lesion and the part of the brain or spinal cord affected.

THE PHYSIOLOGICAL BASIS OF SENSATION

Sensation is the perception of impressions made upon the mind by stimuli conveyed through sensory nerves to nerve centres in the cortex of the brain. Stimuli may be conveyed through the skin, eye, ear, or nose, and are classified as cutaneous, light, sound waves, and chemical stimuli. Each kind of sensory nerve conveys one sensation only. This is called the "*law of specific irritability*" or "Müller's law." Just as muscles become fatigued through excessive use, so do the sense organs if over-stimulated. And if any kind of stimulus is kept applied too long, the perception of the sensation produced is lessened. The sensation, on the other hand, may be increased by the application of different kinds of stimuli one after the other. "Hot water, for instance, feels hotter to the hand after the application of cold" (Roberts). The location of some of the sensory nerve centres in the brain is not known. It is, however, known that the nerve-centre of sight is situated in the *occipital lobe* of the brain at the back of the skull, and those of hearing, taste, and smell in the *temporal lobe* at the side of the skull. Those of pressure, or touch, and temperature are located in the brain cortex.

Very little is known about the physiological basis of *pain*. But, so far as the skin is concerned, it is believed that "there exists a special set of sensory nerve fibres which have a specific energy for pain" (Howell).

The sensations of *hunger* and *thirst* are experienced internally. The sensation of appetite has been thought to be due to sensory nerve fibres either in the muscular layers of the stomach wall or in the lining membrane of the stomach. But, as loss of appetite occurs in diseases of the lining membrane of the stomach, it is generally believed that sensory nerves in that membrane not only regulate the appetite, but also induce, in some way or other, the feeling of hunger when the stomach is empty. The sensation of *thirst* is located in the back of the tongue and the lining membrane of the pharynx, which derive sensory nerve branches from one of the cranial nerves—the glosso-pharyngeal nerve (Gr. *glossa*, the tongue; and *pharynx*). The sensation of thirst is induced through loss of water, which seems to stimulate the sensory nerves.

"This is one reason for assuming the existence of sensory nerve organs." A further reason for this assumption is the fact that "local drying in this region, from dry or salty food, or dry and dusty air, produces a sensation of thirst that may be appeased by moistening the lining membrane with a small amount of water not in itself sufficient to relieve a genuine water need of the body" (Howell).

The Skin Senses. Touch, cold, warmth, and pain are considered to be the only primary senses, but some of them may be mixed. It has been found by tests with fine hairs and sharp and blunt-pointed instruments, either above or below the temperature of the blood, that the skin contains *touch*, *cold*, *warm*, and *pain spots*, each of which, when stimulated, produces one sensation only. The sense of touch is located mainly, in the tactile corpuscles, at the ends of fine sensory nerves in the papillæ of the skin. The papillæ form a series of ridges all over the skin, and can be seen with the aid of a magnifying glass. "And although there may be as many as 2,000 papillæ to each square inch of skin, each tiny nerve communicates with the brain separately as telegraph lines unite at a terminus" (Bernstein). The epidermis or outer layer of the skin is a non-sensitive structure.

The sense of touch varies in degree of intensity. It is highly developed in the points of the fingers. By touch we can tell variations in temperature, whether things are coarse or fine, rough or smooth, hard or soft, and so forth. Some parts of the skin which are extremely sensitive to touch are not so sensitive to heat, as, for example, the palmar surface of the fingers. The parts most sensitive to heat are the eyelids, elbows, and cheeks.

The touch spots are situated at the roots of the hairs, which are supplied with a network of fine sensory nerves which are extremely sensitive and responsive when the hairs are subjected to the most delicate pressure.

Pain is induced when anything harmful touches the skin, and by motor response the part affected is protected either by the speedy removal of the cause of the pain or the withdrawal of, for example, the foot or hand if any hot substance is touched. Pain is thus a *protective sensation*. The sensory nerves of pain are an example of what are called *naked* *nerves*. That is to say, their axons have neither a white nor a grey sheath covering them.

The sense of temperature is believed to be due to *end-bulbs*, which consist of coils of axons of sensory nerve-fibres in the skin. The nerve-bulbs are supposed to be the sense-organs of cold and warmth. They are also supposed to be the sense-organs of touch in the skin of the palms of the hand and the soles of the feet, and partly of touch in the hairs. The sensations of the skin used to be included under one head—the "sense of touch." They are now classified as *pressure* or *touch sense, warmth sense, cold sense*, and *pain sense* respectively.

The nerve-centres of temperature, pressure, or touch and fine muscular sensations are situated in the cortex of the cerebrum.

The Sense of Vision. All visual sensory impressions are due to stimuli, of different kinds, in the form of waves of light passing through the eye and falling on the retina, which is its innermost covering. The retina is composed of the following structures—viz. (1) A pigmented layer; (2) receptive nerve-cells called *rods* and *cones* respectively; (3) two layers of neurones; and (4) an expansion of nerve-fibres from the optic nerve (Fig. 76).

Stimuli reaching the retina are conveyed from it through the axons in the optic nerve-fibres to the nerve-centre of vision, which is situated in the occipital lobe of the brain, at the back part of the skull, where visual sensations are analysed and interpreted. The sensations are then transmitted outwards to the retina, on which objects looked at are depicted in the form of images. The recognition of the objects is learned from experience. That is to say, we become conscious of the differences in the sensations produced by the stimulation of different parts of the retina, each portion of which is assumed to be connected with a different portion of the cortex of the lobe of the brain in which the visual nerve-centre is located.

Owing to some defect in one part of the cortex of the visual nerve-centre area, the perception of words may be rendered impossible. This is known as "*word-blindness*,"

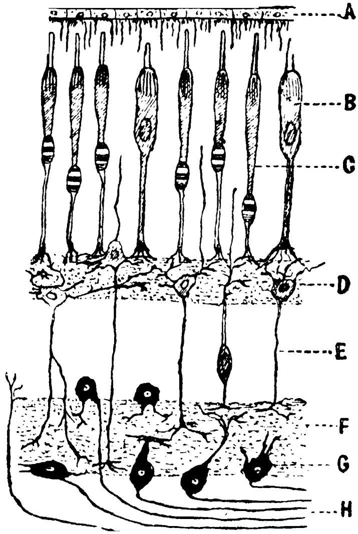


FIG. 76.—THE RETINA SECTION, HIGHLY MAGNIFIED, SHOWING ITS VARIOUS LAYERS.

A, Layer of pigment cells; B, C, of rods and cones; D, E, F, of small nerve cells and their processes; G, of large nerve (ganglion) cells; H, of nerve fibres passing from ganglion cells to optic nerve. (After Stohr.)

(From Drummond's "Physiology." Edward Arnold.)

or it may be that objects are not recognisable because of defect in some other part of the cortex. Persons suffering from this defect are said to be "*object-blind*." It is believed that the function of the cones of the retina is to perceive colours and differentiate them and that the rods respond only to the stimuli of light and darkness. *Colour-blindness* is considered to be due to defects in the cones, and what is known as *night-blindness* to some failure in the functioning of the rods. Changes in the eye which prevent waves of light passing freely to the retina, as, *e.g.*, cataract, which is an opacity of the crystalline lens, may impair vision or completely exclude light and cause blindness. And no impressions of any kind would be conveyed to the visual nerve centre in the brain if the optic nerve were severed or destroyed by disease, or if the nerve centre itself were destroyed.

The Sense of Hearing. Sound-waves, on entering the ear, pass to a structure, in the cochlea, known as "*Corti's organ*," which has already been described (see p. 117). The sounds on reaching this organ are believed to be analysed by the strands of fibrous tissue in the basilar membrane, which forms the base of *Corti's tunnel.* It is stated that there are no less than 20,000 fibres in the membrane which, like the strings of a musical instrument, vibrate when sounds strike against them.

"The combination of the fibres, excited by the sounds, are believed to differ with each tone or combination of tones" (Starling). In order to hear a note the rate of vibration is 16,000 to 40,000 vibrations per second. But it is said that in most people no sound is produced above or below 30,000 vibrations per second. "Two sounds, following one another, are said to be perceived as distinct if the interval between is not less than $\frac{1}{500}$ of a second" (Exner). Although the organ of Corti is believed to analyse sounds, the whole mechanism of hearing is under the control of the auditory sensory nerve-centre, which is said to be located in the temporal lobe of the brain in front of the visual nerve-centre area. It is thought that different parts of the cortex in the auditory sensory-area deal with different kinds of auditory perception, such as word-deafness and music-deafness. With reference to this Woodworth says: "At least, we sometimes find individuals who, as a result of injury or disease affecting this general region, are unable any longer to follow and appreciate music. They cannot 'catch the tune' any longer, though they may have been fine musicians before this portion of their cortex was destroyed."

The Mechanism of Hearing. Sound-waves entering the meatus or opening of the external ear strike against the tympanic or drum-membrane. In doing so they are converted into vibratory movements which are conducted through the three small bones in the *air-filled* tympanum or middle ear to the fenestra ovalis, which is enclosed by a membrane to which the foot of the innermost bone—the stapes or stirrup-bone—is attached. The vibrations push the membrane *inwards* towards the vestibule or entrance of the internal ear which is filled with fluid—the perilymph already spoken of. The vibrations are then continued in the perilymph in the semicircular canals, and in the scala vestibuli to the apex of the cochlea and, downwards, in the scala tympani to the fenestra rotunda, which is also enclosed by a membrane separating the cochlea from the midd'e ear. This membrane is pushed *outwards* towards the middle ear by the swaying movements in the perilymph. The movements in this continuous column of perilymph are reflected to the *endolymph* contained in the membranous labyrinth of the cochlea and excite the minutest nerve-fibres of the cochlear branch of the auditory nerve which are supposed to terminate in the inner and outer highly sensitive nervous hair-cells of the organ of Corti. From these hair-cells the impressions received pass to the auditory sensory area in the brain through the fibres of the auditory nerve

The mechanism of hearing is a most complicated process.

But if the structure of the ear described in a previous chapter has been carefully studied and reference made to the diagram given to show the structure of the ear as a whole, what has now been said about the sense and mechanism of hearing will, it is hoped, be less difficult to understand (see pp. 108 to 118, and Fig. 47).

The Sense of Smell. Owing to the plentiful supply of minute sensory nerve-fibres to its lining membrane the nose is highly sensitive and responsive to the smallest particles of substances of an odoriferous kind. Such particles are given off from gases, liquids, and solids, but the most penetrating odours are derived from gases. The sense of smell is situated in the upper part of the nose in a structure called the *olfactory organ* (Lat. *olfactāre*, to smell; *olēre*, to smell; *facĕre*, to make). This organ consists of cells with tufts of hair-like processes connected with sensory nerve-fibres, the axons of which, like those of the sensory nerve-fibres of pain, have no coverings. Their highly sensitive nature is due to this cause.

When the nasal passages, which are moist normally, become dry the sense of smell is diminished. It varies in degree in different people, and is highly developed in some of the lower animals. In order to detect any very faint odour it is necessary to sniff the air several times in quick succession so as to bring the odoriferous particles into intimate contact with the fine endings of the olfactory nerve. The sense of smell is intimately associated with that of taste. It is almost impossible to taste even strongly flavoured substances when the nose is held.

Owing to the intricate structure of the nasal passages, and the secluded situation of the sensory nerve-fibres, it has been found difficult to determine by tests the exact effect on them of different kinds of stimuli. It is believed, however, that there are only six elementary odours—viz.:

1. Spicy, found in pepper, cloves, nutmeg, etc.
2. Flowery, found in heliotrope, etc.
3. Fruity, found in apples, orange oil, vinegar, etc.
4. Resinous, found in turpentine, pine needles, etc.
5. Foul, found in sulphuretted hydrogen, etc.
6. Scorched, found in tarry substances.

Compound odours may be formed by some of the elementary odours as, *e.g.*, that of roasted coffee, which is a compound of the resinous and scorched, and peppermint, which is a compound of fruity and spicy odours (Woodworth).

The Sense of Taste is located in the taste-bodies or taste-bulbs of the papillæ of the tongue in which the sensory nerve-fibres terminate. Some taste-bodies are also found in the soft palate, epiglottis, and vocal cords. Each papilla has, in its centre, an elongated cell with a hair-like structure attached to it which passes through a small opening to the surface of the tongue. These cells are considered to be the sensory cells of taste. When stimulated by any savoury substance coming into contact with them impulses are conveyed to taste nerve-fibre connected with and surrounding the cells. The impulses are then conveyed through the main branches of the nerves to the nerve-centre or centres in the cerebrum, concerned with the sense of taste. The origin of the nerve-fibres of taste in the brain is uncertain. It is known, however, that the front two-thirds of the tongue derive sensory nerve-branches from the *lingual nerve* (a branch of the facial nerve), and that the back one-third of the tongue gets sensory nerve-branches from the *glosso-pharyngeal nerve.* The *facial nerve*, besides supplying a sensory nerve (lingual) to the tongue, also supplies motor-nerve branches to the muscles of mastication. The *glosso-pharyngeal nerve*, besides giving sensory branches to the base of the tongue and pharynx, also supplies them with motor-nerve branches.

These two nerves are mentioned here as being good examples of what are called mixed nerves or nerves which contain both sensory and motor nerve-fibres.

Association of Taste with Other Senses. Taste is intimately associated with other sensations in the mouth —viz., touch, warmth, cold, and pain. Softness and hardness or smoothness and roughness of food or other substances are examples of the sense of touch in the mouth and tongue. The sensations of warmth, cold, and pain are, through experience known to everyone. Leaving aside these associated sensations, tastes have been classified as sweet, sour, bitter, and saltish, and are called the elementary or primary tastes. Mixtures of the primary tastes are described as *compounded tastes.* Sweet taste is located in the papillæ at the tip, sour taste in the edges, bitter taste at the back, and saltish taste both in the tip and sides of the tongue.

So delicate is the sense of taste that the presence of one drop of sulphuric acid in 1,000 drops of water can be recognised.

The sense of taste is excited only when substances are well dissolved and come into close contact with the sensory cells in the papillæ, and neither sugar nor salt can be tasted when the tongue is dry. One of the functions of the saliva is to dissolve substances of the kind contained in food.

"The flavour of food consists largely of odour. Food in the mouth stimulates the sense of smell along with that of taste, the odour of food reaching the *olfactory organ* by way of the throat and the rear passage to the nose. If the nose is held tightly so as to prevent all circulation of air through it, most of the 'tastes' of food vanish; coffee and quinine then taste alike, the only *taste* of each being bitter, and apple-juice cannot be distinguished from onion-juice" (Woodworth).

THE ACQUIREMENT OF KNOWLEDGE THROUGH THE SENSES

WHILE discussing the physiological basis of sensation we learned that all sensations are due to stimulus and response through nerves and nerve-centres. Reference was made to what are called the *associated areas* of the cortex of the brain, which are sometimes spoken of as the *silent areas* because, as has been shown by experiment, they make no

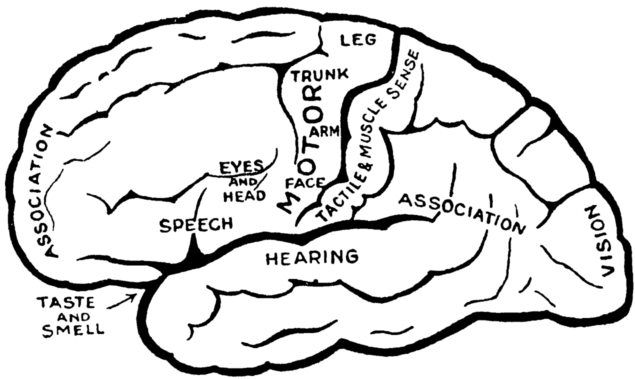


FIG. 77.—DIAGRAM SHOWING THE LOCALISATION OF FUNCTION IN THE CORTEX OF LEFT CEREBRAL HEMISPHERE.
(From Bainbridge and Menzie's "Essentials of Physiology." By permission of Messrs. Longmans, Green and Co., Ltd.)

response to electric stimuli applied to them. It is in these areas that the higher mental activities take place. "They are," as Howell observes, "the regions in which the different impressions are synthetised into complex perceptions or concepts." In other words, they are the areas of the cortex of the brain where the sense impressions are combined to form evidence of existing objects or facts, and also to form images or ideas in the mind regarding them. Diagram

(Fig. 77) illustrates the large extent of the associated areas as compared with the motor and sensory-organ nerve areas.

Bolton, in his classification of the layers of gray nervous matter of the *cerebral* cortex, has observed that, in the frontal and parietal associated areas, the outer layer is very thick, and that, in the visual associated area, the outer layer, which is concerned with the effect of visual impressions on the mind (visuo-psychic), is nearly twice as thick as that in the associated area concerned with the sensations produced when objects are looked at (visuo-sensory). Since it is through the sense of vision that so much of our knowledge is acquired, the relatively greater development of the cortex in the visual associated area will be readily understood.

The outer layer of the cortex is stated to be the last to develop and the first to be affected by disease; that the degree of its development is increased as the animal scale is developed; that its thickness develops with the mental capacity of the individual; that if it is congenitally deficient *amentia*—absence of intellect—is the result; and that degenerative changes are associated with *dementias, i.e.*, insanity. Regarding this Bolton has observed " in persons who are insane wasting of the cortex which takes place depends upon the degree of the mental derangement."

The development of the cortex depends largely on the extent to which the higher faculties of the mind are exercised. Neglect in this respect leads to wasting of the cortex and impairment of the intellect in consequence. Other factors which induce wasting of the cortex are alcoholic excess and senility, in which the most marked features are loss of memory, inability to concentrate or put forth mental effort, and loss of muscular power.

All normal children, at birth, possess the senses of hearing, sight, skin sensations, etc., and certain inborn reactions. They can make muscular movements though they cannot walk, and let their vocal organs be heard though they cannot speak. As the body develops, so also does the nervous system, culminating in the completion of nervous reflex arcs previously described (p. 249), and, in due course, children learn, by imitation and through experience, to walk when their muscles are sufficiently developed, and to combine sounds into words to form speech and get to know the meaning of the words used. Referring to the brain of the child, Professor Sir Arthur Keith, some years ago, in one of his lectures on *Craniology* at the Royal College of Surgeons, London, stated that a child has to grow nearly all its life-time's brain before it is four years of age, and added: "It is born with about 30 per cent. of its total; within a year this has increased to 50 per cent.; by the fourth year it is 80 per cent., and when the child goes to school it has almost its entire mental outfit, though the brain continues growing very slowly until the nineteenth or twentieth year. Contrariwise, the chimpanzee and the gorilla are born with brains as large as that of the human infant, but they scarcely grow at all after birth."

The associated areas are linked up with the sensory nerves by *associated nerve-tracts*, through the combined action of which, and of the sensory and motor nerves and their nerve-centres, all knowledge is acquired. It is in this way, as we know, that we can, through the skin senses, distinguish variations in temperature, perceive pain, and recognise the qualities of things touched; through the sense of vision that we can recognise different objects; through the sense of smell detect the faintest odours, differentiate, and classify them; and through the sense of taste distinguish between sweet, sour, bitter, and saltish substances and different kinds of food, drink, etc. *Putrefaction* in meat of any kind is an interesting example of how the various senses may co-operate to elicit facts, since it can be detected through sight, touch, taste, smell, and even hearing. It is said that a practised ear can, by using a stethoscope, detect gangrene, in injured or diseased parts of the body, in its early stages, by the peculiar crepitant sounds caused by the presence of gas due to the mortification of the tissues. The following are further examples illustrating how different senses may inter-react in the acquirement of knowledge. Children, who are born deaf or become deaf soon after birth and have never learned to speak, possess, nevertheless, the faculty of voice, and can be taught not only to understand spoken words, but also to read by watching the lips of those speaking to them. This, which is called *lip-reading*, is an example of knowledge acquired through the eye which is normally acquired through the ear. *Deaf-mutes* can be taught both to read and speak, though their speech may be imperfect, and can also converse through an alphabet formed by their fingers. Another example of the kind is that of blind persons who can learn *to read*, through the sense of *touch* in the tips of their fingers, by means of what is called *Braille type*, " a kind of type having arbitrary signs consisting of varying combinations of six points arranged thus (⁞ ⁞), there being sixty-two possible combinations of these six points " (Chambers's Dictionary).

Knowledge is not born in any of us, although some persons may be born with special talents or aptitudes for acquiring knowledge of different kinds, owing to certain portions of their brain cortex being more highly organised than they are in other persons. Knowledge or skill in any professional calling, trade, or occupation can only be acquired, through the senses, by individual effort, and success or failure depends largely upon whether or not the higher faculties of the mind have been properly cultivated.

" We learn by doing ! This is the cardinal principle of all acquirement of real knowledge " (Dumville).

PERCEPTION

PERCEPTION is the faculty of reception and recognition of sensory impressions, indirectly, through the associated nerve-tracts. By this means we are enabled to locate sensations in the different parts of the body in which they occur. Perception involves reasoning through which we can revive past impressions formed regarding different kinds of sensation. This implies consciousness. "Our various states of consciousness," wrote Herbert Spencer, "are elaborated out of our perception of change, degree, and facility of changes, etc., all running together in larger and larger groups and series until they embody what is called the *outer world*."

Apperception is the conscious perception of a sensory impression. Whatever is actually perceived as an external object is a *percept* as distinguished from a *concept*, which is a general idea formed in the mind about anything. The main difference between a sensation and perception is that sensation always remains practically the same, whereas perception varies, in consequence of which it may be necessary at times to correct our previous impressions regarding objects and events. In the case of wrong visual impressions, for example, we can, by movements of the eye, look at objects from different angles, and thus derive further information about them, by which we are able to correct them. In the case of the ear, the head can be moved in different directions so as to enable us to identify sounds more readily, and tell the direction from which they come, although it is no easy matter at times to locate the direction from which sounds do come. Dogs have the advantage over human beings in this respect, in that their sense of hearing is much more acute, and in being able to move about their aural appendages with great facility in intentive listening as when suspicious sounds occur in the night when the members of a household are fast asleep. By giving careful attention to objects when they first come to notice and at other times, thereafter, we get to recognise them automatically. This is termed *practical perception*. On the other hand, if objects are only cursorily examined when first observed the impressions conveyed to the mind regarding them may have to be revised. This is called " *corrected perception*." The procedure adopted to correct wrong impressions is, as Woodworth says, " A series, in rapid succession, of what are called ' *trial* and *error perceptions*.' Because this involves a more careful examination of objects in order to get fresh stimuli from their more outstanding characters, which combine to correct the perceptive response, the process is termed *analytical perception*. Woodworth gives numerous interesting examples of errors in perception. The following are two: (1) A faint sound was first taken for a bird singing, then for a distant locomotive whistle, and, finally, for what it was—a tinny noise of a piece of metal carried in the hand and brushing against the overcoat as the person walked. In making this series of " error and correction " perceptions, the time occupied was not over five seconds. (2) On touching an object in the dark you may feel it as one thing and another till some response is aroused that fits the known situation, and so satisfies you. What is termed *anticipatory perception* is the act of trying to foresee the possible consequences of our actions. If, for example, our indignation is aroused by an insult or otherwise, we might feel inclined to act in a way that might lead to consequences detrimental to ourselves, and we decide, therefore, either quickly or hesitatingly, to curb our impulses, knowing that discretion is the better part of valour. " Hesitation between perception and action," observes Woodworth, "may occur in anger due to retaliation or defence, or anticipation of the consequences of the action taken, or it may be due to *substitute perception* when looked at from the other person's point of view."

Besides the forms already mentioned there are many other kinds of perception which can only be referred to here cursorily. The following are some of these, which Woodworth discusses in detail:

1. **The Perception of Space,** which includes, for example, the location of taste, thirst, and hunger, the distances of objects, and the extent of movement of the limbs.

2. **Æsthetic Perception,** by which we recognise what is beautiful in natural objects, music, poetry, or works of art, etc.

3. **Social Perception,** by which, through the senses, we may be able to perceive the motives and intentions of others and form ideas about their character.

4. **Errors of Perception,** as in weighing and measuring things, for which special appliances, such as scales and tapes, are needed to ensure accuracy. These errors may be purely "*errors of sense*" or "*errors of perception.*" By way of illustrating "errors of sense," Woodworth writes: "If you come out of a cold room into a warm room, the latter seems warmer than it is; and if you come out of a dark room into a light room, the latter seems brighter than it is." It is astonishing how quickly time seems to pass when one's thoughts are intensely concentrated on anything of interest. Take, for example, a game of chess. Hours may pass in thinking out "moves," and no conception of the time spent on a game may be possible without reference to one's watch. This is entirely an "error of perception," and in no way an "error of sense." Included under this heading are *constant errors* regarding the time of occurrence of events or happenings of any kind, and

"*variable errors*," due to slight transient causes as, for example, when shooting at a target and trying to hit the bull's-eye.

5. **Illusions,** which are errors of perception. These have been classified as follows:

(*a*) *Illusions due to Peculiarities of the Sense Organs.* Woodworth cites the following example: If a pair of compasses, with the points apart, is drawn across the lips from one side, you get the illusion of the points separating more widely at the middle of the mouth, where the sensory nerve-supply is greatest, and coming together again as the points near the other side.

(*b*) *Illusions due to Pre-occupation or Mental Set.* These are common illusions in persons who are insane; but they occur also in persons with well-balanced minds, as when a mother, with her baby upstairs very much in her thoughts, imagines she hears it crying when a cat yowls or a gramophone starts next door. "The ghost-seeing and burglar-hearing illusions belong here as well" (Woodworth).

(*c*) *Illusions of the Response-by-Analogy Type.* Analogy is an agreement or correspondence in certain respects between things otherwise different. The illusions based on analogy are perhaps the most common of all kinds. Woodworth gives the perception of the buzzing of a fly or an aeroplane as an example of this type of illusion. Another familiar example is that known as Aristotle's illusion, in which, when two fingers are crossed and a marble is touched by both fingers, two marbles seem to be touched. Other small objects may be used instead of a marble. Moving pictures are a further example. Their apparent movements are due to the way in which a series of very small snap-shot photographs are thrown on to a screen.

(*d*) *Illusions due to Imperfect Isolation of the Fact to be perceived.* In this form the figures of objects, depicted by lines, are used to test the powers of observation. The best example of this illusion is the Müller-Lyer figure: "Two equal lines are embellished with extra lines at their ends; you are supposed to perceive the length of the two main lines, but you are apt to take the whole figure in the rough and perceive the distances between the chief parts. You do not succeed in isolating the precise fact you wish to observe" (Woodworth). The most familiar figure is made with arrow-heads thus: > < ← → in which both horizontal lines, although the measurements are the same in length, appear to differ because of the arrangement of the arrow-heads. The same illusion occurs if the middle lines are left out, and the figures measured from their points are compared. Other figures giving illusions can be formed out of circles, semicircles, squares, and alphabetical letters. The Poggendorf illusion, the barber-pole illusion, and the Zoellner illusion, which are shown by figures consisting of straight lines, spiral lines round a column, and a straight thick black middle line with numerous small black oblique lines crossing it, are shown in large diagrams and fully explained by Woodworth,* and those interested in illusions might refer to what he has written about them for further information.

INSTINCTS

The Definition of Instinct. Many definitions have been given, of which the following are examples:

1. Action taken in pursuance of an end without any conscious perception of what the end is (Hartmann). (2) Inherited memory (Butler). (3) A kind of organised memory (Spencer). (4) The sum of inherited habits

* "Psychology—A Study of Mental Life." (See pp. 457-459.)

(Murphy). (5) Inherited capability; or more exactly, instinct is the inherited power of acting habitually and without deliberation in a purposeful intelligent fashion under the influence of internal stimuli, plus or minus others from without (Eimer). (6) A reflex action into which is imported the element of consciousness. (7) An involuntary prompting to action.*

The Instincts of the Lower Animals. These are all inborn, and their instinctive responses to stimuli are, for the most part, made in a definitely fixed manner. Some animals, such as, for example, ants, spiders, wasps, bees, birds, dogs, elephants, and monkeys, perform actions of a more intelligent kind than those due solely to instinctive response. That, however, does not imply that they are conscious of the fact, nor are their instincts always faultless, "for ants store beads instead of grains, and mistake corn-wheat seeds for their own cocoons; flower-visiting insects also patronise brightly coloured wall-paper; and the lemmings, in their instinct for going right ahead, will swim straight out to the sea."*

Lemmings, it may be mentioned, are small animals belonging to the genus of rodent quadrupeds which include musk-rats and water-rats.

In the case of human beings, although they display many instincts from the moment of their birth, many others are manifested during the development of the nervous system. This can be demonstrated by studying the activities of children at different stages in their growth. The development of these latent instincts is one of the characteristic differences between the human subject and the lower animals.

The Classification of Instincts. Great diversity of opinion exists as to what should or should not be called instincts,

* "*The Illustrated Chambers's Encyclopædia.*"

and their classification varies according to the views held. Thorndike in his list enumerates about fifty instincts, among which he includes sucking, creeping, standing, and walking, which other writers regard as reflex actions. He also includes the so-called specific *phobias* or fears, of which the following are examples: (*a*) The dread of spaces or crowds of people (agoraphobia). (*b*) The dread of being left alone (monophobia). (*c*) The dread of being in enclosed spaces (claustrophobia). (*d*) The morbid dread of society (anthrophobia). (*e*) The dread of high buildings lest they should fall (bataphobia). (*f*) The dread of being at a height (acrophobia). (*g*) The dread of disease (pathophobia). (*h*) The dread of railway journeys (siderodromophobia). (*i*) The morbid dread of lightning (astraphobia). (*j*) The dread of everything and everyone (pantophobia). These are all instinctive "dreads" which might be grouped together under one heading, "phobias." The scientific terms applied to the different kinds of phobias may not sound so dreadful if readers will refer to a dictionary for their derivation.

Professor James includes, in his list of instincts, crying and smiling. And since a child can cry from the moment it is born, it is not unreasonable to assume that crying is instinctive. A child, however, cannot smile then: but in course of its development it learns to smile, and may do so when it is only a few weeks old. And it very soon learns to laugh. Smiling and laughing may, therefore, be considered to be due to the development of latent inherited instinct. McDougall classifies instincts under two heads—viz., (1) instincts proper, and (2) innate tendencies.

Instincts Proper. Under this head are included such instincts only as are accompanied with specific emotions or excitement of some kind. In order to illustrate this, Woodworth cites the case of a "broody" hen which, when in this condition, responds to a nestful of eggs by sitting on them as she does not at other times. He gives as other examples the nesting of birds and nest-building, mating instincts, the hunting instinct of dogs, and the gregarious instincts which cause animals to associate or live in flocks and herds. To these may be added the social instincts of mankind. While these instincts may not all be due to conscious response to stimuli, it may be assumed that even in a "broody" hen there is, probably, a feeling or prompting of some kind akin to consciousness with, perhaps, also some element of emotion attached to it.

Among what are called "primary emotions," Woodworth in his "Inventory of Instincts and Emotions" mentions anger, fear, lust, grief, mirth or amusement, disgust, curiosity, and the "tender emotion" which is manifested most strongly in a mother's love for her child. Emotions differ from instincts in that they are internal responses or feelings of the nature of a preparation for action when they are aroused, whereas instincts are involuntary promptings to act in a certain way, and are concerned also with the end-reaction or result—that is to say, with the possible consequences of the action taken. Several of the primary emotions are intimately associated with specific instincts, of which Woodworth gives, as examples, *fear* with the instinct to escape, *anger* with the fighting instinct, *lust* with the mating instinct, *tender emotion* with the maternal instinct, and *curiosity* with the exploring instinct.

Innate Tendencies. This term has been adopted to differentiate between instincts proper and reflex actions, such as swallowing, coughing, sneezing, etc., which some writers, as has been said, include in their classification of instincts. But as reflex actions are not ordinarily attended with any emotions which characterise *instincts proper*, they have been classified by McDougall as innate tendencies.

Instinct is a mental phenomenon, which, like a reflex action, consists of a stimulus, a response, and a reaction. Hunger and thirst, for example, are stimuli, searching for food to eat and water to drink are responses, and the acts of eating and drinking are the reactions or end-results. While most reflex actions occur instantly, automatically, and unconsciously, instincts proper tend to persist.

Woodworth* discusses instincts under the following three heads: (1) *Responses to organic needs—e.g.*, eating and avoiding injury. (2) *Responses to other persons—e.g.*, the mating instinct and the parental instinct. (3) *Play responses*, which he regards as a miscellaneous group, including the playful activity of young children, locomotion, vocalisation, laughter, curiosity, rivalry, and fighting, which he says might be named the *non-specific instincts*, because the stimuli for them are difficult to specify, and suggests that the miscellaneous group might be called the "*play instincts.*" What follows is based mainly on Dumville's† observations on "*instinct and habit.*" He enumerates the following instincts in man:

1. **The Instinct of Flight and Concealment,** with the emotion of *fear*, such as the fear of loud noises, darkness, and the fear of dogs and of pain.

2. **Repulsion,** with the emotion of *disgust*, as that caused when noxious substances are taken into the mouth, or by the action, speech, or general character of a person.

3. **Curiosity,** with the emotion of *wonder* and the desire to examine unfamiliar objects.

4. **Pugnacity,** with the emotion of *anger*, through one's own impulses being opposed or thwarted, whether rightly or wrongly.

* "Psychology—A Study of Mental Life."

† "Child Mind."

5. **Self-assertion** or **Self-display,** with the emotion of *elation* or *pride.* This instinct, when properly controlled, is, as Dumville says, " a cause of our most persistent endeavour and one of the factors in *emulation* and *rivalry.*"

6. **Self-abasement,** with the emotion of *subjection*, such emotion being evoked, for example, by the presence of some person who is regarded as superior to oneself.

7. **Parental Instinct,** with its " tender emotion," which, McDougall affirms, is at the root of all tendencies which exhibit love and tenderness, such as generosity, gratitude, love, pity, benevolence, moral indignation, and even the passion for justice.

8. **The Gregarious Instinct,** which prompts individuals *to seek the society of the fellows.* " *There seems to be,*" writes Dumville, " an opposed instinct which Professor James calls *secretiveness.* When this is the case, it is well to do all in one's power to increase the attractiveness of social communion. For there is no doubt that our best qualities can only be evoked through fellowship."

9. **The Instinct of Acquisition,** called also at times the *sense of ownership*, and at other times the *collecting instinct.* The sense of ownership makes us take an interest and even pride in books and other things which belong to ourselves. The collecting instinct is exemplified in the collection of specimens—botanical and others—coins, stamps, etc., all of which are of educative value, and the accumulation of money and things of monetary value. With regard to collecting money, Dumville remarks: " A child may be induced to begin to save small sums (though not *all* his coppers), and thus to form a habit of *thrift.* But if it is concentrated almost entirely on money and other valuables, the child being encouraged to hoard up every penny he obtains, it may lay the foundation of *avarice* and even give rise to *kleptomania.*" Kleptomania is an insane propensity to steal

10. **The Instinct of Construction,** which is the impulse to make things. Regarding this instinct Dumville gives the following quotation from Professor James's "Talks to Teachers": "Constructiveness is the instinct most active in children. By the incessant hammering and sawing, dressing and undressing dolls, and putting things together and taking them apart, the child not only trains the muscles to co-ordinate action, but accumulates a store of physical conceptions which are the basis of his knowledge of the material world through life."

Innate tendencies are enumerated by Dumville as follows:

1. **Imitation,** which has three forms, viz., (*a*) *sympathy* which implies imitation of those around us. (*b*) Imitation of *thoughts,* which may be called the yielding to *suggestion,* the tendency to which is called *suggestibility.* (*c*) Imitation of actions which, because it has no special name, Dumville suggests may be called *imitation proper* or merely imitation. By way of illustrating the meaning of *sympathy* as a form of imitation, he says: "It is well known that if one animal in a herd of wild beasts shows fear and rushes off in flight the others may follow suit." This is noticeable also in the case of a flock of sheep. In these instances the general stampede may not be due to the perception of what may have frightened the first animal and made it scamper off, but to the instinctive emotion of fear. "The sympathetic spread of emotion," says Dumville, "occurs in the same way among children. We often call it the 'sympathy of numbers,'" and adds, "the 'tone' of a class or school depends largely on the same thing."

But we have other examples, though of more serious import than those pertaining to wild beasts and school-children, in strikes among the working-classes, and in civil disobedience or non-co-operation, or whatever else these may be called, due largely to the many being influenced by the few and following their lead blindly, not knowing whither they are being led or what the consequences may be.

The term *suggestion* is varied in meaning. As an innate tendency it is the process whereby one person is led to believe something and act on the belief without sufficient reason, and merely because he has been induced to do so by someone else. Through imitation by suggestion the actions, manners, vulgar or refined speech and even accent, and the good or bad habits of those with whom we associate, may be acquired.

2. **Play** is an innate tendency. Not only is it necessary for the normal development of children, but to the very young children, says Dumville, " it is everything." Play is also of great importance to grown-up persons, in that it enables them to keep in a fit state of health " (see " Exercise and Recreation," pp. 134-138).

3. **The Tendency to Seek Pleasure and to Avoid Pain.** Of all innate tendencies this is by far the most powerful and the most general that, by many psychologists, Thorndike and Sully among them, it is called an instinct. Dumville goes even further, and says that this tendency " is such a fundamental feature of all our activity that it should rather be regarded as a *general law* influencing all our mental life. It plays a most important part in the modification and development of all our other instincts and innate tendencies, the particular kinds of habits which are formed being largely due to its influence."

Conation, which is the faculty of free agency, includes desire and volition, which is the act of willing or choosing, may be initiated by many varying stimuli of an emotional kind, and the acts are recorded in the memory. No matter from what stimulus conation arises, pleasure and pain initiate additional conation on their own account. If pleasure results we tend to repeat an action. If pain results we tend to shrink from repeating it. The additional conation which arises from pleasure is called *appetition*, which is simply appetite or desire. That which arises from pain, causing us to turn away from an action, is called *aversion*. The influence of these factors on the formation of habits is obvious. While much of the pleasure and pain which come into our lives arise from causes external to ourselves and, therefore, beyond our control, yet, on the other hand, we are responsible to a great extent for the pleasure and happiness or the pain and misery in our lives. For being free agents we have a considerable degree of control over our thoughts, our emotions, and our will. But it has become clear that tendencies which give rise to painful experiences can be suppressed by determined mental effort while, on the contrary, tendencies which produce pleasure and happiness grow stronger the more we encourage them, until certain of our actions are performed quite spontaneously, when they are known as *habits*. Finally, instincts, which are merely *repressed*, are by no means eradicated, which explains why so many children who have been severely repressed at home or at school break out into evil ways when in later years they are able to choose their own course of action.

MOTOR ADJUSTMENT THROUGH ACTIVITY

"The term *motor adjustment*," writes Woodworth, "has been used in psychology with the idea of likening human individuals to an adjustable machine which can be set up for one or another sort of work." Persons who have never heard of motor adjustment in its application to human activities, when asked the meaning of it, at once conclude that it has something to do with a motor-car, how to drive it and direct and control its movements. In its psychological bearing motor adjustment is effected through the sensory and motor nerves and nerve centres. It involves perception, reasoning, and experience gained through various activities. It is through the sense of touch, judgment, and adjustment of muscular movements, etc., that individuals become expert in playing tennis, football, cricket, billiards, and other games, and that skill in any trade or occupation is acquired. Success is always accompanied with pleasure, whereas failure is attended with a feeling of painful disappointment. From this it will be seen that motor adjustment and mental activities are closely associated. As illustrating this, Woodworth cites the following examples: (1) That of *hunger*, which is an inner state and adjustment predisposing the individual to make eating movements in response to the presence of food. (2) *Fear*, which is an impulsive adjustment to escape from some seen danger. (3) *Anger*, which is an impulsive adjustment to get at something and attack it. The activities of children are generally cited as a typical instance of motor adjustment. Dumville writes: "Nobody can watch a healthy infant without being struck by his tendency to handle, look at, roll, rattle, bite, and otherwise experiment upon all objects which come within his reach." These activities, however, are accompanied only with the sensation of movement, and the objects convey no meaning whatever to the child. It may play with its toes, and yet be unconscious of the fact that they are part of its own body. But as the movements afford it pleasure, it keeps repeating them. Later, however, the senses of sight and touch develop, and in creeping about the floor or learning to walk it may knock its head against some article of furniture or have a fall, and through painful experience gained in this way the child learns to adjust its movements so as to avoid risks of the kind in future, and soon gets to know that its head and other parts of its body are its own and how to protect them from injury. "Discovery," says Woodworth, "takes its start with the child's exploratory activity and invention with his manipulation," and says, further, "perception is an adjustment to facts as they are, while motor adjustment is a preparation for changing the facts. Perception does not alter the facts, but takes them as they are; movements alter the facts or produce new facts."

THE FUNCTION OF PLAY

Amusements, diversions, exercises and games of all kinds, and dramas and operas are all included in the term *play*. The instinctive tendency to play is manifested in children in their earliest infancy, and one has only to go to a "*Zoo*" to see the same instinct displayed in the playful activities of the lower animals. Woodworth, in a chapter on "Instincts and Emotions," discusses *play-instincts* under the heads of playful activity, locomotion, manipulation, exploration, or curiosity, laughter, fighting and self-assertion. The following are a few brief observations under each of these heads:

Playful Activity. Although in its early infancy a child may not be able to make muscular movements of an intelligent kind, its activities, nevertheless, help to develop its muscles, and, in course of time, when its nervous system becomes more highly organised, it is not only able to use its muscles freely, but also to control and adjust their movements.

Locomotion.—There can be little, if any, doubt that creeping and attempting to walk are regarded by a child merely as play. Most of the lower animals can walk at birth or very soon after; whereas a child's muscles are not sufficiently developed to enable it to do so until several months after birth. They soon learn to walk, however, when their muscles are ready for use, and when they have gained confidence through their own efforts to do so or a little help and encouragement from someone else. Many children could walk sooner than they do were it not that they are restrained in their attempts, at times, lest their legs should become bent. A child has been known to walk when only seven months old, and it has been recorded that a child seventeen months old, that had done nothing but creep before, has practically got up and walked of its own accord. This fact has been cited to support the view that walking is an instinctive reaction.

Vocalisation. This also involves playful muscular activity. And the playful cooing and babbling that appear when a child is a few weeks or months old are mentioned, as examples, by Woodworth, who writes thus: "A child derives satisfaction not so much from the muscular activity of vocalisation as from the sound he produces, so that deaf children, who begin to babble much like other children, lag behind them, as the months go by, from not deriving this auditory satisfaction from the vocal activity"; and adds: "The baby's cheerful babbling is the instinctive basis on which his speech later develops through a process of learning."

Manipulation has been defined as the use of the hands in a skilful manner. So far as very young children are concerned, their manipulation would seem to tend chiefly in the direction of destructiveness. They certainly do not show any skill in their activities when playing with their toys or anything else. Later on, however, they begin to take an interest in their playthings and other objects, and by handling and examining them carefully gain knowledge about their structure, actions, and uses. "This form of playful activity," says Woodworth, "contains the germ of constructiveness and of inventiveness."

Exploration or Curiosity is the action of searching in order to discover something. It involves the use of all the senses. A child when only a few months old will listen eagerly to the ticking of a watch applied to its ear. It is fascinated by brilliant lights and things of variegated colours, and keeps gazing at them. It can discern the difference between what is sweet to the taste and what is nasty. And, when only a little over a year old, it will bend its head and apply its nose to a bunch of flowers as though to smell them. This, however, may be, for the most part, due to imitation. All this is known to every grown-up person interested in children, who have watched their development in its various stages. "Exploration," observes Woodworth, "though fundamentally a form of playful activity, has great practical value in making the child acquainted with the world. It contains the germ of seeking for knowledge."

Laughter is included in the play-instincts, because it involves muscular effort in playful activity.

Fighting. This may be either playful activity or amount to a *real* stand-up fight, involving the output of great muscular effort. As a rule the stimulus to fighting is restraint or interference. The fighting instinct is born in the lower animals and human individuals alike. Its existence in new-born infants can be demonstrated in the following manner, as described by Woodworth: "Hold the new-born infant's arms tightly against its sides, and you witness a very peculiar reaction: the body stiffens, the breath may be held till the face is 'red with anger'; the child begins to cry and then to scream; the legs are moved up and down, and the arms, if they can be got free, make striking or slashing movements." In somewhat older children, he adds, "Any sort of restraint or interference with free movement may give a similar picture, except that the motor response is more efficient, consisting in struggling, striking, kicking, and biting." With regard to the fighting spirit in general, the following is a further quotation: "There can be no manner of doubt that pugnacious individuals, dogs or men, get more solid satisfaction from a good fight than from any other amusement." By way of exemplifying the suddenness with which the fighting instinct may be aroused, or what might be, more appropriately, described as "much ado about nothing," the following amusing, though no doubt imaginary incident, given by Woodworth, may be introduced here: "Two women were brought before the judge for fighting, and the judge asked Mrs. Smith to tell how it started. 'Well, it was in this way, your honour. I met Mrs. Brown carrying a basket on her arm, and I says to her, "What have you got in that basket?" says I. "Eggs," says she. "No," says I. "Yes," says she. "Ye lie!" says I. "Ye lie!" says she. And a "whoop!" says I, and a "whoop!" says she; and that's the way it began, sir.'"

Fighting may be either aggressive, which is making the first attack, or defensive action. As it has so close a connection with the more generalised self-assertive tendency, Woodworth suggests that it might be included under that instinct. It may be regarded, he says, as a special form of self-assertive behaviour often complicated with the emotion of anger.

Self-assertion. It is difficult to trace the element of play in self-assertion. The four forms enumerated by Woodworth are as follows:

1. Defensive reaction to things, overcoming obstruction, putting through what has been undertaken—the success motive.

2. Defensive reaction to persons, resisting domination by them—the independence motive.

3. Aggressive reaction to things—seeking for power.

4. Aggressive reaction to persons—seeking to dominate. Self-assertion comes more directly under instinctive or innate tendencies.

HABITS AND THEIR FORMATION

Habit has been defined as the ordinary course of conduct or the tendency to perform certain actions. All habits, good and bad alike, are acquired, and become automatic through frequent repetition. Some of them tend to become "instinct-habits," which have already been discussed. They are so called to distinguish them from instincts proper. Habits include within their range moral, intellectual, and physical activities. "'Tricks of habit' are a result of the tendency of certain nerve-groupings to be revived, for it seems to be a law of nerve tissue that what it has done once it is prone to do again" (Nisbet).

Formation of Habits. Habits are formed in the following ways:

1. *Through Instinctive Reactions.* It is sometimes difficult to determine the instinctive impulse to habits formed in this way, but, as Meredith observes, "Careful observation may give us the key to the problem in individual cases." Instinctive reactions, which are attended with agreeable emotions, have a strong tendency to be repeated, and habits thus become permanently fixed.

2. *By Purposive Action.* This implies individual effort to perform in a skilful manner whatever duties may be attached to one's calling in life, whether it be a trade, profession, or any other vocation. All such effort is accom-

panied with the motive of achieving success, and the success which accrues from effort depends largely on the strength of the motive.

3. *By Voluntary Repetition of Reactions.* This applies to habits which individuals can form, of their own accord, by repeated effort and firm determination. They can, for example, acquire the habit of regularity in the time at which they go to bed at night and get up in the morning, take their meals, attend to their hygienic requirements, take exercise or recreation, and so forth. They can, in short, habituate themselves to carrying out their daily concerns and duties, according to a definite programme drawn up by themselves.

4. *Through Inadvertence.* Most so-called bad habits are acquired in this way. Many of them are formed through imitating other persons, and especially those with whom we associate, and the worst type are often formed in early life through instinctive impulses. The following are a few examples of bad habits which might be multiplied indefinitely: Scowling, making faces, picking the nose, promiscuous spitting, biting the nails, slouching when walking, careless postures assumed in sitting or standing, untidiness and uncleanliness, unpunctuality, the use of foul language, telling lies, dishonesty, affectation, boasting and egotism. We must not omit to add to these the habit of using cocaine, morphia, Indian hemp, and other dangerous drugs, and the abuse of alcohol and tobacco. There are, besides these, habits which are grouped under the term *sentiment*, examples of which are love and hatred, fellow-feeling and sympathy, anger and fear, devotion to duty, loyalty and patriotism. These, like all other habits, tend to become permanent through being repeated.

General Observations regarding Habits. Some habits may *be due to nervousness, and others to bodily defects or* disease. When of the nervous type personal effort may help to overcome the habit, or it may be necessary to employ special measures, in individual cases, in trying to counteract it. Slouching and bad postural habits may be corrected by different kinds of muscular exercises, while those due to physical ailments may be remedied by some simple form of treatment. Since all habits tend to increase in strength and become automatic with practice, it is of the greatest importance that every endeavour should be made in early life to struggle hard against the strong tendency to form bad habits and to acquire and cultivate those that are good. "Habits," it has been said, "are soon acquired, but when we try to strip them off, 'tis being flayed alive." It has also been said that "ill habits gather by unseen degrees, as brooks run rivers, rivers run seas."

MENTAL IMAGES AND IDEAS

Mental or Memory Images are pictures or conceptions in the imagination with more or less likeness to objective realities. As used in optics, the term image is defined as the figure of any object formed by rays of light.

Ideas are mental images of external objects, but the term includes, in its meaning, any product of intellectual action, such as memory, imagination, etc. *Ideation* is the exercise of the mind for forming ideas.

"Mental images," writes Sadler, "are true to life and facts only in so far as our sensations and perceptions have been truly formed and correctly interpreted." Images of objects, and of sensations produced by different varieties of colour, sound, taste, smell or touch, can be revived in the mind without the stimulus, which originally produced them, being present. Moreover, by a readjustment of original images or ideas new images or ideas can be formed. It has been demonstrated by investigation that the power of reproducing or recalling mental images varies greatly in different individuals. Woodworth refers to what he describes as a kind of census taken by Galton when he asked many persons to call up the appearance of their breakfast table as they had sat down to it on a particular morning, and to compare the image with the sensory experience aroused by the actual presence of the scene. Some of them reported that the image was "in all respects the same as the original sensation," while others denied that they got anything at all in the way of recalled sensation, though they could perfectly well recall definite facts regarding the breakfast table. "So different," observes Woodworth, "are testimonies in this regard that one is forced to conclude that the power of recalling sensations varies from something like 100 per cent. to practically zero." The general opinion seems to be that visual images are more readily and vividly recalled than auditory or kinæsthetic images (Gr. *kinein*, to move; *aisthēsis*, sensation)—the term kinæsthesis meaning "a sense of movement or muscular effort." Persons have come to be classed as *visiles*, *audiles*, and *motiles*, according as their strength of recall is greatest in one or other of the three types of imagery mentioned. "But," says Dumville, "recent researches seem to point to the fact that usually in a given individual there is not a very great difference between the richness of imagery derived from one sense and that derived from another. Many seem to have good imagery *all round*; and some, especially those who do much abstract or general thinking, seem to have poor imagery throughout, except for words (which may occur in any or all of the visual, auditory, and kinæsthetic types)." Since the senses of taste and smell are so intimately associated in their action, any attempt to separate them into distinct types of mental imagery would be futile. It cannot be denied, however, that the sensory image of the taste of a savoury dish, partaken of long ago it may be, can be recalled as though some of the dainty food were actually in the mouth at the time of recall. The sensory recall of the taste of wines and other drinks seems to be comparatively weak in most people, and such wines, the image of the taste of which can be most realistically recalled, are usually highly flavoured with peppermint, caraway seeds, or other condiments. And no doubt the mental images of both food and flavoured drinks are to a considerable extent due to the recall of the sensory image of smell. Mental images differ in many respects from original percepts. Those arising from sensations are less detailed, less free from doubt as to their correctness, less enduring, less pleasurable in many instances, and in other ways inferior to original sensations. For example, the sensation of pleasure and satisfaction derived from witnessing a play or listening to an orchestral performance far surpasses that of recall. So far as concerns both sensations and percepts, no new facts can be derived from their mental images. But *new facts* can be derived from objects when they become presented to view again, and thereby we get to recognise them more readily. The faces of people with whom we associate become so familiar to us that they can be recalled, even though we may not see them for many years. The recall of words and their meanings enables us to converse with other persons, write letters, essays and stories, describe objects and scenes and relate past experiences of any kind. And in speaking and writing we recall learned speech-movements and writing-movements. "Recall," says Woodworth, "furnishes the raw material for thought. A large share of any one's daily work, whether it be manual or mental, depends on the recall of previously learned reactions."

Hallucinations are sense impressions—*e.g.*, hearing musical sounds which have no external origin, or seeing objects which are not externally present. These come under the category of mental images and ideas, as also does *reverie* and the day-dream or "brown study" in which the thoughts are disconnected and have no bearing on each other or any definite aim in view. To this process of mental abstraction the term *free association* is applied to distinguish it from *controlled association*, in which facts are linked together in proper order, thus enabling correct ideas to be formed from them.

Optical Images. When discussing the sense of vision we learned that visual sensations are analysed and interpreted by the mind, and depicted in the retina in the form of mental images. The following forms of optical images have been classified: *Aerial image*—*i.e.*, seen as in the air, when the eye is being examined with an ophthalmoscope. *After image*—*i.e.*, the impression which remains in the retina after the image proper has ceased to be visible. If, when an object is being gazed at, the eye is quickly diverted from it, the image can still be observed. *Direct image*, which is a picture from rays of light not yet properly focussed. This is observed when the eye is being examined with an ophthalmoscope. The image seems to be behind the eye, and is magnified and erect. *False image*, which is formed in the deviating eye in squint. *Inverted image*—that is, an image upside down. *Real images*, which are formed when the rays of light emanating from objects are collected and brought to one point in the retina.

In defective eyesight known as *astigmatism* (Gr. *a*, negative, and *stigma*, a point), from which so many persons suffer, the rays are not brought to one point in the retina, and the images in consequence are indistinct. The trouble may be due to some defect in the shape of the eye, cornea, or lens, and may be complicated with either short-sightedness or long-sightedness.

Optical illusions need only be mentioned as being false or misinterpreted sensory images (see pp. 268-9).

IMAGINATION

Imagination is the faculty of forming or reproducing images of past experiences and facts associated with them which combine to form new facts. Memory depends mainly on the power of imagination, and a good memory on the associations formed at the time of learning. The first stage in the development of imagination is observed in all normal children when they begin to experiment with their toys. It is at this stage, too, that they begin to acquire manual skill and constructiveness. Sadler stresses the importances of educating, training, and curbing the imagination of children, whose early life, he says, is largely one of fantasy, and suggests that instead of telling them so many fairy tales they should be told about facts and people, so as to excite thought and mental concentration, and made to realise that the world is a workshop as well as a playhouse. "It is better," he observes, "to build on fact and learn how to make the real world more attractive to the imaginative little folks; there is plenty that a child will never have to *unlearn* that is both fascinating and satisfying to the imagination." Those responsible for the upbringing of children should avoid telling them about ghosts or other apparitions, or terrifying them by threats of coming evil if they do not behave themselves. It is due to such causes that children so often suffer from night-terrors, and develop various forms of nervous disorder as they grow older. Neurasthenic (Gr. *neuron*, nerve; *asthenia*, weakness) and hysterical persons who are unable to control their thoughts, or assume the responsibilities of life and fight its battles, are largely accounted for by the manner of their early training—their troubles being to a large extent based on the fantasies and imagination of their early childhood. "Such persons," says Sadler, "might be said to possess an automatic power of fantasy, one that acts quite independently of their ordinary mental processes—and one which forms its conclusions and formulates its statements quite without the conscious knowledge of the higher powers of such individuals' minds." "A child of three years," he adds, "will vividly describe his meetings with lions and other wild beasts in the back-yard, and may relate these things as real experiences which have just happened. He is really recalling the pictures of lions from his story books, or reviving the memory-images of the beasts observed at the zoo; and many of our mediums and clairvoyants are so constituted of mind that their own subconscious mind plays the same subtle trick upon them. They see, hear, feel, perceive, and portray as facts the figments of their own imagination."

A revolution in the methods of education was initiated by a German educationist named Friedrich Froebel (1782-1852) with his idea of the "Kindergarten"—*i.e.*, the children's garden (Ger. *kinder*, children; *garten*, garden). He sought to put his ideas into practice in a Kindergarten which he started in 1837 at Blankenburg, in Central Germany, but his ideas did not commend themselves to the authorities, and the school was closed. But at the present day the Froebelian is the system most widely employed in the education of young children up to the age of about seven years. The root of the system is in what was then a novel idea, that to educate a child you must study child nature. Froebel's object was to enable mothers and teachers *all* to do, consciously, what *some* mothers had done, before his time, unconsciously. The system is based on a metaphor. As we do not, by training, create the nature of a plant but only seek to develop it perfectly according to its own nature, so the child is a plant to be nurtured with the idea of developing to perfection the natural instincts of the child. "Find what Nature wills," says Froebel, "and do that." So came the idea of the Kindergarten. The school is the garden, and the children are the plants. In the Kindergarten the child's instincts are harnessed and guided and made to serve in his development.

The Froebelian system is based on two main principles:

1. *That life is one organic whole.* Each stage—infancy, childhood, adolescence, maturity, age—should be perfect in itself, but should flow naturally one from the other without any sharp transition. "There is not an object of man's thought or feeling which has not its root in childhood." Hence the necessity for perfection in the early stages.

2. *The need of the child for manual work.* "God," says Froebel, "created man in His own image; therefore man, like God, ought to create and work." It will now be apparent that one of the aims of the Kindergarten is *the development of the imagination*, and to this end certain apparatus, technically known as "gifts" and "occupations," is employed. The *gifts* are in the nature of toys—not the modern over-elaborate toys which leave no scope for the imagination, but rather they are raw material on which the child's imagination may work. But they must not be regarded merely as toys or pastimes which are employed because they are attractive to children. They are employed because they have in themselves a definite intellectual character, and because they have the effect of

stimulating individual mental effort. The "gifts" are six in number:

1. Six balls of wool: the primary and the secondary colours.

2. A wooden sphere, cylinder, and cube.

3, 4, 5, and 6. A wooden cube divided up in various ways into smaller cubes and prisms of different shapes and sizes. These are used to make different combinations in accordance with the child's imagining:

(1) *Forms of beauty—i.e.*, pleasing to the eye by reason of their symmetry and proportion.

(2) *Forms of knowledge,* illustrating number and ratio.

(3) *Forms of life*, the combinations representing real objects—*e.g.*, house, train, pieces of furniture, etc.

The "occupations" also give great scope for the development of the imagination. They include the making of patterns with coloured beads, sticklaying, making designs with laths (thin cleft slips of wood), sewing, paperfolding, and papercutting, matplaiting and brushwork. Kindergarten methods are also carried into all other parts of the school work in drill and songs, in walks and short journeys, and in telling of stories. One word of warning should be added. In such a brief paragraph as this an idea of the *letter* of Kindergarten can be given, but it is quite impossible to convey any idea of its *spirit*. And here, as elsewhere, "the letter killeth, but the spirit giveth life." The Froebelian system has obvious defects, and its results should not be judged by the work of those who are ill-acquainted or out of sympathy with it. Kindergarten methods can only be successful when they are employed by sympathetic, enthusiastic, and well-trained teachers.

The following forms of imagination have been classified:

1. *Reproductive imagination*, which is the act of recalling, in the form of images or ideas, past experiences regarding

objects, sensations, scenes, events, and so forth. It is closely allied to memory.

2. *Interpretative or constructive imagination*, which is the act of explaining, in a lucid manner, recalled facts which are related to or are representations of original images. This is illustrated in a dramatic performance, in which the actors seek to represent a story of human life and action by imitating the language, dress, habits, customs, etc., of the original characters.

3. *Originative or Creative Imagination.* This is the power of bringing into existence new facts relating to past experiences. "Strictly speaking," says Dumville, "there is nothing absolutely original or creative in this process. In the mental world, just as in the physical, man can create nothing. He can only rearrange and modify what already exists. The sublimest 'creations' of poets and romancers are constructed out of ideas already in their possession." "It is," as Sadler says, "the province of creative imagination to take our ideas and fashion them into ideals."

4. *Controlled Imagination.* This form of imagination can only be called into action by having some definite aim or object in view. Before beginning to build a house, for example, details as to its general structure, cost, etc., have to be considered, and plans prepared according to which the work is carried out.

5. *Free or Uncontrolled Imagination.* In this form of imagination there is no motive in view. It is, as Woodworth says, "a kind of play which usually if not always contains an element of imagination or invention, and is exhibited in highest degree in children playing with their toys, the effect of play being that of a stimulus to free imagination."

The terms imagination, fancy, and fantasy are often confused and made use of as though they were synonymous in meaning. While imagination and fancy may in some instances express the same meaning, the terms fancy and fantasy are not interchangeable. "Fantasy," says Sadler, "represents what may be called the playhouse of the soul. It represents 'consciousness adrift,' or a state of mind in which the thoughts are uncontrolled."

ASSOCIATION OF IDEAS

Association of Ideas is a mental process by which ideas regarding natural objects, sensations, states of feeling, actions, and past experiences of any kind are linked together, thereby facilitating their recall in the form of mental images. How the linkage is effected has been explained in the chapters on "The Nervous System" and "The Acquirement of Knowledge through the Senses" (see pp. 238, 242-5, 261-4). All that need now be restated is that the strength or weakness of the linkage of ideas depends largely on the extent to which the mental faculties are exercised. When, for example, keen interest is aroused in any object, perception is stimulated to activity and the ideas formed regarding the object become, thereby, more strongly linked together and more easily and vividly recalled to memory than ideas formed about an object which aroused little or no interest. The same observations apply to sensations and all other mental impressions, no matter how they originate. What has now been said may help to explain the signification of the term association of ideas, which is regarded as the most pervading fact at the foundation of intelligence, and forms the basis of all habits and systems of memory training. Locke, who was the first to use the term "association of ideas," wrote: "Ideas, that in themselves are not of kin, come to be so united in other men's minds that it is very hard to separate them; they always keep in company, and the one no sooner comes into the understanding but its associate appears with it; and if there are more than two which are united, the whole gang *always inseparable* show themselves together."*

Writers on this subject were formerly in the habit of writing—and, indeed, some still do—as though there were a number of different kinds of associations, but it must be clearly understood that there is only one kind of association. The working of the law is the same in every case, though merely for convenience we may divide it into several groups. Some writers, for example, recognise three kinds of association—viz., association by similarity, association by contrast, and association by contiguity. Others hold that the last of these includes and embraces the other two. But Dumville would appear to object even to the phrase "association by contiguity" on the ground that it implies that there are other kinds of association. He holds, however, the view that the principle of association by contiguity is at the basis of all associations, and adduces strong and convincing arguments in favour of his contention. As an improvement on the "law of association by contiguity," Woodworth has suggested the substitution of the "law of combination," as applied to learning, "which attempts to show how it comes about that a stimulus, originally unable to arouse a certain response, acquires the power of arousing it; and the law states that this occurs only when the originally ineffective stimulus is combined with other stimuli which can and do arouse the response." But since association by similarity and association by contiguity are still referred to and described in books on psychology, a few observations may be made regarding each to make this chapter complete.

* Quoted by Dumville, "Child Mind," p. 31.

Association by Similarity. Two different things may look so much alike that one of them, when seen for the first time, may be mistaken for the other with which we are quite familiar. The mistake occurs through each of them having something in common. But when we come to examine them with care they are found to differ materially in many respects. For example, a strange face, with some prominent traits which attract special notice, may be mistaken for that of an old friend or intimate acquaintance. Association by similarity has much to do with the ability to invent or find out something new, and reasoning and imagination depend largely upon it.

Association by contiguity differs from that of association by similarity in that it effects the immediate recall of facts relating to all mental processes, whether as regards actions, sensations, states of feeling and ideas, or the time, place, manner of recurrence or relationship to each other. The principle of association by contiguity applies alike to ideas regarding objects and sensations, all learned movements in trades and other acquisitions. In typical cases of association by contiguity when one thing reminds us of another, both of which were associated in past experience and related to each other, an unitary response recalls both of them. The following are two good examples given in Chambers's Encyclopædia: (1) When we see the sky overcast, we think of rain as about to follow, the notion of rain not having previously been present to our mind. (2) If an object is before our eye—*e.g.*, a mountain—we receive an impression or sensation of it, in consequence of the actual presence of the thing; but it is possible for us to remember the mountain, or to have an idea of it, when far from the reality, in which case there must be some power in the mind itself different from the susceptibility to present objects, a power of retaining, revivifying, or resuscitating those states at first induced by contact with the actual. Speech is the recall of words by knowing their meanings, and a single spoken, written, or printed word—*e.g.*, Macbeth or Hamlet—might be sufficient to recall to some memories the whole of either or both these Shakespearean plays.

Simultaneous and Successive Association. *Simultaneous Association.* From what has been written above, the reader may think that the association of ideas is a simple phenomenon, but in reality it is highly complex. In the adult mind, most of our perceptions are not pure, but mixed. An object enters into the consciousness as a sensation, and, to quote Titchener, " this sensation has fixed habits of connection with other central sensations. Hence, when it arises, they necessarily arise with it. When the sensation comes, it comes with a bevy of inside sensations clustered about it." That is, " the assimilations and symbolic perceptions of our minds are put together by way of simultaneous association." To use Titchener's example, if walking along a country road we suddenly hear a rumbling sound, we know at once that it is a carriage coming from behind us. We locate it as being at a certain distance from us, but sounds themselves cannot give rise to space perceptions, so that there must be another explanation of our ability to place the noise. " The fact is, when the noise takes its place among the processes composing your consciousness, it brings with it a number of central supplements. If you are eye-minded these are visual: a picture of the carriage at a particular place upon the road. If you are ear-minded, they are auditory; the sound of the words, ' There is a carriage just there, so far behind. . . .' In reality, then, the noise is perceived as coming from a particular thing and place only indirectly by way of simultaneous association."

Successive Association. When a second idea enters our mind by reason of simultaneous association with the first, the process does not stop there, but the second gives rise to a third, to a fourth, and so on, and a train of ideas is formed in our mind by successive association. We ourselves can trace the course of the ideas, but another person would be bewildered if we told him the first and the last ideas without the connecting links. For any one of the many sensations contained in the first perception has habits of connection, and the mind may go in any one of many directions to arrive at the second idea, and so on, to the third and fourth. The reader, recalling many a daydream or reverie, or "castle-in-the-air," will be able to furnish many examples for himself. An extremely interesting illustration will be found in the introduction to one of Edgar Allan Poe's tales of mystery and imagination: "The Murders in The Rue Morgue"; the reader will realise, however, as he reads, that it is highly improbable that the two men each starting from the fruiterer "who ran up against you . . . fifteen minutes ago" would both arrive, at the end of a long train of ideas, at the same idea at the same moment, since each idea provides a great variety of starting-points for the next.

The Influence of Interest on Association. In the last paragraph we suggested that an idea would originate very different trains of ideas in the minds of different people, the reason being that the direction and character of our associations is dependent upon our individual interests and abilities. An artist associates a red sky with a picture, a farmer with his crops. An idea in our mind cannot possibly form an association with another which is entirely outside the limits of our experience, but the more frequently an idea is present in our mind, in our daily work, our pleasures, our hobbies, our family life, the more likely it is to enter into association with other ideas, and the more likely are our trains of ideas to turn in certain directions.

MEMORY

Memory. In her introductory remarks on "Special Studies Connected with Memory," in chapter vii. of her handbook on "Modern Psychology," Christabel M. Meredith writes: "Few writers now dare to use the word 'memory' in the singular without hastening to explain that they mean not 'memory' but 'memories,' and that they are well aware that such a statement as 'John has a good memory' is meaningless unless we say to which of John's memories in particular we refer." So that, bearing this in mind, we may define memory in its application to individual memories as "the power of the mind to retain impressions of objects, sensations, actions, habits and tendencies, and past experiences generally, and to reproduce them in the form of mental images." Sadler defines memory as "the physical register of mental experience or the consciousness of the restimulation or awakening of the physical registries of past experience." The question as to how memory originates is a vexed one; but the general belief seems to be that, like all other mental faculties, it is based on hereditary and instinctive promptings, and that its development proceeds as the neurones and associated nerve-tracts become more highly organised. The strength of recall of past memories depends, largely, upon whether or not percepts, associated with the memories, aroused interest at the time of occurrence, and whether facts connected with them were attentively regarded and understood. Although all past experiences may not be recorded in the neural areas of the cortex of the brain, such of them as may have made deep and lasting impressions can normally be reproduced in more or less detail. Besides, there is every reason to assume, from observations made by Sadler and others, that past experiences are grouped and sorted in the neural areas, and that facts connected with the experiences can, under certain conditions and within reasonable time-limits, be recalled and reproduced in logical order. "The human brain in its behaviour," says Sadler, "is in many respects analogous to a phonograph record, while the mind performs in the capacity of that power which operates, utilises, reproduces, and otherwise manipulates those things recorded on the brain through the sensory receiving apparatus of the body." So firmly rooted may past memories be that some very aged persons who can no longer memorise anything new may yet be able to recall episodes of their early childhood, and repeat, word for word, verses of poetry and long passages of prose which they learned at school.

The consideration of the subject of this chapter lends itself, more readily than much other of the subject-matter of psychology, to experiment and mathematical statement. The American psychologists have done a great deal of work in this direction. This chapter follows in the main Woodworth's treatment of the subject; and though the mathematical results of the experiments he quotes have been omitted, students who are sufficiently interested may find them in his book. He discusses the problems of memory under four heads—viz.:

1. Memorising (or learning).
2. Retention.
3. Recall.
4. Recognition.

Memorising or Learning. Much of what is known about memory and learning is due to laboratory experiments with *nonsense material* in the form of figures and words, *paired associates* of words, *connected passages* of prose or poetry, and experiments in *economy of memorising.* The following are examples:

1. Suppose a list of twenty one-placed numbers, such as those below, is given:

5 7 4 0 6 2 7 3 5 1 4 0 9 2 8 6 3 8 0 1.

This list might be memorised by frequent mechanical repetition of the figures, but it would be a slow process because there is nothing characteristic about them. But if the figures are separated into groups by commas and semicolons thus:

5, 74, 0; 62,73; 5 1 4 0; 9,286; 380, 1,

they can be analysed and memorised much more easily and much more easily recalled.

2. Take a list of nonsense syllables such as—

wok pam zut bip seg ron taz vis lub mer koj yad.

The syllables might be learned by observing similarities and contrasts, by reading meanings into them, and by grouping them into pairs or otherwise and making them rhyme. "One who learns many lists in the course of a laboratory experiment," writes Woodworth, "develops a system of grouping. First he reads a list through in groups of two, three, or four items, noticing each group as a whole; later he notices the items in each group and how they are related to each other. He also notices the interrelations of different groups and the position of each group in the total series. All this is quite different from a mere droning along through the items of the list; it is much more active and much more observant."

3. Suppose an experiment is conducted by the method

of "paired associates." The person to be tested is handed a list of words—*e.g.*, the following:

soprano .... emblem
grassy .... concise
nothing .... ginger
far away.......... kettle
shadow .... next
mercy .... scrub
hilltop .... internal
recite.......... shoe-string
narrative .... thunder
seldom .... harbour

and so on.

What is required in this experiment is that the person tested should respond by giving the second word when the first is mentioned. In learning to do this the two words may become linked in the person's memory by the sound or look of the words or connection in their meanings to form a unit which simplifies response. If the test is immediately applied after a few readings, 100 per cent. may be scored. But, observes Woodworth, "if the test be suddenly varied and the person is asked to recite the pairs in order of the list, or to tell after completing one pair what was the first word of the next pair, he may be unable to do so, and protest that the test is not fair, since he paid no attention to the order of the pairs, but concentrated wholly on each pair separately." The process of memorising *connected passages* of prose or poetry consists, chiefly, in the observation of the sense and meaning of the passages, the grammatical structure of sentences and phrases, and any characteristic in the phraseology of the writer. "A connected passage can in this way be learned," says Woodworth, "in a fraction of the time needed to memorise an equally long list of unrelated words," and adds, "if a student gets the point with absolute clearness, he has pretty well committed to memory."

We now come to "economy in memorising," which, it may be explained, means wasting as little time and mental effort as possible in endeavouring to commit to memory. Among the methods employed for this purpose are recitation, spaced and unspaced repetition, and whole *versus* part learning.

Recitation. As applied to memorising, recitation is the act of reading aloud to oneself at intervals what one is trying to learn, with occasional reference to the subject-matter. "Where the sense rather than the exact wording of a lesson has to be learned, it is probably best to recite in outline after the first reading, and to utilise the next reading for filling in the outline" (Woodworth). A very good way to improve the memory and add to one's knowledge is to attend public lectures, take part in debates, or ask questions about what is not grasped clearly. Another way is to write a paper and read it at a social gathering, and listen attentively to what is said about it in any debate that follows, whether adverse or flattering.

From the results of the experiments on recitation, described by Woodworth, the following rules may be regarded as established:

(*a*) *The Value of Recitation in Memorising.* The subject-matter is always more easily memorised by recitation than by reading. The advantage of recitation over reading is even more marked after an interval of time than immediately after the effort to memorise—*i.e.,* the inevitable forgetting is slower after recitation than after reading.

(*b*) *Spaced and Unspaced Repetition.* The subject-matter is more effectively memorised if the repetitions are distributed in time—*e.g.,* if a passage is repeated twelve times in succession it will not be as well memorised as if it had been repeated the same number of times with an interval of five minutes, or an hour, or a day between each repetition.

(*c*) *Whole and Part Learning.* It has been proved by experiment that the easiest and most effective method of memorising—*e.g.*, a poem—is to repeat the whole passage every time, and not to learn it by portions and then piece them together. This latter method involves unnecessary labour, and what is memorised is not so well retained as it would have been had the passage been learned as a whole.

Woodworth describes in detail other experiments, the results of which appear to show that there are exceptions to the rules which have just been stated concerning the advantages of spaced learning and of whole learning. This apparent contradiction, he suggests, should warn us not to accept the rules blindly, but rather "to analyse the factors in each method, and govern ourselves accordingly."

Among the factors involved he mentions and discusses the following four:

1. *The factor of interest, confidence, and visible accomplishment—i.e.*, obvious progress. This factor is on the side of memorising by parts rather than as a whole. When the learner is confronted with a long lesson, he may despair of ever being able to learn it by repeatedly reading it as a whole, and consequently may lose interest. It is also in favour of unspaced as against spaced repetition, especially in the case of shorter passages. When the learner is making progress he prefers to finish the task rather than to wait for another day. "To have a task that you can accomplish at once, and to attack it with the intention of mastering it at once, is very stimulating" (Woodworth).

2. *The Factor of Recency.* Newly learned acts can easily be repeated, and facts which have just been observed can be easily made use of. The factor of recency counts in favour of both part learning and whole learning.

3. *The Factor of Meaning, Outlining, and Broad Relationships.* This is in favour of whole learning, because the learner catches the drift and notices the connections of the several parts and their positions in what is being learned. " Even if the part method is preferred, it is wise," says Woodworth, " to begin by a careful study of the whole."

4. *The Factor of Permanency.* This is on the side of spaced learning. Since the neurones benefit by rest, spaced learning gives more durable results than unspaced.

Retention. This is the process on which the value of memorising depends. We all know, by painful experience, that it is very difficult to memorise, but very easy to forget. Retention is the process by which ideas or thoughts which have entered the mind are stored there for future use. Woodworth describes it as a resting state in which learned actions remain until aroused by appropriate stimuli. It is well known that neglect to exercise the mental faculties—*i.e.*, to make use of the "appropriate stimuli"—leads to wasting of the cortex in the associated areas of the brain, and, consequently, to impairment of the intellect. Although the degree of retentiveness in each individual case depends mainly upon the inborn quality of the brain, yet just as the power of retention may be lost through lack of exercise, so, on the other hand, it may be increased by training.

Recall. This is a process of memory by which learned reactions can be automatically called back to mind in response to suitable stimuli. It is the third stage of the sequence—memorising, retaining, recalling. Recall depends for the most part on association of ideas. At times, when one is suffering from mental fatigue or subjected to constant interruptions when engaged in a task which requires much mental effort, or, when one is suffering from emotional stress, such as worry, anxiety, grief, fear, or self-consciousness, it would seem well-nigh impossible to recall anything to memory, while, in other circumstances, thoughts by the process of association flood into the mind like a deluge.

Failure to recall is due to response being temporarily *inhibited—i.e.*, checked. This happens, for example, when we are highly self-conscious or when we suffer from stage fright. The particular response which we wish to recall, or the particular idea which we decide to associate with that which has gone immediately before, is supplanted by some other which we neither desire nor design. We know that there should be another idea in our mind, so we grope for it, we hesitate and "break down."

As *helps in recall*, the following is a condensed summary of suggestions made by Woodworth: Have no doubt as to your ability to recall, know your subject well, and in public speaking have confidence in yourself; avoid worry and self-consciousness, and trust to your ideas to recall the words needed. If you are trying to recall names or anything else you know, but have forgotten, drop the matter for a short time and return to it afresh. The interval of rest puts you on the right track, and recall then becomes possible.

Recognition. Recognition is concerned with perceptions, remembering with ideas. "When a perception or group of perceptions has the mark of familiarity upon it, we speak of recognising someone or something. When it is an idea or group of ideas that bears the mark, we speak of remembering someone or something" (Titchener). Recognition is a simpler process than recall, "but any theory that makes recognition dependent upon recall," observes Woodworth, "can scarcely be correct. . . . The baby," he says, "shows signs of recognising persons and things before he shows signs of recall, and a little later understands words before he begins to speak (recall) them." One theory held is that an object is recognised by recalling its original setting in past experience—*e.g.*, an odour. "Now sometimes it does happen that an odour which seems familiar, but cannot be identified, calls up a past experience and thus is fully recognised, but such 'indirect recognition' is not the usual thing," says Woodworth, "for direct recognition commonly takes place before recall of the past experience has time to occur. You see a person and know him at once, though it may require some moments before you can recall where and when you have seen him before."

Memory Training. The most important factors in this process are careful observation of percepts and understanding of facts connected with them, interest and attention, confidence in one's ability to memorise, and firm resolution to do so. And since the formation of habits, the development of judgment and self-control, and the acquirement of knowledge of all kinds begin in the earliest years of life and greatly influence the recall of what is stored in the memory, it is of the greatest importance, to use the words of Harford, "that the best methods of training should be encouraged from the cradle upwards." So far as laboratory experiments are concerned, all that can be said about them is that while they may improve the memory regarding nonsense and other material used in the tests, "they do not pretend to develop any general 'power of memory,' and the much-advertised systems of memory training are no more justified in such a claim. What is developed in both cases is skill in memorising certain kinds of material so as to pass certain forms of memory test" (Woodworth).

Mnemonics (Gr. *mnēmonikos-mnēmōn*, mindful) is the name given to various artifices by which the memory is assisted more easily to retain and to recall to the mind any fact or number, or a series of disconnected facts or figures. Mnemonics are exceedingly useful at times, but they do not improve, nor probably do they impair, the general power of memory. A mnemonic by which the colours of the rainbow in their order may be remembered is—

Richard	Of	York	Gained	Battles	In	Vain.
Red,	Orange,	Yellow,	Green,	Blue,	Indigo,	Violet.

Readers who are acquainted with formal logic will recognise the mnemonic which is almost indispensable to the student —the five lines of pseudo-Latin which begin: Barbara, Celarent, Darii, Ferioque, prioris—in which all the consonants and vowels easily recall a series of facts which otherwise it would be very difficult to assimilate. But the most useful mnemonics are those which we create for ourselves.

This heading could not be more adequately concluded than by giving the following further quotation: " In training the memory for the significant facts that constitute the individual's knowledge of his business in life, the best rule is to systematise and interrelate the facts into a coherent whole. Thus, a bigger and stronger stimulus is provided for the recall of any item. This, along with the principles of 'economy' in memorising, is the best suggestion that psychology has to make towards memory improvement " (Woodworth).

The object of remembering things is to enable us to recall those things which will be of use to us. The power to forget useless things is of great value. An efficient mind is one which can remember that which is useful and forget that which there is no need to remember.

Memory Abnormalities. Four different kinds are recognised by psychologists. These are: (1) *Imperfect impression* due to weakness of sensory stimuli. (2) *Imperfect retention*, as in cases of accident when persons, after recovery from concussion, cannot recall what happened immediately before the accident. In certain instances it may be possible for them to recall some details a few days afterwards. (3) *Imperfect reproduction*, as when patients are unable properly to recall past experiences or where the memory for certain things only may be lost. "Dissociation of ideas," writes Sadler, "is the explanation of those interesting and remarkable cases where long periods of time are literally blotted out of the mind—at least out of the conscious mind." In some such cases the memories of past experience can be recovered in the hypnotic state. (4) *Defective memory due to disturbance of recognition.* There are four groups of this kind of memory: (*a*) Cases of complete failure of memory or of "never having seen" as Sadler puts it. (*b*) Cases in which there is the illusion of having already seen places, scenery, and so forth, which have not been seen. (*c*) *Distortion of memory*, in which fictitious details are mixed up with facts connected with past experiences. (*d*) *Retroactive memory*, which is attaching to memory what a person may have heard about things which happened before he was born, and getting to think that he actually remembers them.*

REASONING

Reason is a faculty of the mind by which conclusions are drawn, and right, truth, and justice determined.

Reasoning is the course of argument followed in endeavouring to arrive at correct conclusions. To do so requires careful observation of all facts relating to questions involved in doubt, and weighing the evidence in favour of or against the arguments adduced. In lawsuits, *e.g.*, the conclusions or findings of the court may be based on what is called circumstantial evidence—*i.e.*, evidence which is not

* Sadler, "The Mind at Mischief," pp. 334-5.

positive nor direct, but which is gathered inferentially from the circumstances of the case. Reasoning involves the necessity of having some motive or end in view, and forming ideas as to how best to attain the desired result. The question as to whether the lower animals possess the faculty of reason has occasioned much discussion, and many persons incline to the view that they do possess it. With regard to the dog, which is considered to be one of the most intelligent of animals, Woodworth writes: "There is nothing to indicate that the animal recalls facts previously observed, or sees their bearing on the problem in hand. He works by motor exploration instead of mental. He does not search for 'considerations' that may furnish a clue. What the human behaviour does show that is most absent from the animal is (1) attentive studying over the problem, scrutinising it on various sides in the effort to find a clue; (2) thinking typically with closed eyes or abstracted gaze in the effort to recall something that may bear on the problem; and (3) sudden 'insights,' when the present problem is seen in the light of past experience." It is well known to those who have attempted the task that the solution of deductions, based on known propositions, when no definite clue is given to their solution, involves much greater mental concentration and effort, and keener reasoning, than original propositions. There are various types of reasoning, of which the following have been mentioned by Woodworth:

1. **Reasoning Out the Solution of a Practical Problem.** "A problem," Woodworth writes, "is a situation in which we have no ready and successful response. We must *find out* what to do. We observe facts which recall previous experiences or previously learned rules and principles and apply them to the problem in hand. If our exploration is successful we observe a real clue, recall a guiding principle and find the solution."

2. **Rationalisation or Self-Justification.** Rationalisation is subjection to reasonable *principles* which are the fundamental truths on which other truths are based. Self-justification simply means that one must be able to give a sufficient reason for one's conclusion regarding any question at issue. It may be considered as a plea to justify one's actions whether they have been performed or are premeditated, or, as Woodworth puts it, " a reasonable *motive*, some acceptable general principle that explains our action."

3. **Explanation,** which is an attempt to make clear, by giving reasons for their existence, facts which may be difficult to understand.

4. **Application.** This form of reasoning differs from those described above in that, as Woodworth endeavours to explain, " instead of searching a concrete situation for clues and searching your memory for general principles, you search your memory for particular cases where the general law should apply. If all animals are cold-blooded, excepting only birds and mammals, then fish and frogs and lizards are cold-blooded, and spiders, insects, lobsters, and worms; having drawn these inferences, your understanding of the general proposition becomes more complete."

5. **Doubt,** which is uncertainty of mind or hesitation to believe. If assertions are made during an argument or debate the truth of which is disputed, this form of reasoning is at once employed and instances quoted from memory to show that the statements made are not in keeping with facts. This is illustrated by Woodworth as follows: " You say that all politicians are grafters. Theodore Roosevelt was a politician; therefore, according to you, he must have been a grafter. But he was not a grafter, and you will have to take back that sweeping assertion."

6. **Verification,** which involves hypothetical reasoning—an hypothesis being a proposition assumed for the sake of

argument, or a theory to be proved or disproved by reference to facts. All propositions coming under this form of reasoning have to be analysed in order to ascertain whether they are true or false. An interesting illustration, and one which explains clearly the meaning of verification by reasoning, is that of the discovery of the circulation of the blood by Harvey. The line of hypothetical reasoning pursued by Harvey was as follows: "If the blood is driven by the heart through the arteries, and returns to the heart by way of the veins, then the flow of blood in any particular artery must be away from the heart, and in any vein towards the heart. Further, there should be little tubes leading from the smallest arteries over into the smallest veins" (Woodworth). These deductions were all verified later when it became possible to observe, through a high-powered microscope, the minute capillary bloodvessels.

This chapter would be incomplete without some brief reference to two methods within which all acts of reasoning are included. Like M. Jourdain, in Molière's play, who was surprised to learn that, without knowing it, he had been speaking prose all his life, many people would be surprised to learn that all their life their acts of reasoning have been either deductive or inductive.

Deductive Reasoning is the application of a general truth to a particular case; it is the act of proceeding from the known to the unknown—*e.g.*, all liquids which turn blue litmus paper red are acids. This liquid turns blue litmus paper red. Therefore this liquid is an acid. It should be noted in passing that all acts of reasoning can be set out formally as above in a series of short propositions (two premises and a conclusion), to which in logic the name "syllogism" is given. Many of our actions and speeches are the conclusion of a deductive syllogism in which one or more premises may appear to be lacking, but on further consideration they will always be found to be present, but so obvious that we take them for granted—*e.g.*, I am going out for a walk. I glance up at the sky, and then I take either my umbrella or my walking-stick. On my friend Mr. X.'s advice I invest my money, without hesitation, in a certain company. These and all our other acts of reasoning may be reduced to syllogistic form thus:

Mr. X.'s advice is always perfectly sound.

To invest in this company is a piece of Mr. X.'s advice.

Therefore, it is perfectly sound.

Inductive Reasoning. In this we consider a large number of particular instances, and from what we observe as common to them all we draw a general conclusion covering them all. The syllogism will be set out thus:

This, that, and a number of other liquids all turn blue litmus paper red.

This, that, etc., are all acids.

Therefore all acids turn blue litmus paper red.

Induction, then, is the formation of general laws, but the danger is that we shall generalise too hastily, jump to conclusions, like the lady who always treats you as a confirmed invalid because you had tonsilitis nine years ago. Induction is a much more difficult and important process than deduction. It requires infinitely greater power of observation, knowledge, intuition. The greater part, if not, as some philosophers think, the whole of our knowledge is the result of the inductive process. The aim of modern science being the establishment of universals, the name "induction" is now frequently applied to the complete process including deduction. Accepting this view, the inductive process would include—

1. **Observation**—the consideration of a great number of isolated facts—a very difficult process. "There is not one person in a hundred," says Huxley, "who can describe

the commonest occurrence with even an approach to accuracy."

2. **Hypothesis**—an inspired guess at a general law embracing all the observed facts. This hypothesis may, or may not, be correct; so there follows:

3. **Verification**—the deductive stage—testing the hypothesis by applying to it further facts. If it is found not to apply throughout to facts of a like nature, it is rejected and another hypothesis formed. So the process continues until the hypothesis is established, when it becomes a theory or a law, the difference between a theory and a law being that a law states one universal relation, while a theory is a wider generalisation which may cover many laws—*e.g.*, the theory of evolution or Einstein's theory of relativity each include a wide area of knowledge, within which a great number of laws will be formulated as time goes on.

While we have here alluded but briefly and simply to the subject of scientific reasoning in so far as it comes within our province, the subject is much wider and more difficult than we have indicated, and the student who desires to read further upon the subject should consult textbooks on logic.

INTEREST AND ATTENTION

Attention may be defined as the application of mental energy to a given object or, in other words, the function of attention is to single out from consciousness one idea for special treatment.

Interest is the force which directs attention or determines the point to which it shall be applied. As a general rule, the greater the interest we take in an object, the greater is the attention we give to it. This is so obvious that there is no need to give examples. But the converse is not true. We may give a great amount of attention to an object, but our interest in that object is not necessarily correspondingly great—*e.g.*, a child writing out lines as a punishment or learning tables by heart. McDougall sums it up in these words: "To have an interest in any object is to be ready to pay attention to it. Interest is latent attention, and attention is interest in action." The relationship between interest and attention may be illustrated by an example—I am driving a car, and as long as the engine is humming normally I give it scant attention. I hear a sudden rattling noise in the machinery. Instantly I concentrate attention upon it, but if I recognise the sound and know it to be harmless, I cease to be interested and my attention is free for other objects. But as long as I do not know the cause of the noise I am acutely interested in it because I do not know what effect it will have upon the car and me. What, then, is *the cause of interest*? Animals are interested in anything which arouses any of the fundamental instincts, the interest varying according to circumstances—*e.g.*, a plate of food interests a hungry dog, but when full to satiety the dog will only be interested to the extent of sniffing at the food and turning away. The same rule applies to man, but man has power, more or less, to control the instincts; and further, man is a more complex being than the lower animals, and is governed not only by the fundamental instincts, but by many other factors, such as, *e.g.*, the emotions of love and hatred, sympathy, generosity, and so on; by heredity, training, social environment, and by the thought which may be prominent in his mind at a particular moment. "The one interest which dominates all others," says Dumville, "is the interest in ourselves." This is a provision of nature to ensure the preservation and maintenance of the race. There are many events and objects which evoke no interest, and so attract no attention when they are concerned with other people, which would be of absorbing interest were they connected with ourselves. But oftentimes our personal interest must be subordinated to the interests of other individuals or of the race, and according as a person is or is not able to do this, he is public spirited or generous or, on the other hand, self-centred, selfish, and mean.

Attention and Inattention. Inattention does not mean the entire absence of attention. It means only that we are, at any given moment, "not attentive" to some particular object. We are always relatively, while conscious, in a condition of attention. When another person wishes to attract our attention to an object and fails to do so, he may accuse us of being inattentive, but the truth is that, because he has failed to arouse our interest, we are giving our attention not to him, but to some other object which at that moment interests us more. When the teacher says to the child "Pay attention," the child is probably acutely attentive to a bag of sweets in his pocket or a game which he is going to play when school is over. The habit of inattention has ample and definite advantages, and is worth cultivating. To be able to reject at once from the mind what is not worth *while* is obviously an economical habit, and releases powers for things that really matter.

Three Forms of Attention. The three forms of attention are: (1) Passive or involuntary; (2) active or voluntary; (3) secondary passive.

1. *Passive or Involuntary—i.e.*, we attend without any effort on our own part. We cannot help giving our attention—*e.g.*, to a loud noise, a bright light, a violent pain. When our interest is thus spontaneously aroused, it requires a violent effort of the will—and even this may be unsuccessful—to divert our attention from that object. It may even follow us into our sleeping hours, and reappear in the form of dreams and nightmares. In young children and animals

in their natural state all attention is of this kind. With animals (and this applies also largely to human beings) passive attention is essential to their existence. No wild animal would live very long if its attention were not involuntarily attracted by a strange smell—*e.g.*, man or other foe—or an unusual sight—*e.g.*, a trap. The unusual calls forth passive attention when to the usual we might give no attention—*e.g.*, normally we give our teeth no thought, but if they are throbbingly painful we find it difficult to attend to anything else.

2. *Active or Voluntary.* In this form the act of attention is the result of definite and deliberate action on our part. We attend to an object or a thought by an effort of the will. Attention is achieved by action within ourselves, and not, as in passive attention, by action from without. This form develops as we pass from infancy—*e.g.*, a child is writing lines as a punishment, and while there is little interest, there is very active attention. A man is plastering a wall; he finds no pleasure in the task, but he attends actively to it. This is an example which is of general application. There are many people who are engaged in occupations which are exceedingly arduous or repulsive, or for some other reason distasteful, yet they find interest in the work and give active attention to it, not because of the pleasure the work itself gives them, but because it is the means whereby they earn a livelihood, and so procure subsistence for themselves and their families. The reason for performing an action, be it pleasure or money, or safety or excitement, or any other thing, is called the *motive* or *incentive*.

3. *Secondary Passive Attention.* Oftentimes we begin a task not because we wish, but because we know we ought to do so, and we give to it our active attention. But as the task proceeds we may find that our motive has changed and we are taking pleasure in the task, so that the attention

which before was active is now spontaneous. This form of attention is known as secondary passive attention. It differs from passive attention in that the latter is instinctive, while the former has evolved from a previous state of active attention—*e.g.*, a man begins to study for examination purposes. Up to a point his attention is active, but he becomes so absorbed in the subject that he continues to study it even when the examination is past—*i.e.*, active attention has become secondary passive attention.

Conditions on which Attention Depends. There are some things which arouse our interest and so attract our attention more easily and more quickly than others. This fact is made use of in countless ways in everyday life, in advertising, in journalism (headlines), in teaching, and in public speaking, and in many other ways. A number of rules may be laid down:

1. Intense stimuli arouse attention more easily than less intense—*e.g.*, a loud noise, acute pain, a bright flash.

2. Large objects attract attention sooner than small objects—*e.g.*, a tall man in a crowd; a splash of colour on a wall attracts attention when a spot of the same colour would be unnoticed.

3. Attention depends on duration of stimulus—one tap at my study door may fail to withdraw my attention from my work, but continuous tapping, however quiet, will sooner or later force itself upon my notice. But if the stimulus be too long continued, it ceases to attract attention; passengers on board ship "become accustomed" to the noise of the engines; people living in a street along which the trams run become so used to the noise that they are, for a time, unable to sleep when they move to a house past which trams do not run.

4. A moving object attracts attention more readily than

a stationary object—*e.g.*, a rabbit may be invisible while it is still, but attracts attention immediately it moves.

Duration of Attention. Attention may be either diffused (or distributed) or concentrated. When I lie on my back on a hot day and let my eye wander over the landscape while I muse upon things in general, my attention is diffused. But when I see a bird in a tree, and strain my eyes to discover what kind of bird it is, then my attention becomes more concentrated. Concentration is the deliberate exclusion from the mind of any other interest save that to which we desire to attend. The more attention is concentrated, the shorter the space of time we can give attention to an object. "The longest stretch of attention recorded," says Titchener, "is a stretch of twenty-four seconds, and the average length of attention is no more than five or six seconds." After this time we may think we are concentrating our attention upon the object—*e.g.*, upon the bird in the tree—but in reality our attention is wandering to surrounding objects and thus is diffused. We can give diffused attention for indefinite periods of time in reading a book or looking at a painting or picture, for example, because our attention proceeds from one object to another in a series of rapidly successive leaps. Concentration does not necessarily imply any degree of intensity of attention. We may concentrate more or less idly, or more or less intensely, according to the motive or incentive.

Distribution of Attention. It is sometimes said that it is possible to give attention to only one object at the same time. This, as a general rule, is true. Try, for example, the familiar experiment of drawing circles with one hand and vertical lines simultaneously with the other. But when we become so accustomed to certain actions, or so familiar with certain subjects that we give them secondary passive attention, then we may give attention to several things at the same time—*e.g.*, after a certain amount of practice it becomes more and more easy to draw circles and lines simultaneously. Or, again, a mother can knit and read and rock the cradle and listen for her husband's footstep all at the same time. But these are all habitual actions. Where actions are not habitual, we may seem to be attending to more than one at the same moment, but really our attention is flitting from one to the other alternately. A man, *e.g.*, may think that he is writing and smoking at the same time, but the frequency with which he stops to relight his pipe shows that he is smoking only when he thinks about it. The number of objects which may be held in the attention at the same moment is not definitely settled, but is probably not more than four or five. The student may verify this for himself by a few simple experiments.

1. Arrange four miscellaneous articles on a tray and cover them with a cloth. Remove the cloth so that the spectators may see them for a moment (do not give them time to learn the articles), and let them write down the articles to which they have been able to give attention. Repeat the experiment with five and six up to ten, with different articles each time. It will probably be found that the average will not increase beyond five.

2. Make a number of dots arbitrarily on paper thus:  and show them to someone for a moment. He will probably be unable to grasp more than four or five. But arrange the dots in order thus:  and he will be able to grasp a much greater number. The pips upon a playing card and the dots on a domino are arranged in a definite order, with which use has made us so familiar that we can see them all in a glance without the necessity of counting them.

3. Only four or five letters laid out haphazard can be attended to in a single flash, but four or five words can

be attended to in the same space of time—*e.g.*, here are letters laid out haphazard:

A G B L N E A A R S D M

and here are the same letters arranged into words:

BENGAL MADRAS.

This proves that we read, not by letters, but by general impressions, and accounts for the fact that misprints are so frequently overlooked.

The Physical Condition of Attention. "Attention," says Titchener, "is a psycho-physical phenomenon"—*i.e.*, the body and the mind co-operate in producing a condition of attention. We are all familiar with the fact that the face and the body take up a position of strain when we are trying hard to hear or to see or to understand. This raises a wide question, which may be more appropriately considered in the chapter which follows.

THE DEVELOPMENT OF INTEREST

The Conditions on which Interest Depends. Watch a number of people opening their daily newspaper in the morning, and you will observe that they do not all open it at the same page. If you question them, they will reply, "Oh, yes; I always read that page first." A woman will read first the fashion page or social engagements, but a man will turn first to the sports page, or the political news, or the financial column. There are some things in the papers which we never read because "they do not interest us." The fact is, we are all interested in some things, but not all in the same things, and there are many subjects in which other people may be keenly interested which do not awaken the slightest response in us. The editor of the *Medical*

Review does not expect his paper to circulate widely among farmers, and there are probably very few women who are regular readers of the *Metal Trades' Advertiser*. What is it, then, which determines the things in which we are or are not interested?

Apperception Masses. The ideas which we have consciously in our mind at any given moment are very limited in number, the reason being that, as we have already seen, few people can give attention to more than one idea at one moment, so that the ideas in our conscious mind are those only which are relevant to the occupation in hand. But in addition to these there is a vast wealth of ideas present, subconsciously, in our mind, waiting in readiness to be called by an appropriate stimulus from the subconscious into the conscious mind. We may think of this total wealth of ideas as being arranged in our minds in a series of groups or masses. The name given to these groups or masses is *apperception masses*. A sportsman, for example, has an apperception mass consisting of all his ideas about horses and dogs and rifles and tracking and nature lore and the like; a book collector has an apperception mass consisting of all his knowledge about first editions, printing, binding, and so on. Our interests in life are determined by our apperception masses. We have defined apperception as the conscious perception of a sensory impression—*i.e.*, it is the process by which new knowledge is absorbed and combined with knowledge already in our mind. But if there is no old knowledge with which the new idea can be linked up, there is no response in our mind to the new idea, and we are not interested. If a stranger approaches you and says "My name is Jones," you are probably not interested. If he goes on to say "I knew your brother in India," your interest is at once aroused, because you have linked up Jones with the apperception mass which is concerned with your family relationships. A man whose investments are in a precarious condition will, when his newspaper arrives, turn feverishly, not to the cricket scores, but to the Stock Exchange news, because he desires certain knowledge which will link up readily with his predominant apperception mass. Further, the greater the complexity and the variety within unity of an apperception mass, the greater becomes the degree of interest and the longer becomes the time during which an object can hold our attention, because our mind can pass in succession from one aspect of the idea to another. Of two men in a picture gallery, one looks at each picture, but passes rapidly from one to the other, because he "knows what he likes," but knows little else about art. The other man will stand for a long time before each picture. He places it in its period, he compares it mentally with the work of contemporary and of modern painters, he considers the colouring, the technique, the composition. We are now in a position to understand why some people are "interesting" and others "dull." Some people who to me are extremely interesting may by others be considered very dull, and *vice versa*. Speaking particularly from a personal point of view, people are interesting or dull according to whether their apperception masses do or do not correspond to mine. An elderly numismatist is always talking about his own subject, and I consider him a very dull person, because I have no knowledge of coins to which I can link his conversation. But watch him talking to a brother numismatist, and it becomes evident that they find each other exceedingly interesting people. More generally speaking, an interesting person is he or she who has a wide variety of interests, and who is familiar with an extensive range of thought and idea. This is a point of great importance to all who are concerned with the science of education. Life consists not in eating and drinking and sleeping, for the lower animals do this in common with man, but in the number and variety of our points of contact—that is, in the increase in quantity and quality of our apperception masses. The old idea of education was that its aim was the amassing of knowledge for its own sake; the new idea is that the aim of education is the creation of interests. Interest is no longer regarded merely as a means to an end, but as an end in itself. This change has effected a revolution in methods of teaching. We do not now, by various devices, seek to interest the children in order that they may be induced to acquire a store of knowledge; we increase their knowledge in order that we may increase their range of interests. Interest, which was formerly a tool to obtain an educational result, has now become itself the desired result. This change has come about largely through the teaching of Johann Friedrich Herbart (1776-1841), a German educationist, who taught that the ideal to be aimed at in education was to produce a person equipped with many interests, "one who finds nothing in the world alien to him." The same truth has been expressed in other words: "An educated man is one who knows something of everything and everything of something."

Interest and Secondary Passive Attention. In the last chapter the three forms of attention were considered, and we saw that secondary passive attention is that which evolves from a previous state of active attention. The effort involved in active attention is, like all other effort, fatiguing. It is obviously an advantage when the attention is effortless, as it increasingly becomes when we are so interested in a subject that we can give to it the secondary passive form of attention. "Secondary passive attention," says Titchener, "is the chief condition of human progress. The more a piece of work is reduced to a matter of course, the more power has the mind to advance to further work. This becomes natural and easy in its turn, and gives place to new work, and so on. . . . Active attention thus appears as a stage of waste, a stage to be got rid of. At the same time, it is a stage which must be passed through, and passed through again and again, if knowledge is to grow and character to be rightly moulded. The child who did not pass through it would remain at the level of the animals. . . . Active attention is the battle which must be won by those who mean to master their surroundings and rise to man's full height above the animal world." This can be achieved by forming powerful apperception masses in the mind of a child, and so increasing his interest in life that there may be a large number of links to unite the new with the old. The contrary process may also take place. Certain apperception masses may remain so long unused and undisturbed in the subconscious mind that they become atrophied through lack of exercise, and one's interests are thereby diminished to the impoverishment of life. There is a passage in Charles Darwin's Autobiography which has a bearing on this point. After speaking of the great pleasure and delight which up to the age of thirty he found in poetry, music, and pictures, he proceeds: " But now for many years I cannot endure to read a line of poetry. I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures and music. . . . If I had my life again I would have made (*sic*) a rule to read some poetry and listen to some music at least once every week; for perhaps the parts of my brain now atrophied would have been (*sic*) thus kept alive through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character by enfeebling the emotional part of our nature."

Manner is as Essential as Matter in the Creation of Interest. Books on the same subject vary in interest according to the manner in which the books are written; a profound scholar may fail as a teacher because he is a dull lecturer; a good play often fails because, when produced, it is badly acted. This is a matter of deep concern to the teacher, the preacher, and all who in any way have to influence or instruct others. The only instrument by which we can express thought and emotion is the body, and the study of the production of the voice, the expression of the face, the movement of the body in gesture, should be regarded as essential by all who are called upon from time to time to arouse the interest of an audience.

Interest and Bodily Attitude. Sometimes when a person begins to take interest in something which is happening around him, not because he ought, but because he desires to do so, we say that "he is sitting up and taking notice." Those who use this idiom are often unconscious of the fact that they are expressing a profound psychological truth. At the end of the last chapter we quoted Titchener's remark that "attention is a psycho-physical phenomenon"—*i.e.*, the body and the mind co-operate in producing a condition of attention. There are three bodily changes which usually accompany attention, and the greater the interest with which we attend, the more marked as a rule are the bodily changes. Listen intently to a particular noise in the street outside, and two, at any rate, of the following three bodily changes will become manifest:

1. *Respiratory.* The breathing is checked, or it ceases altogether. (Note the familiar phrase "breathless attention.")

2. *Motor.* The muscles are braced up, the body is tense, and the head held firmly in a certain position, straightforward if the object is a sight, sideways if it is a sound.

3. *Vasomotor.* The heart beats more strongly and quickly, and there is a quickening of the flow of the blood in the bloodvessels.

When we are interested in any subject we assume, unconsciously, a certain bodily attitude. Conversely, by placing ourselves consciously in an appropriate bodily attitude, we become as a rule more readily interested in a subject. Further, we cannot expect to arouse the interest of a class of children, or command the attention of an audience if they are permitted to retain an inappropriate bodily attitude. For example, we cannot do acute mental work whilst reclining lazily in an armchair; if we seek to reprimand or exhort with our elbows resting on the arms of our chair, and with the hands hanging downward from the wrist, our reprimand or exhortation will be very ineffectual, but if we say the same words with the hands braced up and palms upward, our words become at once more effective. Dr. Thring, a famous English headmaster, once said that if you permit a boy to maintain an inattentive attitude nothing will make him attentive.

The Aim of the Development of Interest. We have seen that, according to the philosophy of Herbart, the aim of education is the development of a great variety of interests by the creation of apperception masses. But Herbart goes further, as indeed we all must, if our educational ideas are to be of practical value. Interests are of little worth so long as they remain only interests. The value of our interests can only be judged by our outward expression of them. Our aim, therefore, must go beyond the mere development of interests and lead on to their expression, so that children may, in due course, take their rightful place in the family, the society, the nation. Only in so far as interests are expressed in service does a man justify his existence and fulfil his function in the world.

THE WILL

Psychology is not yet, and probably never will become, one of the exact sciences, for it is not at all likely that instincts, emotions, interest, apperception masses, and the like will ever be capable of exact measurement. There will always be within this science a wide range of diverse opinion and point of view. Nowhere is this divergence more marked than in the writings of psychologists on the subject of this present chapter, for of all the branches of the science of psychology, that which is concerned with the psychology of the will is the most obscure. There is no generally agreed and recognised definition of will, and the varying definitions lead to varying treatment of the subject.

Will and Volition. Some psychologists use these terms as though they were strictly synonymous, but the distinction between them may be seen by considering two definitions of "will":

1. Will is that part of the mental process which is concerned with the choosing of one of a number of possible actions.

2. Will is the conscious direction of activities towards the attainment of a desired object.

In the first of these definitions, will is thought of as static—the act of choosing; in the second, will is dynamic—will is "a direction of activities." But the term volition might be kept for this direction of activities. In other words, then, will is the power, and volition is the power in active employment; the exercise of the will results in a great number of acts of volition. These acts of volition include not only physical acts, but also mental—*e.g.*, the will to believe, to be cheerful, to be hopeful. They may also include the "act of doing nothing." When a board of directors resolve that "no action be taken," or when we bask in the sunshine "doing nothing," they and we are making a very definite act of the will. "To do nothing" may be a very deliberate choice of "one of a number of possible actions."

"Attention" and "will" are also sometimes used as synonymous terms, on the ground that a choice of action can only be made by giving attention to each of the possibilities in turn. On the other hand, it is argued that will is the dominant factor, and the first in point of time, because it requires an act of will to bring attention to bear upon the possible choices, so that attention is regarded as a form of volition. McDougall calls attention to "the fundamental act of the will."

The Place of the Will in Human Personality. In speaking of the will in everyday life, people often fall into the error, almost of hypostatisation, of speaking of the will as though it possessed a separate independent existence; as though it were the controller of all the other faculties; as though it were not I who speak, or think, or do, but the will which directs me as to what I shall say, or think, or do. Sir John Adams illustrates this popular idea by the suggestion of the psyche as a court of justice in which the will presides as the judge, and the motives appear one by one and, urging their claims, plead for a decision in their favour against contending motives. But this, as Adams points out, is quite an erroneous idea. The will is not a kind of internal spirit which makes up our mind for us and tells us what to do. We say, "Shall I do this or that?" and our will does not control us, but we control the will. There is no will as a separate entity any more than imagination or memory may be regarded as separate entities. "Will is not a faculty distinct from the rest of our personality. Will is character in action" (McDougall). "Will is only the name of the psyche in its conative aspect, as it may be named the mind when we deal with it in its cognitive aspect " (Adams).

Motives and their Influence on Volition. Motives are not forces seeking to impose themselves upon the will, as in our illustration above. They are the calling up in our minds of the advantages and disadvantages of the possible lines of conduct. We speak of strong or weak motives, but no motive is strong or weak *per se*. It is only strong or weak as it is thought upon in the light of the totality of a situation; it derives its strength or weakness from the probable results of a possible course of action. For example, I have promised to go and spend the evening with the Robinsons, friends at the other end of the town, and I am undecided as to what to do. The motives for not going are to obtain pleasure by sitting by the fireside reading; to avoid the displeasure of going out in the rain and of suffering from the cold I may catch; to avoid the displeasure of becoming more closely acquainted with people I do not really want to know. The motives for going are to give the Robinsons a certain amount of pleasure; to prevent the uneasiness of conscience which will assuredly be mine if I break my promise. No one of these motives is, *per se*, weaker or stronger than another. It is I myself who, in the light of my knowledge of a complex situation, decide the strength or weakness of each motive. It will be noticed that the strength or weakness of a motive is always expressed in terms of the pain or pleasure which will most probably result from the action prompted by that motive. A motive is always a desire or an instinct.

Deliberation is the state of mind while the motives are being considered and weighed one against the other. In more homely language it is just " thinking the matter over." Deliberation, in some measure, is necessary when there is a complexity of unequal motives, or when there is an even balance of motives and none is pressingly urgent. It is generally agreed that deliberate action as a rule is safest, that we should "look before we leap," that we should not "jump to conclusions." The people who jump—or appear to jump—hastily to conclusions do so either because they possess the quality of intuition or lack the quality of caution. *Intuition* is the power of arriving in a flash at a conclusion which others can only reach by a process of deliberation. It is a quality to be desired, if only it is remembered that a person can be intuitively wrong as well as intuitively right. Caution (which is derived from the Latin *cautio*, I take heed) is the realisation of the danger of hasty decision. It is a quality of which some people possess too much, others too little. It must not be confused with hesitation or with procrastination. When we hesitate, we are reluctant to make up our mind; we flit from one motive to another without extracting the full possibilities from any; we return to the consideration of motives which we have already discarded. "He who hesitates is lost," runs the proverb, for the opportunity to act may be lost while he is making up his mind. But procrastination (Latin *crastinus*, relating to tomorrow) means that, having weighed the motives and come to a decision, we shrink from putting the decision into effect; we put off till tomorrow what we might just as well do today. There are occasions when most of us find that we are unable to make up our minds—*e.g.*, one man can never decide which way to vote at a meeting until it becomes obvious which side is in the majority; or a woman wishing to buy a hat may look at forty hats, and then be unable to make a choice of one of them. But sometimes we find people in whom the inability to make an act of will has become a permanent condition, in which the will seems to have become completely paralysed. This is a mental disease which is known as *abulia*.

Will and Character. Actions may be classified as (*a*) involuntary (or instinctive), (*b*) voluntary (or purposive). Instinctive actions do not come within the limits of the subject of this chapter, for they are the result of reflex responses to physical stimuli, applied to the various sense organs. " Spontaneous reflex and instinctive actions, even when accompanied by a mental element—sensation or feeling—can be traced solely to certain organic conditions, and do not proceed from a mental initiative " (Woodworth) —that is, they do not begin in the mind. But purposive or voluntary acts are the outcome of a mental process issuing in an act of the will. The development of habits, of self-control, in a word, of character, proceeds, *pari passu*, with the development and control of the will. As Woodworth expresses it: " Every decision made, every conflict resolved, is a step in the further organisation of the individual. It may be a step in a good or a bad direction, but it is a step in organising the individual reaction tendencies into what we call his character." " A man's character," it has been said, " is nothing more nor less than his will in action."

Potential and Final Choice. *Potential choice* is that which would result, if no other motives entered, from a man's character, temperament, personal likes and dislikes, etc. But only rarely do we find people acting from motives which are entirely personal and internal. There are other motives which should be considered—motives external to ourselves—*e.g.*, family, social, humanitarian considerations, and so on. *Final choice* is that which results when *all* motives, internal and external, have been considered. There are some people in whom the margin between potential and final choice is very wide; there are others in whom the margin is more or less narrow until, in some, potential and final choice equate. It is largely a question of personal character. The man who makes up his mind and " sticks to it" is generally called a man of strong will. But when a man's mind, through fear or selfishness, is impervious to appeals of reason, or sympathy, or to differing opinions and points of view, it is a sign not of his strength of will, but of its weakness. He would be more truly described not as strong willed, but as stubborn. The man who is really strong willed is he who is quite willing to alter his choice of action when adequate reason is shown to him. As steel is stronger than iron because of its power of bending when need be, so a man of flexible will is a stronger-willed man than he whose will is rigid.

The Freedom of the Will. Although the question of the freedom of the will is essentially a matter for the philosopher rather than the psychologist, yet a chapter on the will would be incomplete without some reference to it. The subject has been discussed by philosophers since the dawn of history, and the discussion has been nebulous because there has been no general agreement upon the limits of the subject or upon a definition of the terms.

The question to be settled is that of determinism against the freedom of the will. The determinist position is that the law of causality (*i.e.*, every event, everything which comes to pass, must have a cause) is of universal application; that our character and our acts are controlled by forces which work as uniformly as those which determine the motions of the heavenly bodies or the growth of plants. Our will, the determinist holds, is as determined as anything in the inorganic world. As there are many events which happen in the universe which we have not yet sufficient knowledge to explain, but which we yet believe to be the effect of the working of natural law which is yet unrevealed, so we have not yet sufficient knowledge of the manifold factors which determine our will, but there can be no doubt that there is no event in the mental and spiritual life which does not obey immutable laws. Those who, on the other hand, accept the doctrine of the freedom of the will, insist that the will is free to make a conscious choice when there is the possibility of a number of courses of action. But freedom must not be understood to mean that unhampered and unlimited freedom which is not truly freedom, but which would result in general chaos. They assert that the will is free within certain freely accepted limits. If a man willingly accepts the limits imposed by conscience, by law, by social convention, and so on, his will is essentially no less free than that of a man who chooses to disregard these limits. So, it is asserted, human decisions really are as free as we feel that they are; they are real determinants which have themselves the power to begin a new sequence of cause and effect; we are right in believing that when we have done *this* we might have done *that* had we so willed; the sense of responsibility which we feel for our own actions is not a delusion, neither is that sense of power which we all feel—the sense of our ability to mould events, and so to be, to a certain extent, "the master of our fate."

It is obviously impossible, within our brief limits, to discuss at any length the pros and cons of the determinist or the free will doctrine. The strength of the determinist argument was greatly increased by the scientific discoveries of the last two centuries. The conception of natural laws invariable in their operation was found to be apparently trustworthy within limited regions of nature. From the consequent generalisation that the universe could be explained in terms of invariable sequence man was not excluded.

The determinist doctrine depends upon the law of causality. If the law goes, the doctrine goes with it. As far as Western philosophy is concerned, the question between free will and determinism is no longer an open one, but has become of merely academic interest. A catena of quotations from the writings of modern philosophers might be given, but one will suffice. Even when this chapter was written (November, 1930), Sir Arthur Eddington, Professor of Astronomy in the University of Cambridge, broadcast a lecture in which he used these words: "Another striking change of scientific views is in regard to determinism. . . . Until recently this was almost universally accepted as the teaching of science—at least, in regard to the material universe. . . . But today physical science is built on a foundation which knows nothing of this supposed determinism. So far as we have gone in our probing of the universe, we cannot find a particle of evidence in favour of determinism. . . . There is no longer any need to doubt our intuition of free will. Our minds are not merely registering a predetermined sequence of thoughts and decisions. Our purpose, our volitions, are genuine; and ours is the responsibility for what ensues from them. For we are scarcely likely to accept a theory which would make the human spirit more mechanistic than the physical universe."

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